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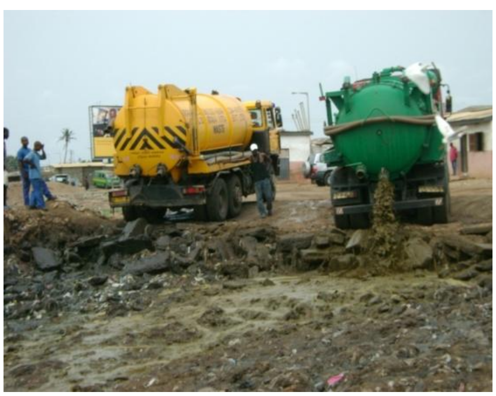

3rd Ghana Water Forum
Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment
5th – 7th September, 2011

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

College of Physicians and Surgeons, Accra, Ghana
5th – 7th September, 2011

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SANITATION

WATER

POSTER PRESENTATION ABSTRACTS

Theme: Sanitation

3rd Ghana Water Forum, Accra, Ghana, 2011
Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Improving Sanitation in Poor Urban Areas: The Role of Non-State Actors in the Sanitation Service Delivery in Ashaiman Municipality, Ghana

Abena Korang Acheampong Abaitey

Abstract

This paper presents a study on sanitation service delivery in an urban poor locality in Ghana, Ashaiman. Ashaiman is a sprawling urban settlement in Ghana and suffers from poor sanitary conditions. Close to 80 per cent of households in the Tulaku area, a suburb of Ashaiman, do not have toilet facilities in their homes because landlords did not deem it necessary to construct toilet facilities (Ashaiman Medium Term Development Plan, 2008-2011). Most public toilet facilities are also in a deplorable state. As a result of these inadequacies, there is over dependence on the few public toilet facilities and this has further led to indiscriminate defecation in open spaces and bushes.Compounding the problems discussed above, is the poor attitude of residents who indiscriminately dispose of refuse, and again, most residents refuse to pay refuse fees. The poor attitudinal problem has made it increasingly difficult for city authorities to maintain good sanitation in the communities despite several interventions adopted by the government, as well as, civil society organizations to improve the appalling sanitation situation.

The study sought to discuss the role played by non-state actors' sanitation service delivery. The study identified some challenges confronting the sanitation delivery in Ashaiman as; Inadequate budgetary and financial allocation for implementing sanitation action plans, lack of sanitation byelaws at the municipal level, thus, weak or no enforcement of laws, Deficient capacity of civil society to mobilize the community to engage in sanitation exercises, the Lack of coordination between local authority and other stakeholders, and the lack of community engagement in the sanitation service delivery.

A major finding that emerged from the study was that there were a range of community actors in sanitation delivery, not withstanding, they were not recognized as important stakeholders and local authorities hardly partner with them in the process of change.

The study has discussed measures of improving sanitation in the poor urban localities of Ghana and recommends that if local authorities collaborate with non-state actors, especially informal service providers and community based groups, it would enhance improvement in the sanitation situation in poor urban localities.

Introduction

Urban Local authorities in Ghana are grappling with the growing sanitation crisis in their localities. Ashaiman, a sprawling 'urban slum' and the fifth largest settlement in the Greater Accra Region of Ghana is one of such municipalities. Despite various interventions adopted by the

Government and civil society organizations, the problems continuously persist. Current sanitation delivery approaches are not able to integrate effective pro-poor community partnerships in a meaningful way.

The question to ask is, how can communities' be engaged to improve the sanitation situation in their vicinities?

The objectives of the study were:

- To identify the range of significant community actors in the sanitation sector at Ashaiman and to find out what each can do to bring about improvement in sanitation;

- To suggest appropriate ways of engaging community actors in supporting sanitation service delivery in the sanitation situation in Ashaiman Municipality;

- To provide adequate information and basis to guide communities and local authorities in the efficient delivery of sanitation services especially in poor urban communities of Ghana.

Analysis and Discussion

Current Conditions and Practices

In most parts of Ashaiman, drains have been used as waste receptacles, and residents often do so especially at night. During rains too, residents often dump refuse in the drains. The Waste Management Officer reported that,

> *"Residents do so as if the collector has come".*

Non-state actors play a significant role in sanitation service delivery in Ashaiman. The study revealed that over 400 informal service providers popularly called the "truck pushers" operate in house to house solid waste collection in Ashaiman. They offer quick services, and their charges are comparatively cheaper. Most residents prefer this option because they pay small amounts on daily basis and charges are flexible and negotiable. Charges are based on the quantum of refuse and are determined by the service provider. However, there is little recognition of their roles by local governments. In an interview with a truck pusher, he said,

> *"I have been working for the past 2 years and I am satisfied with the work I am doing because it is good. I earn at least not less than GH¢25 ($20) a day. Apart from the money, I contribute a lot to keep the communities clean. The Zoomlion alone (private service provider) cannot do this work. The Assembly must not drive as away since we are willing to pay our license".*

Plates 1 and 2 below show truck pushers on their daily routine.

Plate 1: A Truck Pusher Carting Refuse Collected
Source: Field Survey, 2009

Plate 2: After a Successful Day's Work, a truck pusher cleans his Truck
Source: Field Survey, 2009

Other non-state actors identified were Community Based Groups such as the youth associations and religious bodies. However, they are also beset with problems.

The San Diego Youth Association Group members interviewed reiterated that the group faces a lot of challenges, especially getting the support and maximum cooperation from local authorities.

The Chairman of the Association said,

> "*We want to erase the bad perception from people's minds that Zongo Community is noted as bad and dirty place to reside. Therefore, as part of our activities, we organize annual clean up exercises. On the other hand, we lack support and cooperation from our own people. When we need the support of our leaders, they do not turn up. We ask that they open their doors to us when we call on them. They often think we are too young and have nothing good to offer".*

The study revealed that civil society organizations (CSOs) recognize their community empowerment role but do not have the capacity to carry them out.

The study also revealed that Municipality has not embraced the idea of mainstreaming other actors in the sanitation service delivery. Informal service providers are perceived as a nuisance in the community by the Assembly.

Again, non-governmental organizations (NGOs) in sanitation delivery also operate as voluntary workers and their activities are not incorporated in the development plans of the Assembly.

Institutional Environment

The study revealed that the Municipal Assembly had low capacity in terms of financial, logistics and technical support to improve the sanitation situation. In an interview with the Environmental Health Officer, he reiterated that,

> *"Even though our plans and budget are prepared and submitted to the Assembly, we hardly receive any money to implement our plans. I can conclude that sanitation is not a priority of the Assembly and again, the District Assembly Common Fund (DACF) allocation to the sanitation unit is misappropriated for other purposes".*

In an interview with the Waste Management Officer, he added that,

> *"The unit has a working plan, but it is very difficult to implement. Some are achievable though, but others are not because of high cost".*

The study further identified that the Environmental Health Inspectors who conduct daily routine inspection on behalf of the Assembly had not received training for the past ten years. Again, the Waste Management Department hardly exists because of lack office space to operate. In an interview with the Sanitation Officer at the Ashaiman Zonal Council, he commented that even though annual requisition forms are submitted to the Municipal Assembly, no subvention is received to run the unit.

He narrated that,

> *"We have not received monies from the Assembly for the past years to run the unit. Sanitation is not their priority". We only receive support from the Assembly only on emergency cases or when there is a special programme. We are indeed practicing cosmetic sanitation".*

Further analysis revealed that there was lack of sanitation byelaws at the municipal level. The Municipal Assembly operated with in the National Sanitation Policy which is often too broad and hence, not location specific to guide residents. Sanitation bye laws were still in the process of being gazetted. It can be concluded that Assembly do not have the capacity to enforce regulations and therefore the difficulty in implementing laws.

In sum, the study revealed that was little appreciation of the financial benefits of investing in sanitation from both communities and the District Assembly level. Even though the problem of inadequate sanitation services was identified as top priority by the communities which were reflected in the Ashaiman Municipal Medium Term Development Plan (2008-2011), this was rarely translated into actual implementation because of inadequate policy and institutional environment to support the sanitation sector.

Major Lessons/Findings

The study identified the following as the major lessons or findings regarding sanitation service delivery in the municipality.

1. Ashaiman has organized and vibrant community groups in the sanitation sector who are willing to support the process of change. However, they lack the capacity to mobilize the community, express their needs and the lack of financial and technical support from the Assembly to carry out their activities.

2. Informal service providers in waste collection often called truck pushers are one of such groups. This "business" is dominated by the migrants' youth and forms an important job opportunity for them.

3. The study revealed that open defecation is due to inadequate public toilet facilities. A common phenomenon which is emerging is that most residents defecate in polythene bags and

indiscriminately dispose of them in open drains. These open drains also serve as defecating grounds for children and some adults especially during the night.

4. The Municipal Assembly lacks the capacity to in terms of financial, logistical and technical constraints to ensure good sanitation.

5. CSOs in the sanitation sector activities' are not mainstreamed in the medium term development plans of the Assembly. They are rarely recognized as important stakeholders in local level development and local authorities hardly partner with them in the process of change.

Recommendations and Conclusion

It is recommended that improvement in the sanitation services especially in poor urban areas can be sustained through the co-operation and concerted efforts of municipal authorities, non-government organizations, community-based organizations, as well as, the entire community. This paper suggests successful implementation of the following actions;

- **Mainstreaming Non-State Actors in the Sanitation Delivery**
  If governments have interest in addressing sanitation needs, it can start by simply recognising the important roles played by community actors especially the informal private providers by mainstreaming them into the formal system. Identification and Mapping activity of Stakeholders through an inventory process in the sanitation sector should be carried out to support the process of bringing change.

- **Assign Roles and Responsibilities to Community Actors**
  Assemblies can assign specific roles in the sanitation sector. Different components of sanitation such as solid waste management, community public toilet facilities supervision, public dump site management, and drains cleansing should be taken care of by specific groups in the community. This would ensure community ownership and create a sense responsibility by every member of the community.

- **Institutionalization of Regulatory Procedures**
  The Ashaiman Municipal Assembly must institute regulatory measures such as sanitation byelaws to ensure that people do the "right thing". Laws must be enforced and punity measures such as payment of huge fines must be instituted to serve as deterrent to others. However, much would be achieved if the building regulation (as stipulated in the National building regulations), that enjoins every builder to provide a private place of convenience within the building is enforced by the Assembly.

- **Strengthening of Monitoring Control Team**
  The Ashaiman municipality monitoring task force's capacity must be strengthened in terms of providing adequate logistics to carry out daily routine inspections. The Environmental Health and the Waste Management Department of the Assembly must be resourced and adequate capacity building training must be given to staff to help improve general sanitation in the Municipality.

In conclusion, it was recognised that the role played by non-state actors in sanitation sector is very enormous and hence, can contribute immensely to the local level development. Non-state actors including informal private providers must be seen as a fundamental first step in the process of engagement. This requires little investment and therefore less risk. More importantly, local governments must commit efforts to train and build their capacity so that they support the process of change in the sanitation sector of their localities.

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Potential Energy Recovery from Wastewater Treatment - Study of UASB Reactor in Accra, Ghana

K.M. Afful

Abstract

In 2000, the Accra Sewerage Treatment Plant (ASTP) incorporating the Upflow Anaerobic Sludge Blanket (UASB) technology among other treatment units was commissioned (the UASB is the main treatment process). The plant was designed to handle about 16,000m^3/d of sewage. As per the design, the biogas produced was flared off and the dried sludge was sold as fertilizer. Unfortunately, plant operations failed after it was handed over to the Accra Metropolitan Assembly (AMA), the city authority. Currently the plant is non-functional and the sewage is bypassed into the Korle Lagoon, severely polluting it. A study was carried out to determine the "methane recovery potential" of the ASTP from treating sewage, feacal sludge and septage flows with available data obtained during the plant's operational years. A simplified version of the IWA Anaerobic Digestion Model No. 1 (ADM1)(D.J Bastone, J Keller et al. 2002a) was developed and implemented AQUASIM[1](Reichert 1998).

Results from the study shows that the UASB has the capacity of treating the ***sewage flow with additional 30 and 50 trucks per day of faecal sludge of public toilet origin and septage****. This mix of flows has a gas generation potential of about* ***4165 CH_4 m^3/d****. This amount of gas flow has an annual economic benefit of* ***950,000GHC (equivalent to 475,000€)***

Introduction

The management of sewage, septage and public toilet effluent in Accra, capital city of Ghana has been very poor over the past several decades and it is becoming worse. The overflow of septage from septic tanks into drains and water courses and indiscriminate disposal of public toilet effluent pollutes the immediate environment including rivers and the sea with drastic effects on the recreational value of our beaches. With increasing population and urban housing stock more septic tanks and public toilets are being constructed and the challenges of poor septage management will increase several folds; domestic and public toilets using vaults without drain-fields, public toilets and cesspits are the main sources of septage and faecal sludge. The situation of septage treatment in the Greater Accra Metropolitan Area, in particular, is dire – all the gains made during the early 1990s by strategically locating treatment plants at Achimota, Teshie-Nungua (Fertilizer) and Korle Gonno (Lavender Hill) is completely naught. The closure of the Achimota Treatment Plant (redeveloped into a Transport Terminal) and the recent closure of the Teshie Faecal Sludge Treatment Plants (FSTPs) has resulted in more truck loads of septage and faecal sludge being diverted to the Korle Gonno site which does not offer any form of treatment. This situation has brought to the fore the urgent need to revisit AMA’s Accra Sewage Treatment Plant which has

[1] A computer program for the identification and simulation of Aquatic Systems

Upflow Anaerobic Sludge Blanket (UASB) reactor cells as the main treatment process. The plant was commissioned in 2000 and its management handed over to the AMA in 2002; it has remained largely non-operational since then.

As part of efforts to rehabilitate the plant and restore treatment, an urgent need of the city authority, a simulation of the UASB compartment of the full scale plant was carried out with available data obtained on the plant during its operational years. This study was carried out mainly to assess the capacity of the existing plant to treat additional organic loads from septage and public toilets generated from the city. Also it focused on the *"methane recovery potential"* of the facility from treating these waste streams. A major set-back to simulating the full-scale UASB was the lack of requisite data for a more detailed model development to describe a wide range of key parameters of importance in the anaerobic digestion process. Nonetheless, the full scale UASB was simulated to predict methane (CH_4), effluent COD and TSS concentrations.

The Accra Sewerage Treatment Plant (ASTP)

Sewage enters the works from the Central Accra Pumping Station (CAPS). Pumps deliver the raw influent to the elevated inlet works structure and from this point forward it flows through the process by gravity. The initial treatment at the headworks provides for duty/standby stainless steel fine screens and gravity grit channels. The primary plant consists of six separate UASB reactor cells, having a total volume of approximately 6500m^3. Each compartment is equipped with gas-liquid-solids separators in which the biogas is collected before it is directed to the flare stack. Adjacent to each UASB reactor is a gravity thickener that thickens the stabilised sludge from the UASB, and additionally treats sludge from the latter stages of the process. Sludge from the thickeners is pumped directly to sludge drying beds. Two fixed growth reactors or trickling filters (TFs) and two final settling tanks (FSTs) provide secondary and tertiary treatment to the effluent stream. The rotating distribution arms of the TFs are reaction-driven stainless steel, further reducing the need for additional power consumption and costly maintenance requirements. The FSTs incorporate energy diffusing inlets and periphery screening to further enhance effluent quality. The treated final effluent was discharged to the estuarine waters of the tidal Korle Lagoon (see Figure 1).

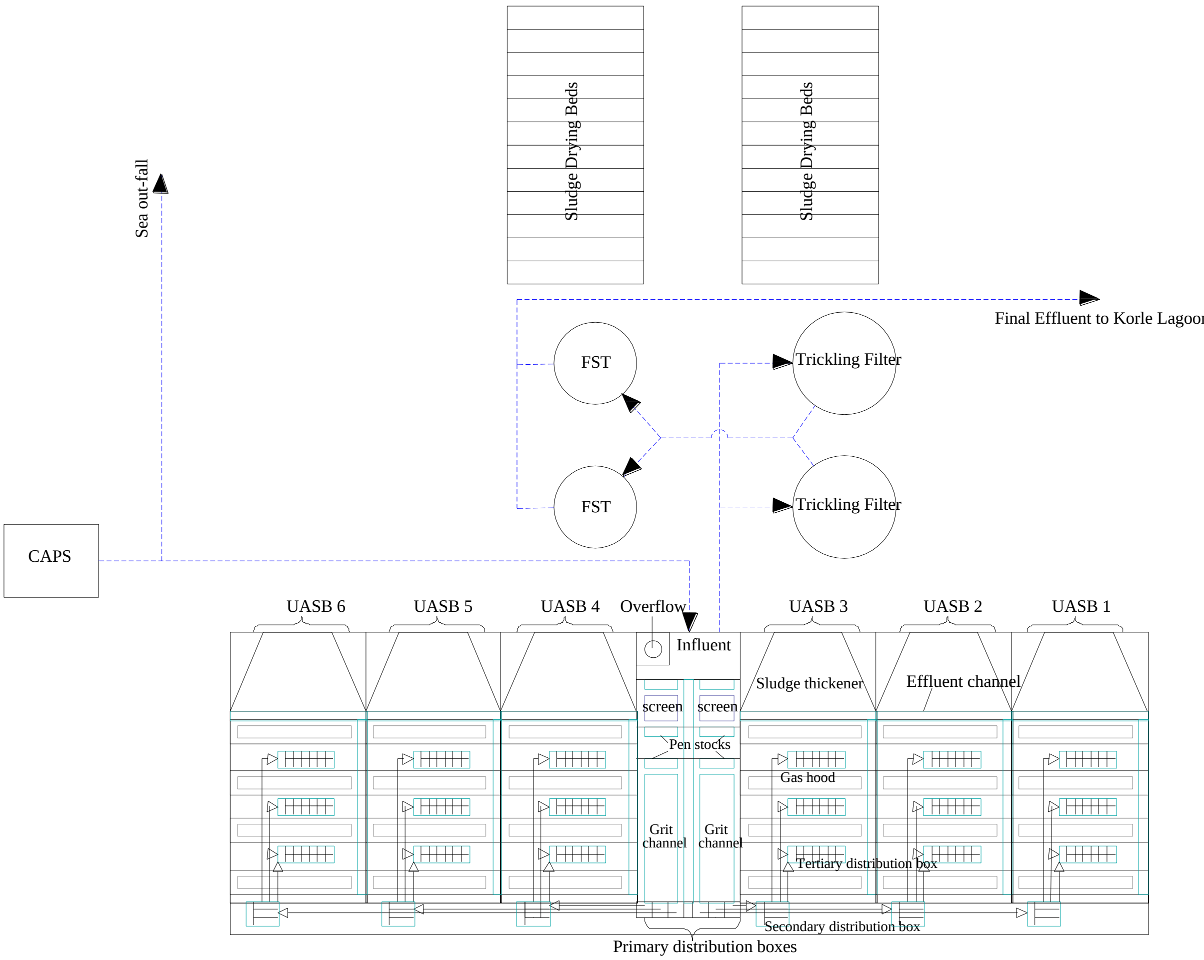


Figure 1: Schematic Diagram of Accra Sewage Treatment Plant (adapted from report of Titia Des Mes)**.**

Materials and Methods

The UASB reactor is considered to consist of the liquid and gas phase. The liquid phase contains soluble components, particulate substrate and the biomass. The gas phase contains the biogas that escapes from the liquid phase. For this study one (1) enzymatic process (hydrolysis), four (4) biological processes (acidogenesis, methanogenesis, decay of acidogens and decay of methanogens) and one (1) gas-liquid transfer process were considered.

Biochemical Process

In the ADM1, fermentation of 8 different substrates is considered separately with 7 bacterial population required for the description of the process. The ADM1 as fully proposed would require simultaneous solution of mass-balance equations for each individual substrate and bacterial population for the system to be described. Such treatment is extremely complex, yielding equations with numerous unknown parameters. Hence the idea for the development and adoption of a simplified version of the ADM1 was driven by the objectives of the study and the availability of data for input and calibration of the model. The seven (7) groups of bacteria in the ADM1 were therefore divided into two major groups: acid producing bacteria and methane producing micro organisms (Noykoya, Muller et al. 2002).

Physico-Chemical Processes

In this model only the methane (CH_4) gas component was considered.

Wastewater Characterisation

As a first step to determining the influent fractions into the model, the soluble biodegradable (Ss), particulate biodegradable (Xs), soluble inert (Si) and particulate inert (Xs) were determined based on the percentage biodegradability of the influent COD relying on data from Des Mes (2002).

Model Implementation

The model was implemented in AQUASIM: Computer Program for the Identification and Simulation of Aquatic Systems (Reichert 1998). The model has been implemented as consisting of two compartments: reactor and the headspace. A diffusive link was used to describe gas transfer between the reactor and the headspace. There were two other "virtual" compartments with advective links for effluent flow and waste sludge collection. A bifurcation link was also defined to describe the recirculation of particulates that escape through the effluent.

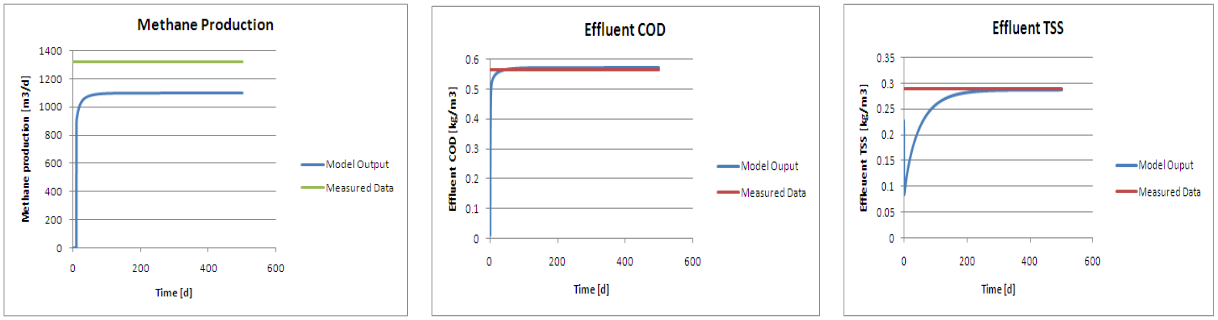
The reactor was assumed to be a Completely Stirred Tank Reactor (CSTR). Similarly the headspace was implemented as mixed reactor compartment. In addition to these, two other compartments, outlet and WAS collector were defined for effluent and waste sludge flows respectively. A diffusive link was defined from reactor to headspace. Advective links were defined from reactor to outlet compartment and from reactor to WAS collector compartment. There was a bifurcation link on reactor to outlet compartment link to describe the recirculation of solids in the effluent back into the reactor compartment.

The identified conversion processes namely: hydrolysis, acidogenesis, methanogenesis and biomass decay, were then defined in the process compartment of the AQUASIM. The dynamic simulation of the entire duration was then defined. With the described processes and the appropriate state variables active in the defined program compartment, the simulation was then performed.

Results and Discussion

Calibration and Validation of Model

The model was calibrated with the average values of measured data on methane generation, COD and TSS in the effluent for the period of 21st August 2002 - 21st November 2002. Due to insufficient sets of data the model was not validated. An iterative method was used for the calibration of the parameters to fit the model output to the measured data. The estimated parameter values providing the best fitting between model outputs and measured data are given in Table 1. During calibration influent COD fractions, yield of acidogenes on substrate (Y_{ac}), yield of methanogens on substrate (Y_{ch4}) and the hydrolysis (k_{hyd}) constant were found to be most sensitive.



(a) (b) (c)

Figure 2: Comparison between measured average methane production (a), effluent COD (b), effluent TSS (c) and the model calculation

As can be seen in Figure 2 (a), there is a disparity (about 16%) between the measured data and model calculation. This percentage deviation was expected to be higher due to the following:

- From the data obtained it was assumed that 70% (theoretical fraction of methane in biogas) of the measured gas was methane, meaning the other gaseous by products of the anaerobic digestion process (CO_2, H_2S, N_2) makes up the remaining 30%. This proportion may be a little under estimated. For instance average influent sulphate measured is 50mg/l (Des Mes 2002). Theoretically this sulphate concentration oxidises about 2% of available COD (1g SO_4^{2-} is takes up to 0.67 gCOD). At low concentrations of sulfate, sulfate-reducing bacteria compete with methanogenic archaea for hydrogen and acetate, and at high concentration the sulfate reducing bacteria also compete with acetogenic bacteria for propionate and butyrate. Sulfate-reducing bacteria can easily out-compete hydrogenotrophic methanogens for hydrogen (Stams, Plugge et al. 2005).

- Also in the model it was assumed that all the gas that collected in the headspace was methane. This again is not necessarily true since there are/may be other gases such as CO_2, H_2, H_2S, N_2. This reduces the total pressure of gas in the headspace and hence its ratio with atmospheric pressure. In the model, the higher the pressure in the headspace, the higher the calculated methane production.

- Again the model did not consider methane lost in the effluent and that all the methane produced escapes into the gaseous phase.

Figure 2 (b) shows the comparison between measured average effluent COD and the model calculation of average effluent COD. Due to the long solids retention time (SRT) and hydraulic retention time (HRT), the effluent COD is assumed to be made up mainly of soluble unbiodegradable COD (S_i). Also in reality, a UASB reactor is not completely stirred tank reactor (CSTR) but rather, solids concentration generally decrease with increase in height. On the other hand, the reactor compartment was modeled as a CSTR.

Figure 2 (c) shows the comparison between measured average effluent TSS and the model calculation of average effluent TSS. The model fitted well with effluent TSS concentration. In the model, effluent TSS was calculated by the sum of particulate COD in the effluent divided by the

COD:VSS ratio of 1.5gCOD/gVSS (to convert the COD to VSS) and the effluent particulate inorganic suspended solids.

Table 1: Summary of Model Parameters after Calibration

Parameter	Symbol	Value	Unit	Reference/Remarks
Fraction of Ss	$f\_COD\_S_s$	0.491	Ratio	Based on model calibration
Fraction of Xs	$f\_COD\_X_s$	0.3088	Ratio	Based on model calibration
Fraction of Si	$f\_COD\_S_i$	0.122	Ratio	Based on model calibration
Fraction of Xi	$f\_COD\_X_i$	0.0772	Ratio	Based on model calibration
Fraction of inert particulates in effluent	f_Xeff	0.01	Ratio	Based on model calibration
Fraction of soluble inerts from decay of complex particulates	f_SI_xs	0.1	Ratio	Bastone *et al* 2002a
Fraction of particulate inerts from acidogenic biomass	f_XI_xs	0.25	Ratio	Bastone *et al* 2002a
Hydrolysis constant	k_{hyd}	0.1	d^{-1}	Bastone *et al* 2002a
Half saturation constant	$K_{s,ss}$	0.022	kgCOD m^{-3}	Bastone *et al* 2002a
Maximum specific uptake rate	$k_{m,ss}$	51	kgCOD COD^{-1} d^{-1}	Bastone *et al* 2002a
Yield of acidogenes on substrate	Y_{ac}	0.085	COD COD^{-1}	Bastone *et al* 2002a
First order decay rate	$k_{dec,ac}$	0.02	d^{-1}	Bastone *et al* 2002a
Half saturation constant	$K_{s,ch4}$	0.5	kgCOD m^{-3}	Bastone *et al* 2002a
Maximum specific uptake rate	$k_{m,ch4}$	19	kgCOD COD^{-1} d^{-1}	Bastone *et al* 2002a
Yield of methanogens on substrate	Y_{ch4}	0.04	COD COD^{-1}	Bastone *et al* 2002a
Decay constant	$k_{dec,ch4}$	0.02	d^{-1}	Bastone *et al* 2002a

Modeling Studies

The calibrated model was used to predict the extent to which the UASB can accommodate the additional loads and the amount of methane generated from treating the organic loads.

Three wastewater streams from the city of Accra were identified under this study. These are sewage, septage and faecal sludge from public toilet origin discharges (we have either discussed this earlier or should have done so). Model calculations for CH_4 production, COD effluent, TSS effluent and flux of excess sludge is presented and discussed. These results are presented in Table 2.

Table 2: Model predictions for various scenarios

Scenario	Model Prediction		
	CH_4 (m^3/d)	Effluent COD Flux (kgCOD/d)	Flux of Excess Sludge (kgTSS/d)
1. Sewage only	2763	527	3574
2. Sewage + Septage	2802	2354	3545
3. Sewage + Faecal Sludge from public toilet	4266	5229	8477
4. Sewage + Septage + Faecal Sludge from public toilet	4294	5428	8294

Based on the design of the ASTP the trickling filter was designed for an average COD load of 6,580kg COD day^{-1}, the sludge thickener was designed for an excess sludge waste of 7420 kgTSS day^{-1} in 8 hours and the drying beds for 9750kg TSS day^{-1}.

From the results of (Table 2), all 4 scenarios meet the average design COD loading for the trickling filter. Scenarios 3 and 4 exceed the average TSS load for the thickeners. Nonetheless, it must be noted that influent wastewater streams parameters for the study were measured in-situ. In reality the influent wastewater into the reactors will have undergone some primary treatment as mechanical screening and grit removal will reduce to an extent the influent TSS concentrations and by extension reduce the TSS flux (because TSS concentration in the reactor is reduced). Same can also be said for CH_4 production and effluent COD.

Determination of Extra Organic Loads from Septage and Public Toilet

The limiting parameter regarding the capacity of the plant to treat loads from septage and public toilet is the TSS load. The allowable TSS flux was set to 7420kgTSS/day (designed excess sludge load).

This gave total flow of septage and public toilet of 780m^3/d. With an average daily truck volume of 9.5m^3/d, the plant can accommodate approximately 80 trucks/day. Going by the daily flow proportion of about 35% public toilet and 65% septage, the plant can then accommodate about 30 trucks public toilet content and 50 trucks of septage content. The estimated methane production is 4165m^3/d.

Overview of Economic Benefit from Methane

This section makes an estimation of the amount of income that could be made from the sale of biogas (Van Lier 2010) and estimated as follows:

- 100kg COD produces approximately 35m^3 CH_4. Therefore 4165m3 CH4 will represents 11,785kgCOD.

- 1tonne COD is equivalent to 3820kWh-e. With 0.85 efficiency of gas treatment unit and a motor efficiency of 40%, 11.785tonnes COD will generate 11.785 x 3820 x 0.85 x 40% = 15,306 kWh-e.

- In Ghana, current 1kWh cost 0.17 GHC. Hence 15,306 kWh-e will cost approximately 2,602GHC. Hence annual income from gas sale is equivalent to **950,000GHC (equivalent to 475,000€)**

Conclusion and Recommendation

Conclusion

- The study revealed the applicability of simplified ADM 1 for UASB treating municipal waste water in the prediction of effluent characteristics.

- There may be an under estimation of the potential methane produced due because the methane produced from conversion of H_2 and CO_2 is not included in the model.

- Due to the unavailability of enough data for the model development, calibration and validation, there is wide uncertainty with the use of this model for precise forecasting. That notwithstanding it gives a fair forecast than can be used for planning purposes.

Recommendation

- Extensive study into influent characterisation of the various waste water streams should be implemented as part of the O&M management of the plant.

- Expansion of the model to describe other processes that were not considered under this study.

- The predicted methane production could be treated with addition of extra harvesting and processing unit and sold to nearby brewery industry. There is therefore the need for an extensive financial model to determine the economic viability of this measure.

Acknowledgement

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Keywords
Upflow Anaerobic Sludge Blanket (UASB), Methane, Anaerobic Digestion Model.

Implementing Environmental Sanitation Policies and Plans

S.E. Amekudzie, R. Boakye & K.M. Afful

Abstract

*The Environmental Sanitation Assessment and Audit (ESAA) process has been applied in the water and environmental sanitation sector as situational and facilities assessment tool since 2007. Salifu et al. during the 33rd WEDC International Conference Accra, 2008 gave a generic overview of the ESAA process. A major output of ESAA is the preparation of Town Environmental Sanitation Development Plan (TESDP) which outlines specific interventions to be undertaken within a specified period. This paper discusses the relevance of the ESAA process as the "**building block**" to meeting the overall objectives of the Environmental Sanitation Policy. The paper goes further to assess the level of implementation of interventions proposed in the accompanying TESDP. Information gathered under the study shows that although quite a number of ESAAs have been conducted across regions in Ghana, implementation of proposed interventions is very low. The Central Government's showing more commitments to funds allocation for implementing environmental sanitation interventions and the development of the capacity of Metropolitan, Municipal and District Assemblies (MMDAs) to market their TESDPs, are among some of the recommendations.*

Introduction

The National Environmental Sanitation Strategy and Action Plan (NESSAP) 2010, prepared to give the national Environmental Sanitation Policy (ESP, revised 2010), "legs", as part of its measures to expedite and guide the systematic development and implementation of programmes and services in the water and environmental sanitation (WES) sector recommended that, Metropolitan, Municipal and District Assemblies (MMDAs) develop strategic District Environmental Sanitation Strategy and Action Plans (DESSAPs). The DESSAPs shall not be static but rather be updated regularly. In order to meet the objectives of the DESSAP as well as a measure to support research into appropriate technologies to meet the needs of all segments of society, especially the vulnerable and poor people, the ESP (revised 2010), proposed "*carrying out assessments to determine effective demand of communities (urban, peri-urban, small towns and rural) for environmental sanitation infrastructure*". A budget of GH¢ 6,000,000 has been set aside in the accompanying Strategic Environmental Sanitation Investment Plan (SESIP) for carrying out ESAAs over the period 2011-2015.

Environmental Sanitation Assessment and Audit (ESAA) comprise two major processes- assessment and auditing. The assessment involves a situational appraisal of the town and comprises field observations and surveys. The auditing processing on the other hand involves finding out the extent to which laid down regulations, guidelines and/or procedures are followed and adhered to by respective District Assemblies (local governments). The detail stages of the process are presented in Figure 1.

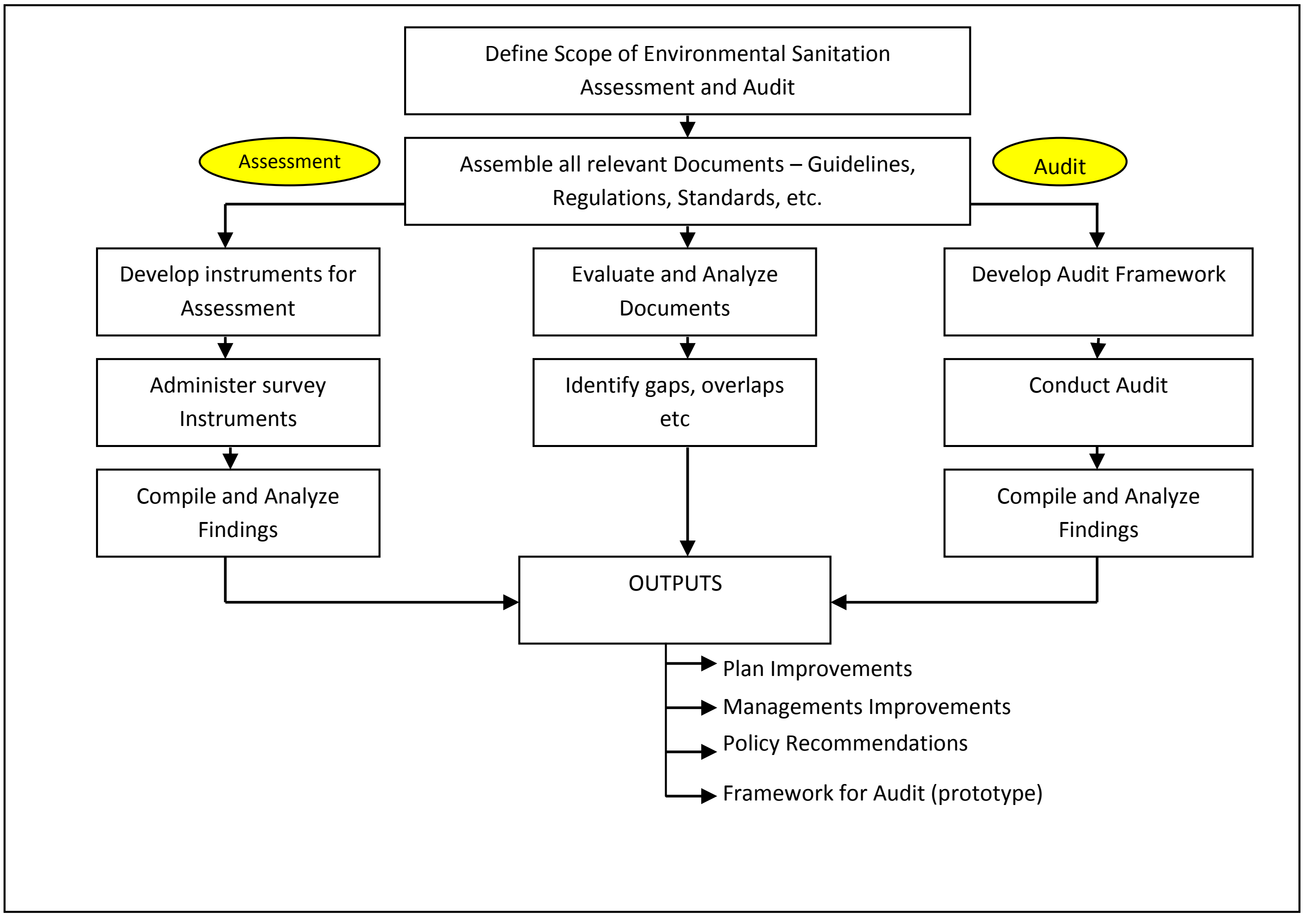

Figure 1: Framework for conducting Environmental Sanitation Assessment and Audit (Salifu *et al*., 2008)

Relevance of ESAA in Meeting Policy Objectives

The ESAA process is highly participatory and in conformity with Strategic Environmental Assessment (SEA) principles. Participatory tools used in the assessment and audit process are derived from the Practical Guide on Strategic Environmental Assessment (SEA) of Water and Environmental Sanitation and supplemented with additional information from other sources. The environmental sanitation components assessed where applicable include- watershed management, water supply, storm water/sullage disposal, solid waste management, liquid (faecal) waste disposal, health and hygiene practices and environmental sanitation bye-laws. These components have also been defined in the policy, as the main components of environmental sanitation. The ESAAs due to their participatory approach ensure community ownership and more importantly allows for the bottom-up approach which the policy recommends.

ESAAs form the basis for the preparation of TESDPs and financing packages which shall be further aggregated into the DESSAPs. Figure 2 shows the hierarchy of planning process to meet policy objectives.

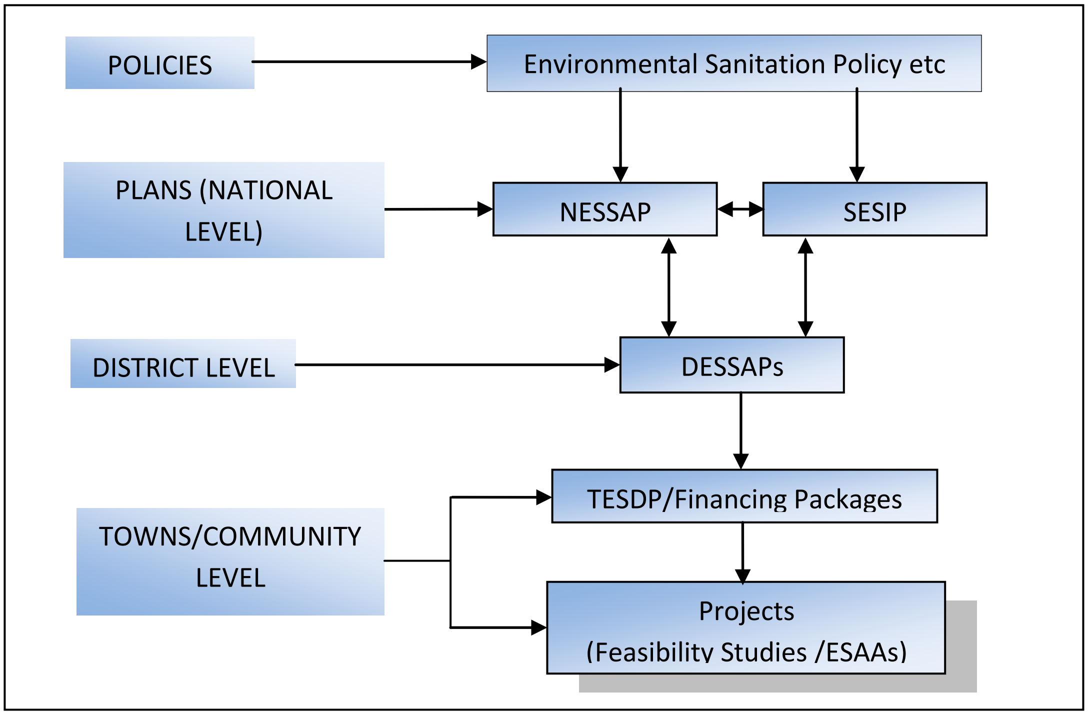

Figure 2: Hierarchy of planning process to meet policy objectives (modified from NESSAP document, 2010)

Review of Implementation of Proposed TESDPs

The TESDP closely follows the generic format prepared for use by cities under the first phase of the Urban Environmental Sanitation Project (UESP-I), aspects of the Guidelines for Preparing Waste Management Plans published by the Environmental Protection Agency (EPA) and the Ministry of Local Government and Rural Development (MLGRD); the Operational Manual for Planning, Budgeting, Monitoring and Evaluation, for Water and Environmental Sanitation prepared by the National Development Planning Council (NDPC) and the Community Water and Sanitation Agency (CWSA); and the Handbook for Preparation of District Environmental Sanitation and Action Plan (DESSAP) prepared by the Environmental Health and Sanitation Directorate (EHSD) of the MLGRD. The TESDPs have been broken down into separate packages for easier implementation-usually three packages within a 10-15 year planning horizon with each package covering the various components of environmental sanitation.

From the review of available information on ESAAs carried out and their accompanying TESDPs prepared for about 20 towns across 4 regions starting 2007, only a couple of the proposed interventions have been implemented to date (see Table 1). Furthermore, these implemented interventions only constitute a part of the first package of the three-package implementation plan. The failure of the respective district assemblies to implement these interventions is largely due to lack of funds. The districts also lack the capacity to solicit for funds from development partners and always rely on funds from central government/projects. This poses a question on how equipped our MMDAs regarding managing their roles in the delivery of facilities and services to their communities.

A close look at Table 1 shows two (2) ESAAs carried out in Akplabanya alone. The first carried out in 2008 by CWSA under the DANIDA supported Water and Sanitation Sector Programme Support Phase I (WSSPS I, 1998 - 2003) and the other in 2010 under the Government of Ghana (GoG)/DANIDA-supported Local Services Delivery and Governance Programme (LSGDP) - Environmental Sanitation Sub-Component. This again raises the issue of effective coordination within the sector in streamlining activities and programmes often leading to duplication of efforts.

Although the NESSAP proposes that ESAA be carried out in urban, rural small and peri-urban towns, from the review, the ESAAs carried so far have been largely skewed towards small towns and communities neglecting the urban and peri-urban areas. It is worth noting that the challenges facing the urban/peri-urban areas (due to rapid urbanisation) are enormous and complex and have a dire effect on facilities and services, hence planning for such areas have to be given all the attention it needs.

Table 1: Review of TESDPs and level of implementation of proposed interventions (Package 1 only).

REGION	DISTRICT	TOWN	YEAR OF ESAA	LEVEL OF IMPLEMENTATION	DONOR- /PROGRAMME/PROJECT
Central (6)	Mfantsiman Municipal	Mankessim*	2007	Yellow	DANIDA-Water and Sanitation Sector Support Programme (WSSPSII) – District Based Water and Sanitation (DBWS) Component
	Komenda Edina Eguafo Abirem	Kissi	2007	Yellow	
	Twifo Hemang Lower Denkyira	Twifo Mamapong	2007	Yellow	
	Abura Asebu Kwamankese	Surodofo	2010	Red	Government of Ghana (GoG)/Danida-Local Service Delivery and Governance Programme (LSDGP)-Environmental Sanitation Sub–Component
	Assin North	Assin Adiembra	2010	Red	
	Gomoa East	Gomoa Akwamu	2010	Yellow	
Greater Accra (8)	Dangme West	Asutsuare	2008	Red	DANIDA-Water and Sanitation Sector Support Programme (WSSPSII) – District Based Water and Sanitation (DBWS) Component
	Dangme West	Dawa	2008	Red	
	Dangme East	Sege	2008	Red	
	Dangme East	Akplabanya	2008	Red	
	Ga East	Abokobi	2008	Red	
	Tema Municipal	Oyibi	2008	Red	
	Ga South	Obom	2010	Red	Government of Ghana (GoG)/Danida-Local Service Delivery and Governance Programme (LSDGP)-Environmental Sanitation Sub–Component
	Dangme West	Kodiabe	2010	Red	
	Dangme East	Akplabanya	2010	Yellow	
Eastern (3)	Atiwa	Anyinam	2010	Red	
	Kwahu East	Kotosu	2010	Red	
	Kwahu North	Mame Krobo	2010	Yellow	
Volta (3)	Jasikan	New Ayoma	2010	Red	
	Ketu North	Penyi	2010	Yellow	
	Nkwanta South	Brewaniase	2010	Red	
Total	17	20			

* Urban Town

- Red: Not Implemented
- Yellow: Partially Implemented/ Implementation in progress
- Green: Fully Implemented

Recommendation and Conclusion

To meet the set targets in both the revised ESP 2010 and NESSAP for improving environmental sanitation services delivery and facilities, the following suggestions are worth considering:

- The Central Government as the prime benefactor shows more commitment by ensuring it provides the needed funding investments allocated to it in the Strategic Environmental Sanitation Investment Plan (SESIP).

- The ESAAs process is also adopted in carrying out assessments for identifying Water and Environmental Sanitation (WES) improvement interventions for urban and peri-urban areas.

- Budgetary allocations for the implementation of ESAA interventions/TESDPs should be considered in the design of projects/programmes in which ESAA forms a part.

- Development of capacity of MMDAs to market their TESDPs/DESSAPs

- Development of a results-based monitoring and evaluation (R-B M&E) mechanism for assessing the relevance of ESAAs as situational assessment and audit tool for the (WES) sector by tracking the improvements in the delivery of services and facilities for towns in which ESAA recommendations/TESDPS have been implemented.

- Effective coordination between WES sector players in the carrying out of ESAAs and the implementation of TESDPs to avoid duplication of efforts.

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Keywords

Environmental sanitation assessment and audit, town environmental sanitation development plans

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Improving Access to Basic Sanitation in Ghana. Lessons from a Water and Sanitation Project in Ghana

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Abstract

The Rural Water Supply Programme IV is one of several water and sanitation projects implemented in Ghana with the objective of improving access to safe sanitation and potable water and to improve health conditions. The provision of subsidised household demonstration latrines and hygiene education was the main strategy adopted by the project for sanitation promotion. A review of the outcome of the sanitation promotion component of the project established varied uptake of latrines between different districts – ranging from 5% to 150% of what was planned. This paper discusses the processes and outcome of the sanitation component of the project and draws key lessons useful for subsequent sanitation promotion interventions in both the rural and urban context in Ghana.

Introduction

Improving access to basic sanitation is a priority of Ghana government as a means to improving health status and living conditions of people. Relevant sections of the Ghana Shared Growth and Development Agenda (2010-2013), National Water Policy and the National Environmental Sanitation Policy underscore the importance of sanitation in Ghana's development agenda. Notwithstanding this level of interest in promoting sanitation, the results in terms of access and coverage rates have been abysmal. The Joint Monitoring Platform (JMP) reports that sanitation coverage in Ghana was 13% in 2008 with the coverage in rural and urban areas being 18% and 7% respectively. Ghana aims at achieving 54% coverage for sanitation by 2015 and 100% by 2025% (Republic of Ghana, 2011). To accelerate the process towards attaining the MDG target for sanitation and addressing other environmental sanitation issues in Ghana, a National Environmental Sanitation Strategy and Action Plan (NESSAP) and an accompanying Strategic Environmental Sanitation Investment Plan (SESIP) have been developed. A National Rural Sanitation Model and Scaling up Strategy based on a two prong approach of sanitation marketing and community led total sanitation (CLTS) has also been developed in 2010 but is yet to be implemented.

The Rural Water Supply Programme IV was one of several water and sanitation projects that did not yield the expected impact in improving access to basic sanitation. The project was implemented in 15 districts of the Ashanti Region of Ghana from January 2005 to January 2009 and was jointly financed by Kreditanstalt fur Wiederaufbau (KfW) and the Government of Ghana within the framework of the National Community Water and Sanitation Programme (NCWSP). Following the implementation of the project, a number of valuable lessons have emerged which are critical in Ghana's drive to improve sanitation coverage in order to meet the MDG target of 54% coverage for sanitation.

Institutional Framework of Sanitation Sector

In Ghana, responsibility for sanitation is within the ambit of three main government institutions i.e. Ministry of Local Government and Rural Development (MLGRD) supported by the Environmental Health and Sanitation Directorate, Community Water and Sanitation Agency (CWSA) and Metropolitan, Municipal and District Assemblies (MMDAs). The Ministry of Local Government and Rural Development is the lead government agency responsible for broad policy formulation, implementation, monitoring and evaluation of sanitation. CWSA facilitates basic sanitation promotion as part of its strategy for rural and small towns' water provision and hygiene education and supports MLGRD to develop and apply international norms in the sanitation sector (Republic of Ghana, 2008). MMDAs are responsible for planning and delivery of sanitation services.

Overview of the Project and Strategy

The goal of the Rural Water Supply Programme IV was to improve the livelihood and health of about 300,000 people in the region by improving access to potable water and safe sanitation and hygiene. CWSA estimates its contribution to rural sanitation coverage in Ashanti Region to be 8.45% as at 2006 (ibid). Only 3.4% of the population practiced open defecation while 87% of the household population used sanitary means of excreta disposal including shared facilities (GSS, 2006). The project entailed facilitating the construction of 3,400 demonstration household VIP latrines through provision of subsidies. The project was implemented within the framework of the National Community Water and Sanitation Programme (NCWSP) developed by CWSA. The NCWSP had as one of its principles, the integration of water, sanitation and hygiene promotion in project implementation and the provision of subsidies as an approach to sanitation promotion as at 2006. In 2008, the approach to sanitation was reviewed to include adopting innovative approaches such as CLTS, encouraging behavioural change and providing targeted subsidies (up to 2015) for demonstration latrines.

The project provided support for the formation and training of District Water and Sanitation Teams (DWSTs) and Water and Sanitation Committees (WATSANs) to be responsible for hygiene and sanitation promotion at the district and community levels respectively. In addition, Partner Organisations [2](POs) were engaged and trained by the project consultant to provide training to the 581 beneficiary communities and their WATSANs. The POs carried out hygiene education and sanitation promotion for all residents and also as part of the training programme for WATSAN Committees.

The extension activities by POs terminated after the signing of a Facilities Management Plan (FMP) to allow for drilling and pump installation. After drilling and pump installation, the POs resume extension activities in the communities. The scheduled break in extension activities was for an anticipated period of 8-10 months, but in almost all cases, the break extended beyond this. In

[2] A Partner Organisation is either a community based organization or a small consulting firm whose services have been engaged to undertake community mobilization and hygiene education in respect of projects being undertaken in communities within the framework of NCWSP

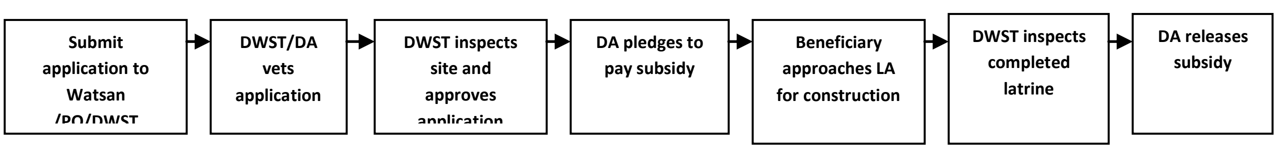
some districts, the break was close to 2 years. Drilling and pump installation activities under the project were beset with numerous administrative, financial and technical problems from the start and throughout the project. The delay in drilling and pump installation brought in its trail, loss of momentum by the WATSAN committees as most of them failed to meet regularly during the period of inactivity and a lull in the construction of the household latrines given the absence of the POs to reinforce and sustain the hygiene and sanitation promotion messages facilitated during the pre-drilling phase.

A total of 190 latrine artisans were trained by the project in the 15 districts to support household latrine construction. The latrine artisans were also trained to promote the concept of individual sanitation not only for their own benefit of getting business but also to expand the concept.

Given the available resources to construct 3,400 VIP demonstration latrines in the 15 beneficiary DAs, the project decided to share the facilities equally among the beneficiary districts. In this connection, it was agreed to allocate 226 to each district. The project consultant in concert with CWSA and DAs agreed to restrict the construction of the household latrines to communities which would be beneficiaries of the water facilities. The rationale for this decision was to ensure consistency in the anticipated impact of the project interventions on the living standards of beneficiary communities. In other words, it was decided not to promote the construction of household sanitation facilities in communities that would not benefit from the water facilities.

The construction of the demonstration latrines and provision of subsidy was administered in line with procedures instituted by CWSA illustrated in Figure 1.

Figure 1: Application Process



Potential beneficiaries were to apply through WATSAN and DWST to the DAs. After site inspection and its approval by the DWST, the DA gave approval pledging to pay the subsidy after the VIP had been constructed in accordance with design criteria. The beneficiary then bought the material and approached one of the trained latrine artisans and negotiated with him the costs of construction whereby he/she could reduce costs by doing the pit digging by him/herself and by using local materials (mud bricks instead of concrete blocks, grass instead of iron sheets etc.). After completion and inspection by the DWST, the DA would release the subsidy. The DA was to administer a revolving fund of about GH¢2,000.00 from which to pay the subsidy and then seek refund through CWSA from project funds. A cash subsidy of GH¢90.30 for the Mozambique VIP and GH¢97.70 for the Rectangular VIP was paid to each beneficiary upon certification of a latrine. This was expected to cover about 50% of the total cost of constructing a basic household VIP latrine. It was to cover the cost of artisan fees, squat slab, vent slab, cover slab and vent pipe for a basic latrine.

Project Results

In the course of the project, it became obvious that the hygiene education and the provision of subsidy towards construction of household latrines showed remarkably varied uptake of household latrines across the beneficiary districts ranging from 5% to 150% of the planned uptake. Out of a total allocation of 3,400 household VIP latrines, only 2,172 (63.9%) latrines were constructed between January 2005 and November 2009 as shown in Table 1. The implication is that the project strategy for sanitation promotion could not raise the beneficiaries' interest in owning a VIP. Potential beneficiaries of the project showed little enthusiasm in constructing private latrines and rather preferred communal latrines.

Table 1: Household VIP Latrines Constructed under Project

Name of district	Number of communities	No. of VIP Latrines Constructed	No of VIP Latrines Allocated	% of VIP Latrines Constructed
Ejura-Sekyedumase	34	10	226	4.4
Sekyere West	24	103	226	45.6
Afigya Sekyere	30	162	226	71.7
Kwabre	32	200	226	88.5
Atwima Nwabiagya	37	176	226	77.9
Atwima Mponua	29	206	226	91.2
Amansie West	47	126	226	55.8
Amansie Central	74	340	226	150.4
Obuasi	22	9	226	4.0
Adansi South	53	165	226	73.0
Adansi North	42	77	226	34.1
Amansie East	55	173	226	76.5
Bosomtwi Atwima Kwanwoma	39	286	226	126.5
Asante Akim North	45	61	226	27.0
Asante Akim South	18	78	226	34.5
Total	581	2,172	3,400	63.9

Source: Preliminary Final Report, RWSP IV, December 2010

The Amansie Central and Bosomtwi Atwima Kwanwoma districts were the only districts that were able to utilise their maximum allocation of 226 latrines. This can be attributed to the high morale among staff of the DWST in the two districts. The DWSTs received financial support from their respective DAs which enabled them conduct follow up visits to beneficiary communities when PO activities had terminated. It was also realised that the location and distribution of trained latrine artisans had an effect on the uptake of latrines. The Amansie Central and Bosomtwi Atwima Kwanwoma districts had most of their trained latrine artisans resident either within or fairly close to the beneficiary communities as compared to other districts and so were able to market the household latrines.

About 40% of the districts were able to construct less than 50% of their maximum allocation. The performance of Obuasi and Ejura Sekyedumase districts was very dismal representing about 4% of facilities allocated. The expected demonstration effect of the promotion of household latrine construction did not materialise in these areas. It was only in Atwima Mponua and Amansie Central districts that there have been claims of household latrine construction without subsidy. These claims are yet to be investigated and documented.

A lot of factors account for the poor uptake of latrines and the low demonstration effect of sanitation promotion strategy. Firstly, the majority of rural community members in Ghana consider excreta disposal as a temporary inconvenience and are not too enthusiastic about accessing improved sanitation facilities. Having a household toilet is not a status symbol in some communities in Ghana and this attitude is not to be changed by paying a 50% subsidy towards construction costs. Changing the attitude requires much more education over a longer period (possibly a generation) and not only by projects like this but as a national task. Secondly, some of the community members in the beneficiary communities were migrants and symptomatic of this category of residents, investment in physical structures is refused since their "temporary" abode is not considered their home albeit long periods of settlement spanning over a decade. This was particularly evident in Ejura Sekyedumase and Obuasi where the majority of residents were migrants and therefore showed little interest in household latrine construction. It is estimated that about 52% of Ghana's population are migrants and this could account for the rather high communal latrine ownership and low interest in household latrine construction.

Thirdly, the period of engagement of the Partner Organisations (about 8 man-month input spread over 2 years) to conduct health and hygiene education was relatively short to make a serious impact on establishing the linkage between safe sanitation and good health. Fourthly, the cost of building materials for the facilities continued to escalate resulting in a corresponding increase in the cost of the VIP latrines. Fifthly, the process for the payment of the subsidy was often times delayed by the DAs thereby frustrating beneficiaries awaiting payment and de-motivating potential beneficiaries. At other times, the trained latrine artisans lived very far from beneficiary communities and this made it difficult to access their services. Sixthly, the poor soil stability in some districts especially Ejura Sekyedumase and Sekyere West districts (now Mampong Municipal) made it difficult to construct household VIP latrines without lining the pits. Given these challenges, the demand for the latrines has at best been average. This phenomenon questions the replicability of the household latrine construction outside the project environment.

Lessons

Project Approach Vis a Vis Service Delivery Approach

The process of approaching sanitation promotion through a "projectised" approach did not work. The project approach requires that interventions are carried out within defined time boundaries and scope. This situation did not allow for flexibility in the approach to sanitation promotion and affected the outcome of the project. This lesson is not isolated and only reinforces the lessons from other interventions that have suffered a similar fate e.g., UNDP/GWSC in Volta and Eastern Regions, IDA CWSP 1 and 2, NORWASP, EU NRWSP, RWSP III, etc.

Baseline Information and Strategy Formulation

It is doubtful whether feasibility studies including baseline studies were conducted prior to the design of the project and whether the results were factored in the design of the project. However, given available information on access and coverage rates for sanitation in Ashanti Region for 2006, the decision to construct demonstration latrines as a strategy for sanitation promotion was purely driven by the desire to comply with the existing national framework for sanitation promotion rather than the background situation. A strong culture of communal ownership of latrines existed so the focus of sanitation promotion should have been sanitation marketing and facilitating the supply of basic minimum affordable household latrines. Although latrine artisans were trained on sanitation marketing, this initiative was not backed by a sustained hygiene and sanitation education to create demand for household latrines.

Adopting Appropriate Engagement Strategy with Communities

The strategy of engaging Partner Organisations over a relatively short period of time (about 8 man-month input spread over 2 years) could not have resulted in a significant change in attitude of the beneficiaries. The delay in drilling and pump installation for almost two (2) years contrary to the planned 8-month break also affected POs work in sustaining hygiene education in the communities. This strategy clearly did not yield the anticipated benefits. But for the follow up support provided by the DWSTs in Amansie Central and Bosomtwi Atwima Kwanwoma districts, none of the beneficiary districts could have been able to fully construct the household latrines allocated. Regrettably, this is the situation in several other sanitation projects in Ghana including interventions based on CLTS.

Limited Low Cost Sanitation Technology Options

The project limited the technology options available for construction to the “mozambique” and “rectangular” VIP latrine types. These technology options were estimated to cost almost GHC300 (US$150). Given the poverty level in most rural communities in Ghana including the project area (39%) (GSS, 2007), these latrine options were beyond the means of most beneficiaries. This accounts for the low patronage and the fact that there has been very minimal latrine construction without the project’s subsidy. Related to this issue is the fact that very few low technology options are available for household latrine construction.

Application Procedures

The process of submitting application for vetting and approval by DA before commencement of household latrine construction also affected patronage. The vetting of applications was delayed and even where construction was completed, there were delays in the payment of subsidies.

Access to Trained Latrine Artisans

It was also established proximity of beneficiary communities trained latrines affected the marketing and uptake of household latrines by beneficiary communities.

Recommendations

- MLGRD has developed the national sanitation model and scaling up strategy. The model has five (5) pillars i.e. creating the enabling environment for sanitation promotion; creating demand for hygiene and sanitation; facilitating supply of basic hygiene and sanitation facilities; strengthening capacity to trigger demand and supply; and providing supportive supervision, monitoring and evaluation. Although the model defines the broad national strategy for sanitation, it is recommended that MMDAs should adapt the model and strategy to the peculiar situations in their respective districts. MMDAs should ensure that district and sub district level structures i.e. DWST, EHAs, latrine artisans are well resourced and adequately motivated to carry out sanitation and hygiene education and promotion on a sustainable basis. MMDAs should carry out adequate baseline studies and use the results in designing and implementing an appropriate strategy for sanitation promotion.

- Sanitation promotion should be approached from a service delivery perspective rather than projectised approach. The Ghana Government should demonstrate its commitment to making basic sanitation promotion a priority by providing the required financial resources indicated in the Sanitation and Water for All Compact signed by MoFEP, MWRWH and MLGRD in April 2010, the National Environmental Sanitation Strategy and Action Plan (NESSAP)/Strategic Environmental Sanitation Investment Plan (SESIP). This would make the required resources available to MLGRD-EHSD, CWSA and MMDAs to enable them carry out hygiene education and sanitation marketing on a sustainable service scale at the national, regional, district and sub district levels.

- There is still room for developing affordable household latrine technology options. The existing approved household latrine technology options i.e. Water Closet, VIP and KVIP are fairly expensive. Given the adoption of CLTS as the approach to sanitation promotion, it is imperative to develop low cost and affordable technology options to meet increasing demand for basic sanitation facilities. It is recommended that the Ghana Government should provide adequate financing for research into low cost technology options which can be promoted through effective sanitation marketing.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Households' Perception of Community Toilets in Low Income Communities in Kumasi

E.O. Appiah & S. Oduro-Kwarteng

Abstract

Ghana is not on track in achieving the target of the Millennium Development Goal (MDG) Seven towards improving sanitation by 2015. The country has just 13% of improved sanitation (JMP, 2010). The JMP classification of community (shared) toilet as unimproved sanitation is a major challenge to the country in meeting the MDG since Ghana has a lot of the shared toilets. A survey of 348 households was conducted using a structured questionnaire to collect data on perception of toilet conditions and management. The results show that only 7.2% of respondents rely solely on household toilet and 63.5% rely solely on shared community toilet and the remaining 29.3% uses shared household toilet as well as the community toilet due inadequacy of the house facility. The general perception on hygiene and privacy were poor but security was generally perceived fair. The people using shared household toilets were usually satisfied with the share household facility in terms all parameters except adequacy. The study shows that the sanitation sector needs to focus on toilet facility management and guidelines that will ensure adequacy, hygiene and good condition of the facilities.

Introduction

The MDG Seven (7) target towards environmental sustainability has as part of it to halve by 2015 the proportion of the people without sustainable access to safe drinking water and basic sanitation. The WHO/UNICEF Joint Monitoring Programme (JMP) classifies shared latrines- used by two or more households – as unimproved form of sanitation (JMP, 2010). Hence all communal toilets in Ghana are unimproved form of sanitation. Households who use community toilet facilities in Kumasi and Ghana in 2000 were 36.8% and 31.4 % respectively (Ghana statistical service, 2002). A shared facility is classified as unimproved not by virtue of technology but because it is shared. In Ghana, the public toilets- meant for visitors - are built close to and in the communities for communal use.

Shared facility is most common in urban sub –Saharan Africa with 31% in the world but the predominant country is Ghana (JMP, 2010). In 2008 the JMP found that 70% of the urban population and 38% of the rural population in Ghana were using shared sanitation facilities. On the whole , Ghana had 13% improved sanitation and 87% of unimproved sanitation which is made up of shared 54%, unimproved facilities 13% and open defecation 25% (JMP, 2010). Communal latrines as alternative to household latrines in congested areas are rarely satisfactory (Cotton et al., 1995) and 71% of communal latrines users in Kumasi were not satisfied (Whittington et al., 1993). Communal latrines irrespective of the type of design have usually proved to fail and malfunction (Wagner and Lanoix, 1958 as cited in Cotton et al., 1995).

Jenkins and Scott (2006) reported that the attributes people dislike about their defecation places, which were not household toilet, were smelly (27.1%), dirty (26.6%), the distance to toilet facilities (8.3%), lack of comfort (7.0%), having to pay to use them (6.0%), and 5.8% having to share with others. Women are found to be more interested in their privacy than the technology type and the structure of the facility (Cotton et al., 1995), but Jenkins and Scott (2006) reported that public toilets usually lacks privacy. The objective of this study was to find the perceptions of the people who use communal toilets and to provide reasons for the various perception attributes.

Methodology

The study was conducted in six low income communities in the periphery of the KNUST campus in Kumasi. A survey of 348 households was conducted using a structured questionnaire to collect data on perception attributes in Table 1. The definitions of the attributes are shown in the Table 1. The communities and their percentages of households were Atonsu (23.6), Ayeduase (16.7), Ayigya (28.7), Bomso (12.9), Gyinyase 6.6) and Kotei (11.5). The structured questionnaires were administered and the data was analysed using SPSS software.

Table 1: Perception Attributes and their Definitions

Perception	***Definition***	***Measuring parameter***
Sharing mode	Number of people households using the facility.	○ Households sharing facility
Accessibility	Latrine opens throughout the day.	○ Latrine being opened everyday and 24hours a day
Adequacy	A maximum of 10 persons per squat hole.	○ Queuing at facility ○ Usage rate per hole
Security	Lighting availability and structural stability of the facility.	○ Illumination of pathway, cubicle and availability of light ○ Structural stability of superstructure
Convenience	Facilities less than 50m from households.	○ Distance to facility
Privacy	Availability of complete non-transparent enclosure/doors.	○ Privacy – cubicles with door
Hygienic	Hygienically separates excreta from human contact.	○ Odour level ○ Emptying of bins ○ Cleanliness of the cubicle

Scores for the perception attributes were calculated using equation 3.1 by assigning ratings of one (1) as poor, two (2) as fair and then three (3) as good. The number of respondents (n1, n2, n3) were then multiplied by their respective ratings and then summed up to get the score. The denominator gives the maximum score of best condition.

———————— X 100%..Equation 3.1

In the grading the best score is 100%, fair score is 66.6% and the worst score is 33.3%, assuming all respondents say good, fair or poor respectively. The ranges for measuring the perceptions are poor (33.33 – 49.9%), fair (50 – 83.9%) and good (84 – 100%).

Results and Discussion

Household's Characteristics

Table 2 shows the households' characteristics such as gender, age, and household size. The people mostly live in compound houses. The house size of more than 31 people lives in 37% of the houses.

Table 2: Household Characteristics

Characteristics		**Number (N)**	**%**
Gender	Male	168	48.3
	Female	180	51.7
Age distribution	Below 18 years	80	23.0
	18 – 35 years	208	60.0
	Above 35 years	60	17.0
House Size	4-30	218	62.6
	31-60	114	32.8
	61-98	16	4.6

Toilet Technology in Use and Sharing Mode

Availability of household toilets is a key to the improvement in sanitation to meet the MGD. Out of the 348 households, 7.2% use single household toilet, 63.5% of them use shared community (public) toilet only, and the remaining 29.3% have access to shared household toilet but they use the community toilets as well due to the inadequacy of the household toilet facility. The study shows that 8.5% of those who use only community toilets have household toilets but they are not allowed to use them. The reasons for this situation are: the decision of the landlord to prevent them from using it, refusal of some tenants to contribute towards the construction and petty quarrelling on cleaning and contributions towards desludging. A total of 92.8% of the respondents use community toilets of different technologies. The commonly used public toilet technologies were KVIP (30.5%), Pit latrine (22.4%) and the Enviroloo (21.8%). The household toilet technologies comprise of WC (71%), Pit Latrine (10%) and 7% for KVIP.

The number of people per toilet hole using a particular technology depends on the toilet technology available in the community. Choice comes into play when different technologies are found together clustered at one place in the community. In such a situation it was found that the people usually patronises the squatting technologies. Hygiene is the dominant reason for choosing a particular toilet by choice. Squatting communal toilets were preferred to the sitting toilet as they perceived them to reduce the probability of communicable diseases infection.

Perception of Toilet Performance

The assessment of the attributes (accessibility, security, adequacy, convenience, privacy, and hygiene) is discussed here to draw lessons for the design and management of public toilets. For accessibility, 76.3% of the users had access all times, but 23.7% are denied access after 10pm by closing of the communal toilets. These people then resort to the usage of "fly toilets" (use of polythene bags) 23%, refuse dump 27%, other nearby public toilet 14% and the rest (36%) have no option.

The security was assessed by asking respondents about lighting availability and structural stability of the facility. Most of the facilities had lighting system with 87% availability inside the cubicles, and 58.5% were very satisfied with the illumination of the pathway to the latrine. The illumination of the cubicles was largely perceived fair (45%). The facilities were perceived as 51% structurally stable and good. The general security perception was poor (19.8%), fair (31.6%) and good (48.6%). In general it is concluded that the communal toilets are fairly secured to use.

On the basis of convenience, 70% just travel less than 50 metres and the remaining 30% travel more than 50 metres to the toilet facility. All the communal toilets were inadequate using 10 people per squat hole as the standard for adequacy. Only 9% of the people have access to adequate toilet facilities, all being household toilets. The rest of the people use inadequate facilities. The maximum number of people per squat hole was 44. Availability of queues was as high as 64% among the people. The queues were relatively high in the morning (74.7%). People will have to wait usually up to 10 minutes (67.3%) and 11-20 minutes (22.4%) in queues. Most of the people (81%) were not satisfied with the long queues in the mornings. The people mentioned impact of the queues to include lateness to work and school (26%), leads to disgrace (34%), unsuitable for the sick to join queue (24%), and sickness and delays (16%).

Table 3 shows the hierarchical reasons from left to right for the perceptions on privacy and hygiene. It can be deduced that the reasons for the perceptions may differ for technologies, but are similar for the same technology.

Table 3: Overall Perception of Toilet Performance and Hierarchy Order of Reasons

Attributes	***Grading***	***Percentage (%)***			***Respondents' Hierarchical Reasons for Grading***
		Both	Male	Female	
Privacy	Poor	51.5	43.9	58.9	No doors available, Broken doors, and Exposed nakedness
	Fair	27.8	40.8	14.7	Exposed nakedness, Broken doors, and Doors cannot close well
	Good	20.7	15.3	25.3	Good doors, and Doors cannot close well
Odour Level	Poor	51.2	49.0	53.7	Poor management, Smelly clothes, and Poor Ventilation
	Fair	38.0	38.8	36.8	Poor management, Poor Ventilation, and Smelly clothes
	Good	10.7	12.2	9.5	Good cleaning, Newly constructed, and Need for rehabilitation
Emptying of Bins	Poor	56.3	53.0	58.9	Bins overflow, Delays in emptying, and Bins emptied frequently
	Fair	23.0	23.5	23.2	Bins emptied frequently, Delays in emptying, and Bins overflow
	Good	20.6	23.5	17.9	Bins emptied frequently, and Bins overflow
Cleansing of Cubicles	Poor	60.7	57.1	64.2	Late and poor cleaning, Children dirties the place and Poor Usage
	Fair	21.6	19.4	23.2	Late and poor cleaning, and Frequent and good cleaning
	Good	17.7	23.5	12.6	Frequent and good cleaning, Good toilet design and Prudent use

Table 4 presents the perception on the toilet technologies. The Enviroloo has declined in privacy over the years due to the fact that the doors to the cubicles have been removed to prevent people from squatting on the bowl. An Enviroloo toilet having a very good structure is not patronised by the people due to lack of privacy to allow them to squat instead of sitting, and this is consistent with what Cotton et al., (1995) found in Maputo, Mozambique, that it is not about the quality of the superstructure that is significant from the users' point of view but the privacy it can afford.

Table 4: Perception on the toilet technology

Toilet Technology	**Freq.**	**Maximum Score of Best Condition**	**Privacy**		**Odour level**		**Emptying of bin**		**Cubicle Cleanliness**	
			Score	**(%)**	**Score**	**(%)**	**Score**	**(%)**	**Score**	**(%)**
WC	10	30	27	*90*	27	90	30	*100*	27	*90*
Pit Latrine	78	234	110	*47*	105	44.9	112	*47.9*	100	*42.7*
KVIP	105	315	178	*56.5*	147	46.7	131	*41.6*	157	*49.8*
Enviroloo	76	228	111	*48.7*	131	57.5	109	*47.8*	117	*51.3*
Aqua privy	21	60	42	*70*	34	56.7	27	*45*	26	*43.3*
VIP	6	18	11	*61.1*	6	33.3	15	*83.3*	8	*44.4*
Pour Flush	21	63	50	*79.4*	44	69.8	44	*69.8*	51	*81*

The pit latrines were graded generally poor in privacy and odour because the cubicles are built without doors and vent pipes. The pit latrines function as holding tanks without vent pipes and they are desludged when they are full. The VIP was perceived to have high odour and was rated poor due to the poor functioning of the vents resulting in heat and high odour generation in the cubicles. Smell and dirt of public latrine were major causes of dislike by people who do not have house latrines but dislike the communal latrines (Jenkins and Scott, 2006), and the situation is not different in this study. Emptying of the bins has degraded over the years and it is really a challenge due to poor managerial practices. There is a relationship between the cleanliness of the cubicles and the sanitation type. The wet sanitation was perceived to be good in contrast to the poor perception of the dry sanitation. The single household toilet users have a fair perception of the communal toilets. There is a poor perception of the three preferred communal toilets (KVIP, Pit latrine and Enviroloo).

A shared household toilet facility which will improve upon their privacy, adequacy, convenience, accessibility and hygiene, offering proper separation between human and faeces is good for the people especially those in the compound houses. The only problem with the shared household toilet is the inadequacy due to the number of squat holes hence forcing the people to use the communal toilets though having access to the shared household toilet. The study shows poor management of the communal toilets since the reasons given for the perception on hygienic parameters were mostly due to poor management of the toilets. The perceptions of toilets about KVIP and Pit Latrine were mainly poor but they are the most widely used. The people does not usually patronise the Enviroloo because of the sitting position and the risk of infections.

Conclusion

The people who have access to single household toilet - used by one household - were 7% and those solely relying on the public toilet were 64%. The remaining 29% has access to shared household toilet but they also rely on the public toilets by reason of inadequacy. The people resort to use of unimproved sanitation (fly toilet and refuse dump) when denied access at night. Management of the facilities was very poor and this explained why the perception of privacy and hygiene on the communal toilets was very poor. None of the communal toilets was found to be adequate resulting in queuing. The perception on the hygiene parameters and the preference of the squatting toilets call for general hygiene to be addressed very well when dealing with communal toilets.

Recommendation

The stake holders of sanitation in Ghana should stop the promotions of public toilets and concentrate on household toilets. In construction of households’ toilets the number of squat holes must be more than one to ensure adequacy. The local governing bodies in charge of the management of the communal toilets should provide standards and enforce them to improve upon the management system of the existing communal toilets in order to provide a rather dignified sanitation as we plan to phase them out with time.

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Motivation for Construction of Household Toilets in Low Income Communities in Kumasi

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Abstract

The commitment to achieve the sanitation target of the Millennium Development Goal (MDG) seven is a real challenge for most sub-Saharan countries. The main objectives of the study were to assess the motivation to construct the households' toilets, constraints towards the construction, and the effect of house ownership on sanitation in low income communities in Kumasi. A survey of 348 households was conducted using a structured questionnaire to collect data on toilet preference and motivation to construct household toilet. The results show that most respondents (94%) prefer household toilet to the public toilet (6%). The preferred toilet technologies were: WC (73%), KVIP (13%) and Pit Latrine (5%). Most of the respondents (63%) affirmed that the landlords should be responsible for the construction and 30 % suggested that both the landlords and the tenants could jointly construct the toilet, but demanded that the landlord should initiate the construction. Vulnerability and security were the main motivating factors. There are major challenges for scaling-up households' toilets and these include limited funds, multiple ownerships of houses and competing priorities of single landlords. The single landlord houses have higher priority- medium (24%) and high (8%) - to construct than the multiple ownership houses- medium (12.5%) and high (1.6%). A solution to the sanitation problem is to stop construction of communal toilets and provide incentives to motivate house owners to own household toilets.

Introduction

The issue of sanitation is a big challenge in Ghana especially in the country's desire to meet the Millennium Development Goal 7, to halve by 2015 the proportion of the people without sustainable access to safe drinking water and basic sanitation. A report by the WHO/UNICEF Joint Monitoring Programme (JMP) (2010) describes the sanitation situation in Ghana as 13% improved sanitation and 87% unimproved sanitation. The unimproved sanitation is made up of shared 54%, unimproved facilities 13%, and open defecation 25% (JMP, 2010). Households who use community toilet facilities in Kumasi and Ghana in 2000 were 36.8% and 31.4 % respectively (Ghana statistical service, 2002).

The Kumasi Metropolitan Assembly (KMA) has been promoting improved household toilets but the promotion has had low impact on the people. A greater proportion of the people without improved household toilet did not hear anything about the promotion to upgrade from the existing bucket latrine into improved household toilet (Oduro-Kwarteng et al., 2009). The challenge of sanitation in the urban areas is mostly found in the low income communities where most households are renters (Whittington et al., 1993). The construction of household toilets is a requirement by law but the enforcement has been weak. The question that arises is: can the house owners and tenants be motivated to construct household toilets? How can the people who live on meagre income and are also renters be motivated to support the construction of household toilets?

Motivation is an internal state that guides our behaviour and gives it direction or intentions (McConnell and Chalk, 1992). The motivation of households to own household toilet is needed to create the necessary intention to construct. Motivation is linked to beliefs about costs and benefits (financial incentives) as well as behavioural change in attitudes and social norms. The motivation and ability of households to carry out their intentions is influenced by a number of factors. One is the proximity of public toilets in the midst of low income communities for daily use by the residents (Oduro-Kwarteng et al., 2009).

The main objective of the study was to assess the motivation of house owners in low income communities to construct households' toilets.

Methodology

The study was conducted in six low income communities in the periphery of the KNUST campus in Kumasi. A survey of 348 households was conducted using a structured questionnaire to collect data on the motivation towards construction toilet. Table 1 presents the variables used for the assessment. The selected communities were Atonsu, Ayeduase, Ayigya, Bomso, Gyinyase and Kotei. The structured questionnaires were administered to the respondents in these communities to gather information relating to the study and the data was analysed by SPSS software.

Table 1: Variables used for data collection

Aspect of study	***Measuring parameters***
Awareness of sanitation issues	○ Awareness of MDG target on sanitation ○ Awareness of sanitation promotion
Technology preference	○ Household preference ○ Types of toilet technologies ○ Water availability for wet sanitation
Factors of motivation	○ Unaided responses from respondents using open-ended question
Priority for construction	○ Decision to construct toilet ○ Constraint towards
Contribution towards toilet construction	○ Tenants and tenure ○ House ownership type

Results and Discussion

Households' Characteristics

Table 2 shows the households' characteristics (gender, age, and household size). The gender was almost just a representative of the gender balance the Ghanaian population per the 2000 Population census. The target groups were households of tenants and landlords.

Table 2: Households' Characteristics

Characteristics		Number (N)	%
Gender	Male	168	48.3
	Female	180	51.7
Age distribution	Below 18 years	80	23.0
	18 – 35 years	208	60.0
	Above 35 years	60	17.0
House Size	4-30	218	62.6
	31-60	114	32.8
	61-98	16	4.6

Awareness of the MDG Seven and Sanitation Preference

The people were found to have a fair knowledge of MDG 7, where about half of them were aware of it and 57.4% have heard of the sanitation campaign promoting household toilet. However, most of them were not aware of public toilets described as unimproved form of sanitation by the JMP.

Most of the people prefer household toilet (improved sanitation) as against the unimproved public toilet. The results show that 94.3% preferred household latrine but 5.7% still opted for the community toilets. The technologies preferred are: WC (72.9%), KVIP (13%), Pit Latrine (5.1%) and VIP, Enviroloo or Aqua privy altogether 9.1%. Previous studies showed that more than 70% preferred household toilet and the WC is the preferred technology (Oduro-Kwarteng et al., 2009). The proportion of people who preferred household toilet in the low income communities over the years were 83.3% (Bassah, 2005), 77.6% (Dumelo, 2007), and 79.3% (Pireku, 2008), and high percentage of the people preferred the Water Closet toilet in these studies.

Wet sanitation was preferred to the dry sanitation hence the need to assess the water availability to support the sanitation. Ghana Water Company Limited (GWCL) does provides water directly in their homes for 65.2% of the people, whilst 19.3% buy water from their neighbours which are usually sourced from GWCL and sometimes boreholes. Only 9.8% have their water sourced from wells and 1.7% from boreholes. Even among those who buy water from neighbours some buys it right in their houses. The houses initially not connected to the GWCL pipelines have been connected by the landlords, and they then commercialise the water even to the households of the houses. Some of the landlords claim this helps in the paying of the water bills smoothly to avoid petty rifles among households in the house in the payment of the bills. Kumasi earlier on had 57% private water tap connections in houses, 32% of the people were buying water from neighbours, 7% depended on the well and 2% on public tap which was in its phasing out stage by GWCL (Whittington et al., 1993). This current study then shows an improvement in the water supply in Kumasi in the low income areas, since 67% of the people were fairly satisfied with the level of service of the water supply, 25.5% were satisfied and 7.4% were not satisfied at all.

Motivation and Constraint to the Construction of Household Toilet

The results show that the vulnerability, security, adequacy and cleanliness were the main motivation factors for the household toilet preference. The various combinations of the factors of motivation were: security and vulnerable (43.2%); vulnerable, security, adequacy and cleanliness (20.5%); convenience, accessibility, security and cleanliness (14.8%); privacy, convenience, hygienic and accessibility (13.6%) and 7.9% for other combinations. Motivation factors precipitating the need for household toilet which were identified by Jenkins and Scott (2006) are:

vulnerability (need for sick or old relatives) (23.2%), to offer safety at night (security) (18.8%), convenience (12.5%) and to make it easier to keep the facility clean (9.8%) and the other 35.7% representing the others reasons given. The security and vulnerable proportion was 42% and therefore consistent with this study. The implication is that the people are aware of the need to own household toilet but may not have the ability to carry out their intentions.

Table 3 shows the priority of households to construct household toilet. Priority is related to the eagerness of the people to construct. It was measured by three criteria: low (never been discussed), medium (discussion stage) and high (mobilisation stage) for the construction. The house ownership style was multiple ownerships – family house – and the single landlord ownership. Multiple ownerships houses are being owned as rooms by individuals usually through inheritance whilst the single landlord has the whole house being owned by an individual. Among the houses without improved household toilet multiple ownerships constitute 73.2% and this is consistent with Oduro-Kwarteng et al. (2009) that 70% of the houses without improved household toilet had multiple ownerships. The multiple ownerships type has difficulty in decision making because they usually do not come to a consensus to construct household toilet. A single landlord ownership has the advantage of easy facilitation of the decision making process than in multi ownership houses.

Generally priority to construct household was low in the multiple ownerships and single landlord multi-families houses. Single landlord house was found to have a slightly high priority to construct the household toilet than the multiple ownerships. In multiple ownership houses the landlords of one or two may not be willing to contribute for the construction of the house toilet and hence recording a low priority (Oduro-Kwarteng et al., 2009). The ownership style has an influence on the priority for the construction of the facility. There is an influence of the tenure and ownership of the house on the demand for improved household toilet (Oduro-Kwarteng et al., 2009).

Table 3: Priority to construct household toilet

Priority to construct toilet	Both ownership styles (%)	Multiple Ownership (%)	Single Landlord (%)
Low (never been discussed)	81.1	85.9	68
Medium (discussion stage)	15.6	12.5	24
High (mobilisation stage)	3.3	1.6	8

Table 4 shows the constraints towards the construction of household toilet. Financial and tenant–landlord contribution are the dominant constraints (60%) to the construction of the household toilet. Tenant-Landlord contribution constraint was found to be a major constraint in houses with multiple Ownerships, but for single landlords the constraints were the financial and competing priorities. Competing priorities includes payment of tuition fees for wards, family welfare and others which all depend on the same meager income received by the people.

Table 4: Constraints to Construction against Ownership Type

Constraints	All households (%)	Multiple Ownerships %	Single Landlord (%)
Financial Constraint	34.5	37.9	28
Tenant-Landlord Contribution	26.2	34.5	8
Unavailability of space for construction	11.9	6.9	12
Competing Priorities	9.5	3.4	24
Limited spaces and Finances	8.3	10.3	12
Other reasons	9.6	7.5	16

The unavailability of space for construction was 12% of the houses. Some houses have been built with no space made available for the construction of improved household toilet (Oduro-Kwarteng et al., 2009). Rooms designated for toilet in the house plans of some building has been converted into bedroom sometimes due to shear negligence.

Responsibility to Construct the Household Toilet

Table 5 assesses willingness of the tenants to take up the responsibility to construct the household toilet. The responsibility to construct toilet is very important if construction of the household toilet is to be implemented. Most of the respondents (63%) suggested that the construction of the facility must be undertaken by the landlords. In houses with single landlord, the tenants (18%) were willing to construct it on their own than 1.6% for the multiple Ownerships. This situation confirms why tenant-landlord constraint is not a major constraint faced by the single landlord houses. In a study in Ghana, Jenkins and Scott (2006) reported that 56.2% of the household latrines were put up by the landlords (owners of the compound houses) and in extremely rare cases (1.5%) the tenants took the initiative to construct the latrine. The current study shows willingness of the tenants (36%) to support household toilet construction compare to the 1.5% of tenants agreeing to construct in the case of Jenkins and Scott (2006) study.

Table 5: Responsibility to construct

Who should construct	General %	Multiple Ownership %	Single Landlord %
Landlord must provide	63.6	65.6	59.3
Tenants could provide	6.8	1.6	18.5
Both landlords and tenants	29.5	32.8	22.2

The main reasons for the results of Table 5 were that the house belongs to the landlord (41.2%), and others also said the toilet will bring benefit to both the tenant and landlord (26.2%). The other reasons given are the chances that the tenant can be ejected anytime from the house (13.8%), the toilet should be part of the house plan (5.0%), toilet availability is already part of the tenancy agreement (7.5%) and support will be given to the landlord (6.2%). Tenants are usually motivated to support the construction when the landlord takes the initiative. The motivations to support the landlord in the toilet construction and maintenance are: support construction if initiated by the landlord (39%), support because it will ensure security of tenant (17%), support construction if the contribution is made by all including the landlord (11%), support because it will benefit both tenant and landlord (9%), and 13% will only contribute towards the maintenance of the facility. Tenant in Ghana have little or no control over the sanitation infrastructure where they live (Jenkins and Scott, 2006). The tenants know that unless the landlord agrees to construct it they can do nothing about the sanitation problem.

Conclusion

The people prefer household toilet irrespective of their awareness of the MDG. Water Closet is the most preferred technology and this is mainly due to the good hygiene and security it offers. The motivations for the household sanitation preference were the security offered especially at night and for the sake of the vulnerable. A focus on vulnerability and security in sanitation promotions will increase construction of household toilet in the country. The tenants usually are not certain of their stay in the houses, and hence unwilling to contribute towards the construction of the facility, but would support if the landlord will take the initiative. Strategies to deal with the funding constraint will positively impact the sanitation challenge in the country.

Recommendation

The local governing bodies should ensure that landlords construct the improved household toilet in their houses by enforcing the law that all households should get an improved sanitation facility. The tenants in the single landlord houses must be motivated to make their sanitation a priority, these people are willing to construct on their own but it is only a matter of priority in the use of their income. The stakeholders in the sanitation promotion should help provide some sort of financial aid towards the construction to help curb the sanitation challenge in Ghana.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Meeting Ghana's MDG Target on Sanitation, through Dissemination of Biogas Plants

Richard Arthur & Edward Antwi

Abstract

According to the MDG report on Ghana for 2008, only 21.2% of Ghanaians will have access to improved sanitation by 2015. This is below the target figure of 52%, suggesting that there are still challenges with the existing sanitation policies and programmes. This paper presents the status of sanitation biogas technology in Ghana. The paper suggests that current policy recommendations should be expanded to include individual household biogas plants in addition to institutional and community plants. A nexus is also made between the provision of basic sanitation and energy through the use of biogas plant which could further support the creation of sustainable development in Ghana. The paper suggests that greater emphasis must be laid on developing funding schemes for households for the adoption of biogas systems. The paper also argues that it is possible for Ghana to achieve the MDG target on sanitation by developing a comprehensive and implementable programme involving all the stakeholders using the biogas technology as the focal points.

Introduction

Access to safe clean water and adequate sanitation is a fundamental right and a condition for basic health for every human being. However, in the developing world, one person in three lacks safe drinking water and sanitation [14]. Ghana has its share of the sanitation problems. It is expected that increasing population in the rural and urban areas should be accompanied with corresponding expansion of sanitation facilities which could aptly deal with social and environment issues regarding sanitation. In the past, numerous efforts have been made to combat poor sanitation in Ghana. However, The United Nations Development Programme [1] in its Human Development Report (HDR) for 2007/2008 estimated that about 82 % of Ghanaians lacked access to improved sanitation at the end of 2004. According to the HDR for 2007/2008, the 2004 figure of 82 % is higher than the sub-Saharan average of 68 %, this makes Ghana's sanitation situation alarming. Some disease causing agents get into the human system because of such practises as not covering food, eating unwashed food, not washing hands and drinking untreated water. According to Joint Monitoring Programme most recent report on sanitation in Africa, open defecation rate in Ghana reduced marginally from 24% in 1990 to 20% in 2006 [2] and dropped to 13% in 2008 [16]. Both local and international reports indicate that more than 4 million people in Ghana still resort to defecating in fields, drains and bushes. Poor sanitation has been identified as one of the greatest drivers of poverty globally and it is an affront to human dignity. The objective of this paper is to present biogas systems as one of the technical options to improve sanitation in Ghana and to meet the MDG target on halving by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation.

Status of Sanitation in Ghana

In Ghana sanitation has become a major development issue in recent years. Poor sanitation and waste management practices have contributed to the pollution and unsightly conditions hindering economic development and causing public health problems. Domestic wastewater is mostly discharged directly into drainage systems that end up in water bodies such as streams, lakes, rivers and lagoons [5]. This has led to drastic decline in desirable aquatic conditions. Sewerage systems are virtually non-existent in Ghana apart from Tema (in the Greater Accra Region), some satellite systems in some of the regional capitals and very few cities. According to the Environmental Health and Sanitation Directorate (EHSD) of the Ministry of Rural Development and Environment, only about 4.5 % of Ghanaians have access to these systems [2]. According to the Ghana Living Standards Survey – Round Five report for 2008, about 70 % of households in the savannah areas have no toilet facilities, with only 33 % of households living in Greater Accra having access to flush toilet facilities as shown in table 1 which presents an opportunity for providing improved sanitation facilities.

Table 1: Household by locality and type of toilet used by the household (%) [4]

Locality								
	Urban Areas			Rural				
	Accra	other						Ghana
Utility	GAMA[1]	Urban	All	Coastal	Forest	Savannah	All	
Flush toilet[2]	33.2	16.7	22.2	1.4	1.1	0.7	1.1	10.2
Pit latrine	5.0	21.0	15.7	43.6	57.6	20.9	43.5	31.5
KVIP	15.8	13.8	14.4	11.3	11.8	4.6	9.5	11.7
Pan/bucket	3.2	2.3	2.6	0.1	0.3	0.3	0.3	1.3
Public toilet(flush/bucket/KVIP)	41.3	37.5	38.7	13.9	19.1	4.6	13.6	24.4
Toilet in another house	0.4	1.3	1.0	1.9	2.6	0.1	1.7	1.4
No toilet facility(bush, beach)	1.1	7.4	5.3	27.2	7.3	68.9	30.2	19.4
Other	0.0	0.1	0.0	0.5	0.2	0.0	0.2	0.1
Total	100	100	100	100	100	100	100	100

[1]GAMA: Greater Accra Metropolitan Assembly
[2]Flush toilet and KVIP are strictly for households

The main types of municipal treatment facilities used in Ghana are the oxidation or waste stabilization ponds, aerated lagoons, trickling filter and activated sludge process treatment facilities. According to an Africa Water Facility (AWF) report in 2010, less than 10% of the existing treatment plants in Ghana operate as designed based on the findings of survey carried out in 2008. The 55 existing WasteWater Treatment Plants (WWTPs) and 7 municipal Faecal Sludge Treatment Plants (FSTPs) in the country have a total design capacity to serve about 25% of the urban population but discharge into the environment without any effective treatment is dominating.

A Ghana Statistical Service Multiple Indicator Cluster Survey report for 2006 indicates that, open defecation is prevalent in all the ten regions in Ghana but mostly widespread in the Upper East Region with about 82% without any form of latrine, followed by the Upper West Region with about 79% and then the Northern Region with about 73%.

According to table 1, 32% and 12% of Ghanaians use Pit latrine and Kumasi Ventilated Improved Pit (KVIP) respectively as toilet facilities whiles about 10% use flush toilet and over 19% defecate in the bush, beaches, etc. This is quite alarming as human faeces are the primary source of diarrhoea pathogens. Diarrhoea diseases are ranked the third greatest public health problem after malaria and upper respiratory tract infection in Ghana from 2002 to 2008 [5].

MDG Target 7.C: Ghana's Case

One of the MDG goals, Goal 7 - Ensuring environmental sustainability, Target 7.C is aimed at halving by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation. According to the 2008 MDGs report for Ghana, the country is on track to achieving the target on halving the proportion without access to safe water but challenges exist in achieving the targets of reversing the loss of environment resource and reducing the proportion of people without access to improved sanitation. At the current trend the proportion of the population with access to improved sanitation will reach 21.2% by 2015 instead of 52%, while the proportion of urban population with access to improved sanitation will be 23.4% instead of 55% by 2015. In the rural areas, only 20.6% will have access to improved sanitation instead of 50.5% [6]. Currently, the national coverage on improved sanitation is 12.4% instead of 52% target by 2015 indicating that there must approximately five times increase in the coverage to be able to achieve the set target. According to Sachs et al [7], for Ghana to meet the MDG target set for sanitation and wastewater management needs, a total of about US$ 941 million will be needed from 2005 to 2015. The Local government and Rural Development points toward an amount of US$ 1.5 Billion within the next five years to achieve the set target by 2015. About US$ 51 million was needed for solving sanitation problems in the urban areas in 2010. This figure will increase to about US$ 70 million by 2015, if the set targets are to be achieved. Between 2005 and 2015 about US$ 240 million will be needed for the wastewater management in both urban and rural areas [7].

Biogas Generation from Faecal Sludge

The bio-latrine (or bio-toilet) is a special type of the sanitary biogas plant where the digester receives the excreta from a community or institutional facility; the excreta enter the digester in a 'long drop' without being mixed with water. The main advantage of the bio-latrine is its ability to solve the sanitation problems of public toilets in communities where water is scarce. The bio-latrine can provide a viable solution to the public health and environmental problems posed by improper sewage waste disposal. During anaerobic digestion of night soil at a Hydraulic Retention Time (HRT) of 30 days, there is a remarkable reduction (up to 85%) of Biochemical Oxygen Demand (BOD) of the effluent of biogas systems [15]

Status of Biogas Technology in Ghana

A 10 m^3 Chinese fixed dome digester was the first biogas demonstration plant in Ghana. It was constructed in 1986 by the Ministry of Energy supported by the Chinese government at a cattle ranch in Shai Hills in the Greater Accra Region. In the following year, UNICEF also provided support for the construction of a couple of domestic biogas demonstration plants as Jisonavilli and Kurugu in the Northern Region [8]. The Ministry of Energy established one of the first major comprehensive biogas demonstration projects in Ghana - the "Integrated Rural Energy and Environment" at Appolonia- a village located some 46 km from Accra. The feedstock for the biogas plant at Appolonia were animal dung and human excreta providing biogas for a 12.5 kW generator to provide power for street and home lights as well as cooking whiles the bio-slurry was used as organic fertilizer [9]. The total number of biogas plants in Ghana is unknown however; a survey conducted by authors [10] on 50 biogas plants in Ghana showed that 76% of the plants have been constructed for treatment of human excreta with 14 of the plants not functioning. This is attributed to poor design and construction of digesters, wrong operation and lack of maintenance by users, poor dissemination strategies, lack of project monitoring and follow ups by promoters, and poor ownership responsibility by users [12]. Following the lack of government involvement in developing a biogas dissemination strategy at domestic and community levels, a number of private biogas companies have marketed the technology on purely business grounds, and mainly based on the ability of biogas plants to improve sanitation. There are at least 10 biogas service providers who have been actively involved in the design and construction of both domestic and institutional size biogas plants across the country [11]. The biogas digester designs that are common Ghana are fixed dome, floating drum and Puxin digester for domestic and institutional use [17] providing biogas to supplement energy needs.

Lessons

At the current trend, the proportion of the population with access to improved sanitation will reach 21.2% by 2015 instead of 52%, while the proportion of urban population with access to improved sanitation will be 23.4% instead of 55% by 2015. The absence of adequate sanitation facilities presents a major challenge in the socio-economic development socio-economic for most Ghanaians partly due to the lack of adequate support from government. A number of private biogas service providers have on purely business grounds, marketed the technology [12] providing biogas plants for individual with biogas plant sizes between 8m^3 and 12m^3 [8] whiles institutions have sizes from 40$m^3$to 800m^3. The existing Biogas systems are used to treat sewage in addition to producing biogas for lighting and heating. The individuals with biogas systems are not directly involve with the sewage treatment process except during maintenance of the system. In some households, the effluent from the digester is used as an organic fertilizer to boost crop productivity. Even though biogas is capable of solving some of the energy and environmental problems of the poor rural populations, urban communities and industrial estates, there is usually high investment requirement. This limiting factor discourages individuals from owning a biogas plant. The pathogen levels in digested faecal sludge from the bio-latrines would be reduced; hence disposing it would be less harmful as compared with the fresh faecal sludge. Farmers in developing countries are in dire need of fertilizer for maintaining cropland productivity. At the same time, the amount of technically available Nitrogen (N), potassium (K) and phosphorous (P) in the form of organic materials is around eight times as high as the quantity of chemical fertilizers actually consumed in developing countries.

Conclusions

Ghana might not meet the MDG target on sanitation by 2015. For Ghana meet the MDG target, biogas systems should be one of focal points when disseminating sanitation facilities for communities. The presence of domestic biogas plants not only treat faecal sludge but, but can also digest kitchen waste and food leftovers. This will reduce the amount of solid waste at the domestic level. The biogas produced could substitute woodfuel and supplement Liquefied Petroleum Gas (LPG) used for cooking and heating. Even though there are no clear-cut policies for the promotion of the domestic biogas technologies in Ghana [9] a number of plants have been constructed since 1996 [8]. According to [13], the government will promote biogas-for-heating in institutional kitchens, laboratories, hospitals, boarding schools, barracks, etc. The benefits it provides to the country are environmental sustainability, improved health and increase in agricultural productivity inter alia. It will further to reduce the workload of women in households providing avenues for other social and economic benefits when proper programmes are followed. Implementation of biogas technology will support the global climate change mitigation interventions through methane capture. The biogas produced from community bio-latrines can be used to provide lighting at night for the immediate environs of the bio-latrines. The presence of the light, can the opportunity for the community folks to sell at night to earn some income.

Recommendation

The government should begin to focus on the dissemination of bio-latrines in communities where there are plans for constructing KVIPs. The bio-latrines in this regard, will treat the faecal sludge under anaerobic conditions to produce biogas. Consequently, the designated sewage dumping site will become redundant preventing direct exposure to individuals which could otherwise affect their health. The effluent from the digester has been proven to be the best fertilizer for farms which provides farmers with an improved organic fertilizer. This could increase crop productivity in these communities. Biogas systems not only could help Ghana achieve its MDG target on access to basic sanitation, but would help in the creation of sustainable development through the provision of renewable energy source, environmental sustainability, economic empowerment and increase in agricultural production.

The government should develop a domestic biogas dissemination programme which should include the introduction of financial incentives such as soft loans and subsidies at the initial stage. This can be done by involving ministry of Environment Science and Technology, Energy Commission, Universities and other institutions should be involved in developing such a plan. The various technologies applied in Ghana should be studied by Centre for Scientific and Industrial Research (CSIR) or by other research institutions mandated in this regard.

There is need for intensive ad extensive public education during the project planning and implementation phrase. The basic facts about biogas technology should be made clear beforehand, so that possible problems of biogas technology are transparent to the stakeholders involved. Obstacles can arise from religious and social taboos in respect of prohibitions in the use of biogas primarily for the preparation of food and in the use of the effluent. The government can also provide support to local energy Non-governmental Organizations (NGOs) such as KITE and Centre for Energy, Environment and Sustainable Development (CEESD) who will then provide periodic technical and financial support to domestic biogas owners.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Ghana's Revised Environmental Sanitation Policy 2010: A Review

Edem Cudjoe Bensah, Edward Antwi & Julius Cudjoe Ahiekpor

Abstract

About 78 % of Ghanaians lack access to improved latrines and the challenge of meeting the Millennium Development Goals for sanitation are becoming increasingly difficult. The revised Environmental Sanitation Policy of 2010 is expected to deal effectively with the issues that have led to the persistent underlying causes of poor environmental sanitation and its vital link to health. This paper reviews the revised Policy and examines its readiness to close gaps in the delivery of sanitation interventions in Ghana. The paper shows that the revised Policy prioritizes waste collection and disposal at the expense of the four Rs: reduction, reuse, recycling and recovery. The policy also fails to set concrete targets on various aspects of waste management, a situation that makes it difficult to evaluate the Policy with regards to the policy actions and measures outlined. Even though the challenges as well as policy actions and measures touch on every aspect of environmental sanitation, the Policy fails to set the right priorities which mean incentives and other support mechanisms are likely to end up in the wrong hands. A more robust Policy with concrete targets and timelines, and which revolves around the principles of the 4Rs is urgently needed.

Introduction

Sanitation in Ghana

Sanitation is a critical intervention needed to improve the standard of living of all Ghanaians, and to reduce or prevent the incidence of communicable diseases. Sanitation has become a major development issue in recent years. The lack of adequate sanitation facilities in both rural and urban communities is recognized in Ghana's Medium-Term Development Policy Framework (MTDPF) which covers the period 2010 – 2013. MTDPF recognizes the importance of improved sanitation and thus contains strategies for improving sanitation such as prevention of slum formation and promotion of private sector involvement in flood control and coastal protection [1]. Solid and liquid waste disposal is said to be one of the problems facing peri-urban and urban communities [2]. Most public toilets are under undue pressure due to the fact that most houses in both rural and urban areas lack adequate toilet facilities; moreover, overcrowding in cities and towns, insufficient housing units, illegal structures, and streetism have worsened the problem [3].

Baseline data gathered by local authorities in 2007/8 put the percentage of household relying on poor waste collection and disposal methods at 76 %, and only 5 % have access to house-to-house collection. The five largest cities comprising Accra, Kumasi, Sekondi-Takoradi, Tamale and Tema generate over 3,200 tonnes of solid waste daily in addition to over 5000 tonnes of solid waste generated by about 105 other towns in Ghana [4]. Data on sanitation coverage in Ghana as given by various studies are summarized in Table 1.

Table 1: Data on coverage of improved household sanitation facilities based on various studies

Survey	Year	Improved household sanitation facilities (%)		
		Rural	Urban	National
Multiple Indicator Cluster Survey	2006	45	83	61
Ghana Living Standard Survey V	2006	21.9	26.6	
Ghana Demographic and Health Survey	2008	-	-	11.3
District Environmental Health Directorates	2007/8	-	-	76
Human Development Report 2008	2004	-	-	18

Source: [4; 5]

Ghana's sanitation crisis is better understood when compared with the state of sanitation of sister countries in Africa as seen in Figure 1.

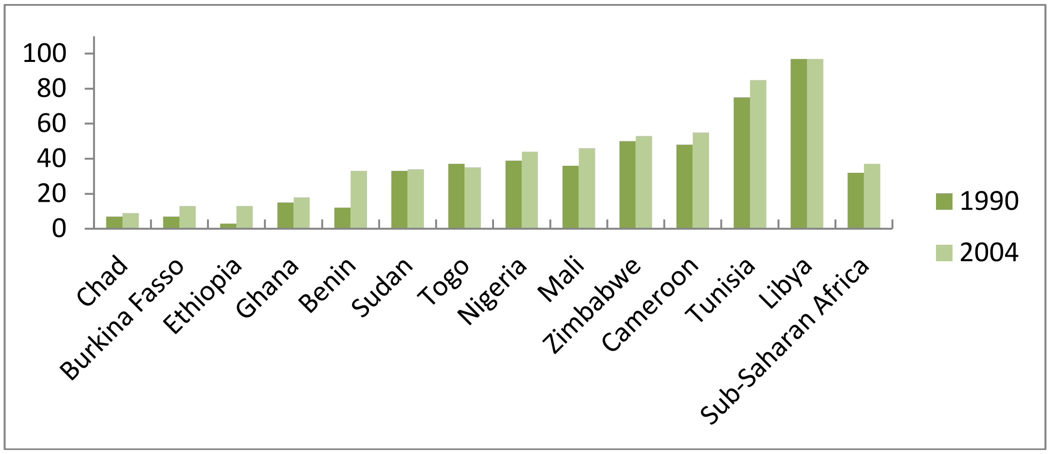

Figure 1: Percentage of population with access to improved sanitation for selected African countries
Based on data from UNDP [5]

History of Environmental Sanitation Policy in Ghana

Environmental sanitation policy and other collateral policies, legislations and guidelines on waste are not new to Ghana. Government in her efforts to address the waste management problems has developed various strategies and solutions that are expected to reduce pollution and improve the environment. Relevant legislations enacted to control waste include: Local Government Act, 1990 (Act 462); Criminal Code, 1960 (Act 29); Water Resources Commission Act, 1996 (Act 522); Environmental Protection Agency Act, 1994 (Act 490); Pesticides Control and Management Act, 1996 (Act 528); Environmental Assessment Regulations, 1999 (LI 1652); and National Building Regulations, 1996 (LI 1630). Ghana also has several guidelines for integrated waste management such as: National Environmental Quality Guidelines, 1998; Ghana Landfill Guidelines, 2002; Manual for the Preparation of District Waste Management Plans, 2002; Guidelines for Bio-medical Waste (2000); Guidelines for the Management of Healthcare and Veterinary Waste, 2002; District Level Environmental Sanitation Strategy and Action Plan (DESSAP), and National Environmental Sanitation Strategy Action Plan (NESSAP) [6].

Environmental Sanitation Policy in Ghana came into force in 1999. It was developed mainly to harmonize several policies related to waste management and sanitation that were being applied by various national bodies. The policy was used until 2007 when it was revised due to its failure to capture sanitation targets of the MDGs and national developmental strategies and action plans such as the Growth and Poverty Reduction Strategy (GPRS) plans of the government of Ghana. Moreover, it failed to address issues such as capacity building and new trends regarding the changing nature of municipal waste such as increasing percentage of plastics in the waste stream.

In 2010, the policy was again revised in order to update the scope to meet current developmental objectives according to Hon. Yieleh Chireh, the then Minister for the Ministry of Local Government and Rural Development (MLGRD). The revised Policy of 2010 is expected to deal more effectively on data collection on all forms of waste to engender research and development. The Policy is also expected to build better partnerships with stakeholders at both local and international levels and with the private sector, and to revise unsustainable strategies and those that were not implemented [4].

Overview of Ghana's Revised Environmental Sanitation Policy of 2010

The 2010 policy document is aimed at developing a clear vision of environmental sanitation as an essential social service and a major determinant for improving health and quality of life of people living in Ghana. It is sectioned into three main parts: Part 1 highlights the framework under which the policy was revised; Part 2 presents actions and measures outlined to meet challenges and bottlenecks in environmental sanitation; and Part 3 deals with issues such as stakeholder roles and responsibilities required to implement the policy measures. The policy is cognisant of changing trends in waste generation caused by changing lifestyles of Ghanaians due to modernization and urbanization as well as improving wealth status. It identifies all stakeholders and actors and considers positive behavioural and attitudinal issues required for the realization of improved environmental sanitation.

Moreover, emphasis is laid on the need to identify and harness resources for value-for-money services with regards to economy, effectiveness, and efficiency. The principles that underlie environmental sanitation such as, *inter alia*, waste collection and disposal, storm-water drainage, food hygiene, cleansing of domestic and public places, education, and enforcement of regulations and laws have been considered in the revised policy document. Major challenges as outlined in the policy include increased population growth and urbanization, poor planning, inadequate drainage facilities, poor refuse collection, inadequate management services, and poor personal and communal hygiene. The rest are low capacity of central and local authorities regarding enforcement, managerial, and adequate financing of waste management.

The Seven Policy Focus Areas

The 2010 policy outlines strategies and actions for seven policy focus areas, namely: capacity development; information, education and communication; legislation and regulation; levels of service; sustainable financing and cost recovery; research and development; and monitoring and evaluation. Problems and challenges facing each focus area are identified and policy objectives, measures, strategies and actions needed to tackle the challenges are outlined and clarified. Institutional arrangements as well as stakeholder duties and responsibilities needed to realize the goal of the policy are articulated and clarified.

Evaluation of the Environmental Sanitation Policy of 2010

While the policy identifies challenges affecting all forms of sanitation delivery, it is handicapped in defining the priorities with regards to policy actions and measures for fighting the myriad of problems enumerated. In the arena of solid and liquid waste management, the policy fails to emphasize the application of the principle of the four Rs (Reduce, Reuse, Recycle, and Recovery) which are globally accepted as integral part of integrated waste management. While the 4R concept is recognized by the Policy in a few sections, it fails to apply the principle to the seven policy focus areas.

The Neglect of the Four Rs

The revised Policy of 2010 puts too much emphasis on waste collection and disposal contrary to internationally accepted strategies for achieving integrated waste management. The four Rs – Reduce, Reuse, Recycle, and Recovery is a waste management strategy that outlines four means of dealing with waste in a preferential order, from the most useful (Reduce) to the least favoured (Recover). The concept of the 4Rs aims at reducing to the barest minimum the quantum of waste generation while realizing the maximum practical benefits from products. Though disposal has a place in an integrated waste management system, it is usually the last option on the table.

With Ghana's population currently estimated at over 24 million coupled with the growth of cities and towns, waste generation is increasingly at a fast rate. The fraction of waste collected is small in most peri-urban communities but has increased in major cities such as Accra (70%), Kumasi (75%), Sekondi-Takoradi (60%), and Tamale (55%). Well engineered waste disposal sites are absent in all the cities except Kumasi. Waste treatment facilities for both solid and liquid waste are woefully inadequate leading to open dumping of waste and discharge of faecal sludge in water bodies. According to the National Population Council [7], only 4.8 % of household waste is collected. A staggering 57.6 % of all waste generated ends up at public dumping grounds untreated and in unhygienic conditions. Burning contributes 7.9 % whiles 25 % of the waste is dumped elsewhere and 3.9 % are buried [4]. Moreover, close to 76 % of households still rely on improper waste collection and disposal methods, and only 5 % rely on house-to-house collection, according to the baseline environmental sanitation data gathered in 2007/8 [4].

Regionally, Greater Accra performs better than all the other regions with 19.5 % of waste generated collected. Central and Brong Ahafo Regions have the lowest quantities of waste generated collected, 0.8 % and 0.9 % respectively. The three northern regions – Northern, Upper East and Upper West have the highest rate of indiscriminate waste disposal, 55.3 %, 55.2 % and 65.6 % respectively. Analysis of municipal waste in Ghana gives the following composition for waste collected: organic (40 – 70%), plastic (15 – 20%), paper and cardboard (4 - 13 %), metals (2 – 5 %), and others comprising glass, textiles, e-waste, and ashes (7 - 25%) [8].

The numerous problems facing the sector thus require a realistic strategy that tackles the problem right from the source. While it is understood that the fraction of waste collected and disposed appropriately is woefully poor, prioritizing the 4R concepts will lead to reduced waste reduction in the first place, a situation that will put less constraints on waste collection companies and local authorities as there will be less waste to collect and dispose.

Waste Reduction
There is the need to apply the 4Rs to each category of waste. Reducing waste leads to prevention and minimization of waste in the first place. That means there is less waste to worry about. The benefits of waste reduction are numerous: less pollution and therefore improved sanitation, reduced financial constraints on waste collection, time savings from waste collection, reduced pressure on dumps and landfills, among others. The policy should also look at issues pertaining to the reduction in the use of toxics, inorganic chemicals, pesticides, e-waste, and hazardous chemicals. The policy should for instance encourage:

1. Sorting of waste at source

2. Household composting of organic waste

3. Reduced packaging materials by industries

Waste Reuse
Reusing waste creates resources out of waste. That means the material or substance called waste is no longer considered waste. Finding new uses for old materials avoid waste generation and thus promote environmental sanitation. Organic waste reuse involves the use of technologies such as composting to organic fractions of municipal waste.

Waste Recycling
Recycling of waste ensures that waste materials that would have ended at the landfill are rather used for another purpose. Recyclable products should be promoted through appropriate policy guidelines on education and awareness creation. The policy should explore avenues for creating incentives for companies involved in recycling. Several initiatives that can be promoted to improve waste recycling include composting for organic waste and purchasing of materials with higher percentages of recyclable components and packaging,

Waste Recovery
This involves the identification and reprocessing of useful components of items considered as waste. The recovered part may be reused or recycled. Waste recovery ensures that only unusable parts or components of old materials, gadgets and equipment are sent to the landfill site. It helps in reducing the volume of waste disposed. An example of waste recovery is the removal of certain useful components from old computers before the computers are disposed.

The Lack of Targets
While the 2010 Policy adequately identifies challenges and gaps in the delivery of environmental sanitation services in the country, it fails to set targets with regards to policy measures and actions outlined under the seven focus areas. The policy, for example, does not have targets on the percentage of Ghanaians that are expected to enjoy improved household latrines within a time period. It also unclear whether the Policy aims at achieving the MDG targets on sanitation. Targets on house-to house waste collection as well as waste reuse and recycling are not clearly defined. It is also unknown when ad-hoc disposal dumps that receive waste from the major cities would be replaced with engineered landfills.

In order to address non-existence of targets in the Policy, future reviews should take cognisant of targets on waste collection as stipulated in the NESSAP [9]. Moreover, the NESSAP should also be reviewed to include targets on waste reuse, reduction, recycling and recovery, as well as targets on the provision of public toilets, which are currently non-existent. While targets were set for dislodging faecal matter, pertinent issues such as disposal sites and treatment options were not clearly outlined [9].

Even though NESSAP contains minimum targets for home-latrines, the baseline underlying the target is not clear. It is also not clear the type of technology that will be promoted. While some aspects deal with support for biogas digesters, no targets were included and the exact digester models that would be promoted are not listed [9]. NESSAP fails to outline deliverables for instance and milestones that are essential in evaluating the policy.

Lessons

Policies that set the right priorities create the framework for incentives to go to the right receivers and for the right activities and programmes. It leads to the development of sustainable and effective programmes and ensures that limited resources are used judiciously and at the best interest of society. If the priorities are gotten wrong, resources would be wasted in the long run. It should also be noted that policies engender programmes and dictate where incentives should go and the people/organizations that should receive them. Looking at the current Policy, it is clear that attention is focused on the collection and disposal of waste. That means much of the incentives and support will go to individuals and organizations that collect and dispose waste which should not be the case. A bigger fraction should rather be channeled into activities and programmes aimed at reducing, reusing, recycling and recovering waste.

The lack of concrete targets in the Policy has made it extremely difficult to monitor and evaluate the implementation of the policy. The document is replete with numerous policy actions and measures that cannot be verified.

Conclusion and Recommendations

The revised Environmental Sanitation Policy of 2010 has its strong and weak points. The seven focus areas of the Policy embrace every sector of the waste management chain. It adequately creates an enabling environment that encourages access to and use of sustainable sanitation services and this facilitates the tasks of those concerned with sanitation provision. The weak point of the Policy is its failure to build the seven focus areas around the principles of the four Rs. This has created a situation where waste collection and disposal are given paramount interest at the neglect of the four Rs. This means government, local authority and donor funds will mainly go into activities such as waste collection and disposal as opposed to waste reduction, reuse, recycling, and recovery.

It is recommended that the Policy is revised again to make the principle of the 4Rs the central focus of a new revised policy that gets its priorities right and embraces the core principles of integrated waste management. The proposed revised policy should set concrete targets in all aspects of environmental sanitation and realistic policy measures and actions should focus on achieving the targets against specified timelines.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

The Canker of Open Defecation

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Abstract

Even though the International Drinking Water Supply and Sanitation Decade (IDWSSD) was launched in 1991 and was expected to have ended in 2000 with many developing countries increasing accessibility and usage of potable water and improved latrines, many in Africa are still lagging behind these two basic necessities of life particularly in sanitation (WaterAid, 2008). In Ghana, in spite of fair progress made in water coverage, less than 15% of the population has access to improved sanitation (WSMP, 2008). Indeed, it has been reported that about 20% of Ghana's population defecate in drains, fields, streams, the bush and beaches. Given the pace of development with respect to basic sanitation, there is no way the country can achieve the MDG targets by 2015. This paper examines the reasons for Ghana's slow pace in sanitation delivery and makes suggestions on what can be done to accelerate progress.

Background

Between the 1980s and late 1990s to-date, much of the approach to basic sanitation improvement in rural areas has been through the assistance of Development Partners and non-governmental organisations as part of water and sanitation programme interventions. These have been done through the training of latrine artisans for construction of certain types of latrines[3] on the one hand and the provision of selected items or direct cash payments as subsidies to rural dwellers within the project areas on the other hand. Even though these latrines were to serve as demonstration models for others to emulate and construct accordingly, the "knock-on" impact has been slow and discouraging. Only 12.4% of the population uses improved sanitation facilities which are not shared (GSS, 2008). The Ashanti, Greater Accra, Brong Ahafo, Western and Central Regions have the highest use of improved latrines while many residents in the Upper East, Upper West and Northern Regions resort to "open defecation" (GSS, 2006). The slow pace of latrine construction and proper usage can be attributed to a number of challenges. They have been classified into physical, financial, psycho-social and institutional/legal and are examined in the sections hereunder.

Challenges

Physical

Lack of adequate space/land especially in urban areas or densely-populated neighbourhoods is one factor that accounts for construction of inadequate latrines and predisposes people to open defecation. One reason given why people are unwilling and sometimes unable to construct latrines

[3] Artisans were trained and provided with equipment for the construction of (a) Mozambique type Ventilated Improved Pit (b)Reinforced Ring beam Ventilated Improved Pit (c) Kumasi Ventilated Improved Pit and (d)Sanplat latrines.

is that they simply do not have the space available. About 25% of people interviewed in a recent survey said that even though they would have liked to build their own latrines, there is simply no land available (WaterAid, 2005). Areas are built-up with little space for construction of latrines and this is attributed to open and wanton disregard for laid-out plans for many settlements with little space for dislodgement if even the latrines are built (Smith-Asante, 2010). The housing density in Accra in 2009 was estimated at 558 houses per square kilometer (CHF, 2011).

Given this phenomenon, residents are prepared to pool resources with a few households to enable them to share a common latrine as has occurred in a number of countries where the Community-Led Total Sanitation (CLTS) has been triggered e.g. Bangladesh, Nepal and Nigeria.

Unhygienic and unkempt nature of many public latrines become "push factors" for people to defecate openly. A visit to a majority of our public latrines (except for some of the most recent types e.g. water closets and pour flush) reveals unsightly scenes such that it is extremely difficult to go in and come out without being subjected to extreme stench. Human contact with faeces is even possible owing to the poor maintenance culture and negative attitude of users. For example, as much as 30% of Accra residents report that they are dissatisfied with the state of public latrines owing to how they are poorly managed and maintained (World Bank, 2010).

Unstable soils that cave in when pits are dug are a related physical reason for open defecation, though not justified. One of the biggest challenges facing both rural and urban dwellers regarding digging pits for latrine construction is weak soils and high water tables (Smith-Asante, 2010). In some cases, residents have attempted digging pits over and over again, only for the pits to collapse. The implication is that these pits have to be lined and this has cost implications. If there was no need for lining to be effected prior to the construction of the main building or habitat of the people who dwell in the house, they do not see why they should line a pit for what they consider "temporary use".

Financial

Some opine that it is a waste of resources spending funds on "waste product" from your system/body. For them, it is illogical that one should spend hard-earned money to finance a structure to take care of something that is unwanted. In the cities, there is the phenomenon of the conversion of latrines by landlords into sleeping places for financial gain. In many urban areas, the increase in demand for residential accommodation has made a number of landlords/ladies change originally-meant rooms earmarked for toilets into dwelling places (Bessey, 2011). Tenants are too glad to rent a place to lay their heads without a corresponding place to let go what they take in. In Accra-Tema, Kumasi and Sekondi-Takoradi, the three most urbanized centres in Ghana, the rate of growth is over 4% per annum (Ghana Statistical Service, 2003) and this has become a source of ready income for some landlords in those places.

In spite of the wrong priorities people place on acquisition of certain material things, it is equally true to admit that there are some 18% of the extremely poor in Ghana who may not find it easy to construct a basic latrine of about GHC200[4] (equivalent to about $140). These are those whose standard of living is insufficient to meet their basic nutritional requirements even if they devoted their entire consumption budget to food (Ghana Statistical Service, 2007).

[4] 1US$=GHC1.50

Psycho-Social

Anecdoctal evidence suggests that some people mostly illiterates and those living in fairly homogenous communities where there is a high rate of open defecation get addicted to such behavioural patterns. In a survey carried out in 1990 among people living along the coastal parts of Ghana, it was discovered that almost 70% of the populace were using the beach as their place of convenience. Where people have grown up in communities there is open defecation, they are more likely to continue in similar vein rather than attempting to change what they have become accustomed to.

Sanitation and hygiene have not been accorded premium by authorities (M/M/DAs.). Right from the top, our leaders (political, administrative and the elite in general) do not appear to be enthused about household latrine and hygiene promotion. Many see them as trifles whereas politicians and decision-makers appear to be concerned with grandiose physical structures and projects that will win votes and popularity. In the few cases that some attention has been devoted to sanitation, this has either been in the form of construction of storm drains in large settlements, large refuse disposal sites and public or communal latrines. Promoting household latrine construction and ensuring the eradication of “free range” has always been relegated to the background

The long distance and waiting time at public latrines are perceived as “wasted time” and hence it is “faster to do it in the open”. When people have to walk for more 500 metres in the cities and towns to the nearest public latrine and have to queue, they resort to open defecation as a “prompt and ready” strategy. On average, people find it difficult to spend more than 20 minutes waiting for their turn in order to use either a KVIP, aqua privy or most recently the public water closet system. Considering that this could be inconvenient to people, they would rather resort to open defecation where there are no restrictions regarding time or distance.

It has also been realized that there is no sense of shame for many including adults who defecate openly. One of the biggest reasons people defecate openly is that unlike the “initiated”, most people do not have any sense of disgrace whatsoever while easing themselves.

Closely related to this reason is the perception of some people that excreta disposal is only “a temporary inconvenience”. If people are going to spend just a few minutes every day to dispose of “waste” from their system, they do not see why they should bother constructing a latrine for it.

There are a also a number of migrant communities or groups of settlers in Ghana who, because they do not consider their present places of abode as their permanent home towns, do not deem it necessary to build latrines they would leave behind eventually. The irony however is that while it has been realized that these settlers are not interested in constructing household latrines for their use in the communities they have migrated to, they do not have the improved latrines in their areas of origin or permanent homes either. The number of migrants in our communities is fairly high. The Ghana Statistical Service estimates that 52% of Ghana’s population is migrants.

Owing to misplaced priorities, people deem it expensive to build a latrine as compared to spending money on other “prioritized needs”. People who give the impression that they are poor are prepared to spend funds on issues such as annual festivals, “out-dooring”[5] ceremonies of newly-

[5] In Ghana, the traditional naming ceremony of a a newly born child (usually after 8 days) is referred to as outdooring

born babies, funeral ceremonies, lottery, multiple marriages, alcohol intake on a regular basis, units for mobile phones, expensive clothes especially wax prints for women, regular "dressing of the hair" for women etc. (Dotse & Laryea, 2001).

Legal/Institutional

Laws on indiscriminate defecating have not been applied on people who are found defecating. In a few cases where people have been arrested, the judgment passed on them has not been punitive enough to serve as a deterrent hence people get away with the practice Only a small minority of people who defecate openly are apprehended and the fines only range from GHC50 to GHC100 (equivalent of about $70).

Inadequate staff of the Environmental Health and Sanitation Directorate (EHSD) to monitor and check the menace is another challenge. Inadequate resources, logistics and incentives for Environmental Health Assistants and their officers to monitor sanitation generally is another big challenge. Whenever resources are made available to the water and sanitation sector, much more goes into hardware and the construction of physical facilities rather than on hygiene promotion and community mobilisation which are not perceived as the more basic essentials for change in behavior than the structures (Simpson-Herbert & Wood, 1998).

It is opined that until the 1970s and 80s, Environmental Health Assistants who used to champion the adoption and proper use of improved latrines were seen and/or perceived as "policemen" who only cracked the whip on defaulters. Defaulters who were often found in the rural areas or relatively poor sectors within the urban enclaves were fined. People neither understood the nature of their "crimes" nor were they made to appreciate the health linkage of their actions or inactions. In the few cases where EHAs engaged residents in discussions, they were primarily didactic and only "pushed information down the throats of their audience" without assisting them to establish the cause/origin, transmission routes and effects of their deeds or misdeeds. Beneficiaries were made mere spectators rather than participants of their own development.

Way Forward

A national crusade should be launched to rid the population of this canker and move away from these disgraceful acts and ensure that people own latrines and use them effectively as to reduce and possibly eradicate certain diseases associated with poor sanitation in our country! Some of the ways in which this can be done effectively include the following:

Governmental support

Having realized that we are off-track to achieving MDGs for sanitation, Ghana and its Development Partners pledged to allocate US$200 million annually from 2010 to 2015 and an additional US$50 million annually to reinforce hygiene promotion. It is recommended that the Ghana government should provide the required financing to support hygiene and sanitation promotion across all levels in the country.

Stronger Collaboration and Sector Harmonisation

The various institutions involved in aspects of sanitation should harmonise their approaches for a concerted effort at combating open defecation in Ghana. This has to be spearheaded by the Ministry of Local Government and Rural Development, supported by the Community Water and Sanitation Agency, MMDAs and Development Partners operating within the water, sanitation and hygiene promotion (WASH) sector. Some of these are WaterAid, Plan Ghana, World Vision Ghana, Ghana Education Service-Ghana Health Service under the School Health Education Programme (SHEP), Ministry of Information, UNICEF, DANIDA, KfW, European Union, CIDA etc. This will help build concensus on issues such as abolition of subsidies for household facilities and concentration on school facilities. It will also ensure that a single strategy is adopted in hygiene and sanitation promotion.

Review of Annual MMDAs Performance Assessment Indicators

To put a stop to open defecation, it should become mandatory for an MMDA to achieve a minimum percentage of latrine-use by residents/households in that district as a minimum condition for the assessment of MMDAs under the Functional and Organisation Assessment Tool (FOAT) which enables MMDAs to qualify for funds allocation under the District Development Facility (DDF)[6]. This will trigger political and administrative interest in hygiene and sanitation promotion at the district level and contribute to stopping open defecation.

Communal Septic Tanks & Support to EHSD

In urban areas where land becomes a key issue, a number of households (e.g.10) could be brought together for them to use “communal septic tanks” that will be connected to a central sewerage system like the one being done for Accra under the Accra Sewerage Improvement Project (ASIP) (Smith-Asante, 2010) – this approach would not only reduce open defecation but also require less space as compared to insisting that every household should have a latrine which is not feasible. In rural areas and areas with uninhabited land such as large portions of the Northern, Upper East and Upper West Regions, emphasis must be placed on the CLTS approach coupled with adequate resourcing of staff of the Environmental Health and Sanitation Directorate at all levels to provide sustained hygiene promotion.

Conclusion

In conclusion, it must be emphasized that the approach to ending open defecation should be a full-scale and sustained head-long attack which would be similar to the earlier programmes waged for malaria, HIV-AIDs etc. We should use print and electronic media e.g. FM stations, newspapers, television and other sources including celebrities to advocate proper disposal of human excreta and improved hygiene messages like hand-washing with soap at critical times to drum home this idea.

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No Household Sanitation Facilities: What Options Remain For Urban Dwellers?

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Abstract
Nowadays the poorest and the most vulnerable have little access to individual sanitation in low income and high density urban areas of sub Saharan Africa. In Ghana, more than 60% of the urban dwellers use shared sanitation facilities. This paper explores the diversity of shared toilets with a focus on Ashaiman. Several models of toilets with different sizes, prices per use, level of formalization and management model serve the urban dwellers. The spread of each type of facility is linked to the specificity of the urban development of each neighbourhood. This research argues that in a context where providing household sanitation to all in the short term is not possible, shared sanitation can be a transitional solution. However adequate shared facilities need to be defined according to the specificities of the areas, the users 'perceptions of such facilities and the legal and local institutional framework. If shared facilities that meet certain agreed criteria are recognised in policy statements, it can encourage more investment by entrepreneurs.

Introduction
In Ghana, more than half of the urban population is sharing sanitation facilities. Sharing is done in many different ways: with neighbours, through community blocks, or using public toilets. The Joint Monitoring Programme (JMP) using primarily technological criteria, do not consider shared facilities as improved sanitation, however UNICEF and WHO recently acknowledge the limits of such thinking (WHO & UNICEF, 2010, p. 36). Examples from India (Burra et al., 2003), certain projects in Kenya (Peal & Evans, 2010) show that shared facilities can provide a healthy alternative in the context of high density and low income areas. Therefore the JMP called for investigating the user perceptions of such facilities and for including in the investigations a range of aspects such as health, maintenance, operation, safety, privacy and inclusion of most vulnerable groups.

Shared sanitation facilities range from public toilets shared by anyone to toilet shared by two families. Each shared toilet can be characterized by its management model, targeted public, ownership, price and other aspects (Mazeau & Ramsay, 2011; WSUP, 2011). Understanding the reasons for implementing and using these different models of facilities is a first step towards understanding the role played by shared facilities in the provision of adequate urban sanitation.

The paper, through a case study in Ashaiman, aims to improve the understanding of sanitation provision in a rapidly changing environment. Ashaiman is typical of a town where infrastructure and sanitation cannot keep pace with urbanization. This paper discusses first the range of shared facilities at a global level, and describes the specificity of sanitation coverage in urban Ghana. Then, the paper presents the range of toilets available in Ashaiman and considers links that exist between urban planning and sanitation. It concludes by underlying the necessity of reconsidering some of the shared facilities in terms of funding and a better understanding of the user's acceptability.

The Range of Facilities

Before implementing sanitation provisions in urban areas, practitioners often consider that they must choose between large public or communal blocks and private toilets for households ignoring intermediate options. And despite the non-recognition of shared facilities as improved sanitation by the JMP, many implementers, NGOs and municipality develop sanitation blocks and public toilets. There are many reasons for developing such toilet blocks, including reducing open defecation in high density areas, but also the implementing organisations can claim credit for introducing very visible new facilities.

Affordability, availability of space and people's tenure (Tayler et al., 2003; Mara & Alabaster, 2008) are some of the main factors that can justify the use of shared facilities because no other options seem to be applicable. On the other hand, the daily use of communal pay as you use latrines tend to be more costly than the comparative cost of owning an individual toilet (Tayler et al., 2003), therefore alternative solutions may be considered. The appreciation of affordability, cleanliness, access or ideal number of users will depend on the kind of shared toilet facility used. There is then a need to disaggregate the so called "shared sanitation category", cf. Table 1.

TYPE OF FACILITIES	DEFINITION
Household toilet	Toilet serving a single household.
Neighbour shared toilet	Toilet shared by several surrounding households and run following an informal agreement made between the households themselves or by a common landlord.
Community toilet	Toilet often located in a residential area serving numerous households implemented and managed by community based organisation or private business.
Public toilet	Toilet often located near markets and stations. Public facilities can be privately or publicly owned and/or managed.

Table 1: Definition of range of shared toilets (adapted from (Schaub-Jones et al. 2006; Mazeau & Reed, 2010)

The boundaries between most of the model are not clear cut; even household toilet can be used by neighbours or more than one household in same house (WSUP, 2011). Acknowledging the different types of facilities, Schaub-Jones suggests implementers to reconsider their views on shared toilets, showing their potential for being a transitional stage. Several phases can then be identified, going from public and communal toilets to facilities shared amongst a group of neighbours and then to individual facilities (Schaub-Jones et al., 2006).

Ghana and Shared Facilities

The strategy for providing sanitation facilities in Ghana has been historically based on the implementation of public toilets (Ayee & Crook, 2003) and the urbanization pattern has reinforced the prevalence of this model of facilities. But this model is not recognized at global level. By consequences, facing international standardized statistics, Ghana is poorly rank by the JMP in term of sanitation coverage (WHO & UNICEF, 2010). On the other hand, the MICS (Multiple Indicator

Cluster Survey) survey, which also uses technology criteria, encompasses shared facilities in the improved sanitation category. Thus in 2006 according to the MICS, 80 % of the urban population of Ghana has access to improved sanitation.

Several sanitation stakeholders call for clear decision in terms of definition in order to better decide sanitation strategy (WSMP, 2008). Many countries have national sanitation policies (e.g. in Malawi (GoM, 2008)) that have different definitions of what is improved sanitation compared to the JMP definition, often with higher standards than the JMP definition. The challenge for the sanitation sector in Ghana is to arrive at a definition and criteria for improved sanitation that may include certain types of shared sanitation and physical design characteristics. This will form the basis for sector targets and funding for 2015 and beyond, after the current MDG (Millennium development Goals) target period.

Case Study: Ashaiman

This paper does not challenge the importance of the technological dimension but focuses on the user interface, and on the difficulties for urban dwellers to access a sanitation facility from a financial, social, and geographical perspective. User perspectives are often not adequately taken into consideration when new shared sanitation facilities are being developed. As seen above, sanitation in the high density and unplanned urban areas is in most cases provided through shared services. The diversity of these services depends on a group of local factors. Therefore the paper makes the choice to focus on one city in Ghana: Ashaiman.

In May 2011, a research team observed several areas of Ashaiman, conducted six focus groups, facilitated three participatory mapping and conducted 20 households' questionnaires and interviews with sanitation providers. Ashaiman is a city of approximately 200 000 inhabitants. Population increased massively during the last 40 years (20 000 in 1970). The area that was initially a satellite settlement of Tema became an autonomous municipal assembly in 2008, known as AshMA (Ashaiman Municipal Assembly).

A month of observations in Ashaiman confirms that the city is characterized both by a diversity of population with origins from more than 50 ethnics groups and by heterogeneity in term of urban development (settlement's structures, quality of housing, and level of services). Due to the interconnection of traditional and formal power, land ownership is a sensitive issue (Gough & Yankson, 2000), new land is expensive. Therefore, the core areas of Ashaiman are dense and land availability is very limited which poses a lot of challenge for sanitation services delivery.

Sanitation Models in Ashaiman

The Figure 1 shows the spectrum of type of sanitation facilities available for dwellers living in high density areas of Ashaiman, bearing in mind that there is no clear cut between the models.

Categories	Household toilet	Landlord - Tenants toilet	Private shared toilet	Commercial toilet	Public (AshMA) toilet
Location	House	Compound house	Neighbourhood	Residential and commercial areas	Residential and commercial areas
Targeted clients	Household members	Compound members	Neighbours	Any dwellers	Any dwellers
Price per use	/	Part of the rent	10 to 30 pesewas	15 to 35 pesewas	10 pesewas
Ownership	Household or landlord	Landlord	Individual	Individual	AshMA
Management	Household	Compound members	Individual (informal)	Hired attendant	Contracted

Figure 1: Spectrum of model of shared sanitation facilities in Ashaiman

The management of **public toilets** in Ashaiman (called AshMA toilets) has historically suffered from unplanned modifications and disruptions whenever there is a change in the political leadership. The nature of the change is characterised by political activists forcefully taking over the management of public toilets because their management has been seen as a lucrative. This has obviously had effects on the sustainable and financial management issues of the facilities. The recent seizure of toilets occurred in 2009 and currently there is no evidence of any agreement between the operators and the owners of the toilets (AshMA). Before the forceful take-over in 2009, the AshMA had met with the previous operators and had agreed on revenues to be paid to AshMA from the operation of the facilities. However, since the seizure, the new operators have not made any payments. There are 24 public toilets in the town and the price per use had recently gone up from 5 to 10 pesewas.

The **commercial toilets**, as well as the public ones are supposed to serve customers only in commercial areas and public spaces such as stations (GoG, 2010). Understanding the lack of household toilets, private entrepreneurs driven by financial and sometimes philanthropic interests develop commercial toilets in many residential areas. These toilets are often made of 8 to 20 cubicles and propose different levels of services (shower, water supply) and comfort (fan, toilet paper...). Due to the different level of comfort but also their locations and the motivations of the owner, the price per use of these toilets vary in Ashaiman from 10 to 35 pesewas in Ashaiman. The Ashaiman municipality welcomes the development of commercial toilets also in residential areas, as it increases the availability of sanitation facilities in some neighbourhoods. According to the Ashaiman municipal assembly, there are 144 formalized commercial toilets in the town.

Similarly to the commercial toilet, the **private shared** ones are built by private initiative, but they usually do not offer more than one or two cubicles. Individuals, who build them, invest in a toilet to serve their family then receive some extra income by selling the service to their neighbours. This system is widespread in the middle density area of Ashaiman where land availability is less of an issue. Such commercialisation is informal and mechanisms of sharing are not clearly understood as arrangements between owners and users may vary from one situation to another.

In the most densely populated area of Ashaiman, there are fewer **toilets inside compound house** than a few years ago (Bertrand, 2002). This option is of two types: one that is used by only one household (the landlord's) and the other that is used by more than one household. Providing household sanitation is in the hands of the landlords and influenced by the landlord - tenant relationship. Ban of the pan latrines, the conversion of old toilets to new renting space and the absence of sewerage system have pushed the toilet out of the familial area. In high density areas, household toilets are not prevalent, and household members have to deal with sanitation issues in the collective space relying on the models presented above.

A Typology Influenced by the Urbanization Pattern

Different segments of the municipality characterised by dissimilar urban pattern are served by diverse combination of the models. Comparing two areas of Ashaiman distant of only a kilometre allows us to understand this heterogeneity.

Kaketo is located in one of the poorest area of Ashaiman. Kaketo had been developed without any urban planning, streets have an irregular pattern model and infrastructures provisions are very low, quality and pattern of housing is very heterogeneous. Conversely, Asensu is characterised by a grid plan model of urbanization. All housing is done in compound houses with a high density of populations. Looking at sanitation provision in these two areas, Kaketo is mostly served by public toilets and private shared facilities. In Asensu where available land is limited and expensive, sanitation facilities are fewer and mostly own by local entrepreneurs (commercial toilets). Individuals do not seem to have resources to build a facility for their own use or for an informal business. This single example illustrates both the heterogeneity of Ashaiman and the importance of the urban patterns. Similar observations are found in Uganda where the authors state that the "sanitation is spatially defined by nature of urban development" (Letema et al., 2010, p. 156).

Enabling More Investment in Urban Sanitation

Despite the number of shared sanitation models, the municipality and the inhabitants remain concerned about the sanitary conditions of Ashaiman. Open defecation and use of polyethylene bags are widespread practices. Participatory mapping and interviews confirm that many individuals who do not have household toilet do not also use any of the shared facilities. Following focus group discussions and interviews with dwellers, some individual explain that such facilities remain unsafe, too expensive, inaccessible or uncomfortable. Further work is on-going to understand usages and perceptions of shared facilities by the different groups of dwellers. This corresponds to the second part of this research which the paper is drawn from. The relative acceptability of shared sanitation amongst users will be assessed against key agreed determinants, using participatory techniques.

Another explanation relates to the lack of investment in the construction and management of new facilities. During the last decade, the number of new facilities does not seem to have kept pace with the large population increases in Ashaiman. The service providers, both private and public, do not or cannot meet the potential demand. Land availability and land ownership together with political lobbying and in some cases lack of initial capital explain this gap between supply and demand. If there was clear policy guidance that certain types of shared sanitation, that meet agreed criteria, are acceptable; it would give implementers and key stakeholders more confidence and incentives to invest in acceptable forms of shared sanitation with good design features. Such minimum design features could relate to access, space, and ease of cleaning etc., depending on the size of the shared facility. Individual household sanitation is not feasible in many areas such as Ashaiman, so we need to carefully examine alternative shared sanitation models.

Lessons Learnt

This paper is drawn from a larger study which aims to understand the approach of both providers and urban dwellers concerning shared sanitation facilities. At this stage of the research, a set of lessons can already be drawn:

- Careful judgements need to be made about the acceptability of shared sanitation facilities; depending on the characteristics of the different shared sanitation models being used.
- The particularity of each shared facility model may answer constraints of some neighbourhood given the nature of their urban development.
- The town or the slum cannot be seen as a homogeneous unit and the urban planners need to better apprehend the heterogeneity of the city.
- In determining acceptable forms of sanitation in the future, we need a better understanding of the users' perceptions of relative acceptability for different sanitation models, including shared sanitation alternatives.
- If we find that some forms of shared sanitation do have reasonably good levels of acceptability amongst users, consideration should be given to providing clear policy guidance that certain types of shared sanitation that meet agreed criteria, are acceptable. This would give implementers and key stakeholders more confidence and incentives to invest in acceptable forms of shared sanitation with good design features. More investment in effective shared sanitation facilities together with appropriate management arrangements can in turn lead to better sanitation services and excreta disposal, which in turn can contribute to better health and well-being outcomes for urban dwellers living in high density areas with limited services.

Conclusion

Shared facilities are still relevant given the present challenges in Ashaiman. However there is the urgent need to look at how to improve the services that the users experience. There is the need for greater stakeholders' dialogue to understand the needs and perceptions of users, to improve sanitation and generate interest for local investment in sanitation. Future policy guidance can increase incentives for implementers to invest in specific types of shared sanitation that meet certain criteria, provided there is clear evidence of reasonably good levels of acceptability amongst users.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Biofil Toilet Digester: An Innovative On-Site Treatment

V. Mema & Evelyn Gyampo

Abstract

National government is committed to eliminating the backlog in basic sanitation services and to progressively improve levels of service over time in line with the original aims of the Reconstruction and Development Programme in 1994 (City of Cape Town 2008). Although this is the most important policy priority, with this right comes a responsibility to service providers to provide appropriate and acceptable sanitation systems. A range of toilet technology types are currently used in South Africa, including: buckets, chemical toilets, simple pit toilets, ventilated improved pit toilets etc. High service levels, such as flush toilets are viewed as burdensome and as having costly O&M requirements.

The biofil toilet digester has been applied to replace septic tanks for water-closet systems, correct existing failed septic tanks and replaced non-flush/micro-flush systems in properties where water supply in an issues. When the digester is attached to the collector, the water can be collected, treated and reused or the water directed into the French-drain where the liquid percolates slowly into the ground. The technology can also be incorporated into superstructures made to sit on VIP's or other onsite treatment options making biofil toilet digester a highly flexible system. A single unit of biofil system is able to support a family of eight people without being overstressed.

Introduction

Water-, sanitation- and hygiene-related diseases are a huge burden in developing countries. It is estimated that 88% of diarrhoeal disease is caused by unsafe water supply, and inadequate sanitation and hygiene (WHO 2004c). The Millennium Development Goal 7 emphasizes on the need for countries to strive for environmental sustainability and to "halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation" (Abuom 2004). In the drive to achieve this goal the primary focus of many country programs is to facilitate infrastructure provision for safe household and school sanitation. Under the emerging approaches to sustainable development, preferred sanitation systems must;

- Be ecologically friendly
- Be affordable and safe
- Improve health by minimizing the introduction of pathogens from human excrements into the water cycle
- Promote safe recovery and use of nutrients, organics, trace elements, water and energy

- Preserve soil fertility and improve agricultural productivity
- Conserve resources

The Biofil Toilet Digester is a simple compact innovative on-site human waste treatment system that uniquely combines the benefits of the flush toilet system and those of the composting toilets and eliminates the disadvantages and drawbacks of both systems. The technology works by providing an enclosed environment for the natural process of aerobic decomposition of human excreta including cleaning material. The digester is constructed as a living filter where oxygen inflow into the digester allows living organisms (Bacteria, fungi, macro-organisms) within the digester to degrade solids at the top layer aerobically and liquids filter into the lower layers before the liquids are directed out of digester through a pipe into constructed drain field or collected/treated for reuse (Figure 1). This is the same type of environment on forest floors which decomposes wildlife droppings and converts them into valuable nutrients for vegetation. Decomposition of organic materials is facilitated by the introduction of macro-organisms such as earthworms which feed on materials. On the other hand, excess water is drained rapidly through the filter medium to prevent the slowdown of the biological process therefore eliminating sludge build-up.

Figure 1: An exposed biofil digester to show the solids where living organisms are meant to feed and digest the solid matter (Photograph by Biofil)**.**

Motivation

Fully waterborne sanitation (where wastewater is directed through underground pipes to sewage depots distances away) is only practically and economically possible for homes located in towns and cities. High maintenance and running costs has rendered waterborne option inappropriate for many communities in developing countries including South Africa. Health and environmental hazards have resulted from blockages and sewage overflow as well as inability of municipal WWTW to handle high volumes of wastewater inflow. High costs of construction materials and services that are necessary for the construction of appropriate WWTW and proper operation and maintenance is considered to be the main cause of these blockages as most municipalities and communities are unable to afford due to limited funding and low economic status of communities (Mema 2010). Badly managed sewage ends up in water bodies, often contaminating drinking water and rendering others unproductive.

Onsite sewage treatment systems are the basic level of service in most rural and urban periphery areas as they offer the only affordable technical solution for improved waste disposal in many parts of the developing world. However, despite the seemingly low technology of these systems, failure is common and can lead to significant adverse impacts.On-site sanitation systems often sunk deep into the ground causes groundwater contamination.

Biofil digester is by far the only technology that provides popularly accepted flush toilets while relieving the municipalities of high volumes of sludge disposal with simple design attached against the wall of the house. It is constructed as a compact concrete living box within which layers of filter medium are arranged to foster the rapid separation of liquids and solid components of the wastewater. The solid waste in the flush liquid is treated onsite with the introduction of macro-organisms (earthworms) while the liquids are either directed into a French-drain or collected for reuse.

Objectives

This paper purposes to demonstrate the benefits of biofil digester as an alternative to waterborne toilet systems currently adopted in urban areas. Its design, operation and maintenance, and economic benefits to both the user and the service provider are discussed.

Technology Outline

The key difference between the Biofil digester and the existing traditional onsite systems such as the septic tank is the rapid drainage of liquids from the waste product. This allows the system to operate more efficiently under aerobic conditions, eliminating the foul smells associated with anaerobic decomposition of the traditional systems (Anno 2009). There is no sludge build-up in the Biofil Digester thus eliminating the need for the excavation of the ground to install large tanks to deposit wastewater and sludge or sludge dislodging. The space required to install the biofil digester is less than half the size of the space required to install a traditional digester while excavation is almost unnecessary especially if the effluent drainage is allowed to filter into the ground where the soil is sandy.

Introduction of macro-organisms into the digester allows a much faster and more efficient break down of organic solids deposits in the biofil toilet digester than it is the case with traditional systems. Since the design inside the digester allows speedy separation of effluent from solids the environment is able to allow macro organisms to survive while the closed but aerated nature of the digester maintains the temperature and flow of oxygen inside the digester.

Technology Design

The Biofil Toilet Digester (vault) is built with panels (slabs) manufactured with high strength reinforced concrete. All panels are reinforced with 4.0mm diameter deformed wire in mat form. The wire mats are positioned in the panels with 6.0mm diameter iron rods to conform to specifications as laid down in the code of practice. All panels currently are 3.0cm thick. The vault can also be built out of bricks or concrete blocks. The typical dimensions of the digester are 0.61m high, 0.61m wide and 1.83m long.

The internal arrangement within the digester is designed to separate the liquids in the wastewater from the solid components immediately and to keep the liquids free from suspended solids. Fines (Porous) concrete made out of cement, stone aggregates and water and shade cloth make up the inner filtration unit. A collection basket is placed inside the digester to contain the solid components of the waste in one place to make room for decomposing organism movement (Figure

2). Composting materials like shredded coconut husk, lawn clippings, wood shavings, dried leaves etc. are introduced into the composting chamber to simulate a natural habitat for the composting organisms in the absence of the worm cast (compost).

Figure 2: Red worms used as decomposing organism of the solid material in the biofil digester
(Photograph by Biofil)

Inoculation of macro-invertebrates (earthworms) into the digester as shown in figure … provides stabilisation and volume reduction of solids. Their movements in and out of the solid material ensure aeration of the contents therefore, creating a favourable environment for them to survive. Air gaps within the digester allow for positive suction of air at all times facilitating aerobic degradation of the waste-end products. In the presence of oxygen and appropriate aerobic micro-organisms, biodegradable material is converted to CO_2, water and more cell mass for the participating micro-organisms. Therefore at a steady state of operation the system is odourless.

Operation

The digester is useable in a wide variety of contexts. Macro-organisms inside the digester are able to decompose anything organic; including food scraps, egg shells, paper and cardboard, lawn clippings and even clothes from natural fibres.

Operation of the toilet which is usually done inside the house is the same as the operation of a normal flush toilet. The difference come only after the toilet flush wherein the flush is directed into the biofil digester just on the outside of the house and is usually designed to lean against the wall of the house. As the flush material reaches the digester it is collected inside a framed bucket which is surrounded by macro-organisms usually earthworms. The liquids are separated from the solids and are directed into the bottom of the digester. However, to avoid movement of solids with the liquids to the bottom of the digester the liquids are filtered through the sieve and from the sieve through porcelain concrete. The solids which are left behind immediately become feed for the earthworms. The liquids on the other hand are redirected from the digester to either into a collection pond where they can be made available for reuse or directed into the French-drain via a PVC pipe.

A standard size of the digester which is usually 0.61m high, 061m wide and 1.83m long and can accommodate a family of 8 people without being over worked. There is almost no maintenance required especially if the digester is used according to specifications provided by the manufacturer. Figure 3 below shows the Biofil digester installed in a household.

Figure 3: A biofil digester installed in a household (Photograph by Biofil)

To prevent groundwater contamination the digester is installed above ground, half-buried in the ground or below ground (600cm depth) to increase the depth of the unsaturated zone where attenuation of contaminants is most effective.

Summary of Benefits for Using the Biofil Toilet Digester

Table 2: Key benefits of using the biofil digester

Area of benefit	Benefit/s
Economic benefits	Long-term savings as a result of eliminated need for dislodging.
	Near zero operating cost
	Appropriate for any soil conditions (clayey) / solid rock sites /high water table
	Minimum land-take
Environmental Health Impacts	They eliminate the possibility of costly site remediation and clean-up
	Suitable for all soil types – no leakage of nutrient to ground water
	No potential discharge of effluent into water courses
	Health impact mitigation
	No inappropriate disposal of sludge
Ecological impact mitigation	The system eliminates water and air contamination.
	It has a potential of reducing greenhouse gases emissions through the avoidance methane emissions directly into the atmosphere.
	Biologically filtered effluent does not trigger prolific plant growth (e.g. algal blooms).
Health Benefits-Disease prevention	No human contact with excreta.
	No odours or sludge to attract flies
	Impossible for rodents to burrow into digester
Replicability	Fabricated from local materials
	Rely entirely on local manufacturers
	Do not require heavy equipment
	Easy to build /Quick and easy to install
	Low / ease of maintenance
Ease of Use and Maintenance	Meet the specific needs of all user groups
	Provides privacy and comfortability
	User education ensures end-users know system's principles of operation and maintenance

Impact on Service Provision

There is great demand in South Africa for safe, reliable, affordable sanitation systems. Flush toilet systems are usually preferred over other systems as they provide acceptable convenience to the user. If it was possible, flush toilets would be supplied in every location across South Africa; however, water supplies and wastewater disposal options are limited. As a result of this situation, supply of sanitation services is usually achieved through the provision of aerobic composting toilets as they offer a more viable solution. Unfortunately, composting toilets have earned a rather dubious reputation, especially in rural South Africa where these systems are mostly provided, with at least as many reported failures as successes (Still, 2003).

Due to environmental concerns, careful selection of a flush toilet system is required before this service is implemented in any community. There are certain standards that should be considered if a flush toilet system is to be considered for application in a certain environment. According to Brikké and Bredero (2003) these standards must include Technical, Institutional, Environmental and Community factors. The ability of the Biofil toilet digester to incorporate the highly accepted flush toilet while eliminating sludge disposal and encouraging onsite biological treatment of sludge and reuse of wastewater in food production gives this technology an ability not only to address sanitation needs but also food security among communities. Elimination of sludge disposal into municipal treatment works relieves the municipality of high wastewater treatment and maintenance costs. The biofil toilet digester has been applied to replace septic tanks for water-closet system; correct existing failed septic tanks and replaced non-flush/micro-flush systems in properties where water supply is an issue.

Conclusion

The technology for biofil digester construction is simple and easy to replicate. The digester has been designed with environmental, sanitation and health considerations. Replication of the Biofil Toilet System in schools and communities will reinforce the service provider's sanitation and environmental commitment in the eyes of intervention schools/communities. Cesspit emptying and the general indiscriminate disposal in water bodies by third party waste disposal due to lack of satisfactory operating sewage treatment plant would be avoided.

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Theme: Water

The Human Factor in Urban Water Services in Ghana

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Abstract

It is human beings that run businesses. The Ghana Water Company was set up to add and maximise value for the people of Ghana by providing them potable water for social and healthy well being and economic growth. There must therefore be professionals of all relevant categories who have the knowledge, understanding, ability and freedom to choose from alternatives to be able to deliver this service on a continuously improving basis. This paper explores this human factor in the water supply delivery in Ghana and spells out its importance and how the resource should be deployed to yield the desired outcome.

Introduction

Businesses, institutions, organisations are set up to fulfil a need. The Ghana Water Company was established to provide potable water for use by people living in Ghana, whilst the Community Water and Sanitation Agency was set up to facilitate the provision of potable water by district assemblies to small towns and rural communities. These were set up by the government of Ghana to add value to the lives of its citizens and others living in Ghana. Human beings have therefore been employed to get things done. The staff employed should therefore have the knowledge, understanding, ability and freedom to choose from alternatives to do good business. The staff must know what those alternatives are, their worth and the consequences of a chosen alternative, with the ultimate aim of adding value to the business. These staff are of various disciplines, (engineers, accountants, chemists, operators, labourers), experiences, qualifications, interests, skills and goals, all working as a team to provide the expected services. Even though other factors of production such as materials and money are needed to provide the service, the human resource is the most important since human beings apply the other resources. The effectiveness and efficiency with which those other resources will be utilised greatly depends on the calibre of the applicants-the human resource.

Knowledge of Staff

Water supply is basically an engineering discipline which involves a number of professional disciplines. On the technical side, these include engineers (civil, electrical, mechanical and geodetic, computer specialist, etc), chemists/bacteriologists and their technicians. However, the whole industry requires the support of other professions including marketers, accountants, administrators, auditors, and their clerks.

For public water supply, large metropolitan and urban centres make use of surface water sources whilst smaller communities, private businesses and institutions normally use underground sources. The requirements of a public water supply demand that the water shall:

1. Contain no disease causing organisms.
2. Be sparkling clear and colourless.
3. Be good tasting, free from odours and preferably cool.
4. Be reasonably soft.
5. Neither be scale forming nor corrosive.
6. Be free from objectionable gas, such as hydrogen sulphide and objectionable minerals, such as iron and manganese.
7. Be plentiful and produced at a low cost.

The water therefore has to be treated to meet those requirements. The principal methods used are: Aeration, Coagulation/Flocculation, Sedimentation, Filtration, Disinfection, Corrosion Protection and Desalination. It must be pointed out that depending on the nature of the raw water a combination of some of these methods is used for treatment so as to obtain the desired results. The treated water obtained from the waterworks has to be sent to the consumer at the place of need. This could be their homes, commercial houses, offices, hotels, institutions and factories. The water is delivered to the consumer through a series of pipelines either by pumping or by gravity flow. The water could also be stored in service reservoirs to either balance the flow in the distribution network or for later use.

There is a cost involved in the supply of water which has to be recovered adequately to ensure sustainable service delivery. These costs include:

1. The raw water source
2. The civil structures of the treatment plant
3. Mechanical and electrical equipment
4. Pipes and accessories for transmission and distribution of water
5. Service reservoirs
6. Operation and maintenance
7. Labour
8. Unaccounted for costs
9. Replacement of facilities

People employed in the water supply industry therefore must have the requisite knowledge and skills to conduct the business and all its processes as outlined above.

Continuous Development of Staff

There is a basic qualification requirement to be met before people can be engaged to play various roles in the water supply industry. Just like any other growing industry, new developments take place in the water supply industry. Better, faster and modern methods are evolved to reduce costs and provide a more efficient quality service to the consumer. The staff should therefore be given regular and periodic training and retraining, either on or off the job, to improve on their skills and work methods for increased productivity and efficient deployment of the other resources of the industry. In Ghana there is a clamour for off-the-job training especially abroad because of the ensuing personal economic benefits arising from per diem, etc. Sometimes, unsuitable staffs rather manage to be included in such training courses for which no returns are gained to the business on their return. Such staffs pride themselves for being abroad. Staff on on-the-job training sometimes do not benefit from experienced staff that are reluctant to impart knowledge. Willing staff who impart knowledge to other workers should be adequately rewarded.

Resource Deployment

The utilization of every natural resource follows a laid down procedure. If these procedures are not followed, the full benefits of the resource or its subsequent benefits are not realised. For example, if a water supply system is designed to produce a given quantity and quality of water, it must be constructed and operated according to the design. The location and sizing of the treatment plant components, the pumping regimes, the sizing of the electro-mechanical equipment, the amount and timing of chemical application, the material, sizing and laying of transmission and distribution pipelines and storage tanks and the frequency of monitoring the performance of the treatment plant and pipe network, all have to comply with specifications. There are laid down procedures for the operation and maintenance of the components of the water supply systems. The same pertains to the equipment and tools used in the industry. It is not only the use of materials and money that these procedures exist, but are also required for the staffs that deploy these other resources. Time and duration of work, work methods, procedures and duration, rewards and sanctions, facilities application, etc are also spelt out for compliance by the staffs. Enforcement of standards, rules and regulations is therefore absolutely necessary and mandatory for the achievement of the objectives of the water supply business.

In my opinion, incompetent staffs wrongly apply resources resulting in wastage, losses and malfunction of facilities, but explain their inefficiency as political interference. Examples include extensions of utility services beyond service areas, wrong sizing or inadequate provision of facilities, inflation of prices of materials and services, etc.

Impact of Other Services

Obviously, water supply services are provided on land, and are located with respect to other services needed for the convenience of people. These include buildings, roads, bridges, railways, telephone, electricity, waste disposal, etc. For example, a power source is needed to run a water treatment plant, access to the plant is made possible by road, and telephone provides the other means of access or communication to the waterworks. Pipelines are laid in the ground and pass along the natural topography which may be undulating with streams or rivers and bushes as well as all the other structures on the ground. This therefore requires proper planning and coordination of the provision of all facilities on the land. The use of the land has to be properly planned and implemented in a well coordinated manner involving all relevant agencies.

Experience shows that planning and provision of infrastructure in Ghana is haphazard and no government has been able to coordinate effectively for smooth implementation and maximum realisation of the benefits expected from such investments. The building of individual empires by ministries, departments and agencies has to stop. Why should we at this age of our development grow by trial and error when we have the developed world to copy from? Cost of infrastructure provision is unnecessarily expensive when compensation has to be paid to undisciplined public who erect structures on lee ways. Ghana seems to have all the good laws for a peaceful and perfect livelihood, but lack of timely enforcement is the bane of our woes. We are quick to explain away our reasons for lack of enforcement as corruption, political interference and an inefficient judicial system.

Lessons for Ghana

When we are unable to fully and effectively deploy the right quality and numbers of human resources in the business of water supply, we encounter the problems of poor services that prevail. The staff need to be oriented about the appropriate standards of moral conduct and a good understanding of their purpose in life and work. Proper recruitment and selection of staff also results in what Wriston said "I believe the only game in town is the personnel game. My theory is that if you have the right person in the right place, you do not have to do anything else. If you have the wrong person in the job, there is not a management system known to man that can save you". Therefore, political leanings, nepotism, "old boyism", sexual favours, tribalism, bribery and corruption, favouritism, religiousness etc, should not be applied in the recruitment and selection of staff. Politicians are myopic in thinking and believing that fielding their cronies in management positions is rewarding. Wise politicians will field competent staff whose performance will realise the objectives of the business for the benefit of society, thus bringing them the credit and maintenance of political power. All human resource management activities must be performed professionally keeping in mind the ethics of business. The major activities include human resource planning, recruitment and selection, equal employment compliance, job analysis, performance appraisals, compensation and benefits, employee relations, management-labour relations, health and safety, training and development and human resource information systems. It is the lack of professionalism and ethics in the utilisation and treatment of the human resource that creates problems in the work place resulting in low worker productivity, low financial rewards, overstaffing, occupational hazards and accidents, upheavals, shut-downs, removal of chief executive officers, dismissals, incompetence, and conflicts and so on. Guidelines, procedures, and authority limits, rules and regulations must be drawn up and strictly followed and implemented so that discretion is sparingly used. Politicians or other interest groups interfere with staff discipline. It should be noted that transfers of staff is not a disciplinary action but rather a perpetuation of indiscipline. Irrespective of these seeming interferences discipline must be instilled at work places and the "hot-stove" rule is the best guiding principle for instilling discipline because it is fair and just. The "hot-stove" rule is as follows:

1. The hot-stove <u>burns immediately</u>. Disciplinary policies <u>should be administered quickly</u>. There should be no question of cause and effect.
2. The hot-stove <u>gives a warning</u> and so should discipline.

3. The hot-stove <u>consistently burns everyone</u> that touches it. Discipline should be consistent.

4. The hot-stove burns everyone in the same manner regardless of who they are. Discipline must be impartial. People are disciplined for what they have done and not because of who they are.

Recommendations and Conclusions

Efficient operation and maintenance of the water supply industry will deliver water in adequate pressure and quality to the consumer. This can be achieved by the utilization of competent staff, their efficient deployment of the available resources of the industry, their continuous acquisition and application of knowledge in the business, coordination and cooperation with other utilities and businesses and the instillation of discipline can change things for the better in the water supply sector.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Wet Oxidation of Paper Mill Debarking Water: Improving the Rates of Contaminant Removal

Daniel Adjah Anang

Abstract

Highly concentrated wastewater from a Finnish paper mill was subjected to wet oxidation process. The study assesses the impact of temperature, oxygen partial pressure, catalyst loading and initial chemical oxygen demand concentration on pollutant removal in a wet oxidation process. A study on the process was conducted at 120-180 ^{o}C temperature, 0-10 bar oxygen partial pressure, 0-1 g/L catalyst concentration and 1000-3000 mg/L initial COD. Chemical Oxygen Demand (COD), Lignin/tannin concentration, Total Organic Carbon (TOC), Biochemical Oxygen Demand (BOD) and pH were measured and analyzed. A Platinum (1-wt %) on activated catalyst was used for the work. It was observed that increment in temperature (120-180 ^{o}C), oxygen partial pressure (0-10 bar) and catalyst concentration (0-1 g/L) improved the rate of contaminates reduction from the wastewater during the oxidation process. Lower initial COD concentration improved the contaminants removal. The optimum conditions were at 180 ^{o}C temperature, 10 bar oxygen pressure, 1 g/L catalyst concentration and 3000 mg/L initial COD. At these conditions, 74% of COD, 97% of lignin/tannin, 54% of TOC and 90% of color were removed from the wastewater.

Introduction

Effluents from pulp and paper industries are a major worry since large volumes of wastewater are generated per each metric ton of paper produced [1]. Wastewater from paper mill contains toxic, hazardous and non-biodegradable organic chemicals derived from the different stages of paper making [2]. Many traditional wastewater treatment methods are already in use but they are not able to effectively deal with the toxic and or non-biodegradable nature of the organics in the water.

Wet oxidation (WO), an advanced oxidation technique, which takes place at higher temperatures and pressures, governed by the generation of active species such as hydroxyl radical is known to have a great potential for the treatment of effluent containing high content of organic matter (chemical oxygen demand (COD) 10-100 g/l), or for toxic contaminants for which direct biological purification is unfeasible [3]. The WO process can significantly be improved by the use of catalyst as well as operating at optimum conditions of temperature and pressure. Therefore, this work investigates the effects of catalyst, increment in oxygen partial pressure and temperature on the rates of contaminants reduction during WO process.

Materials and Methods

The feed for this study was a concentrated dark brown debarking wastewater obtained from a Finnish paper mill. A Platinum (1-wt %) on activated carbon catalyst was used for the investigation. The lignin concentration was measured with a photometric method developed by

Hach Company. COD was measured by a closed reflux dichromate method, using a COD reactor (Hach Company, USA) and a spectrophotometer DR/2000 (Hach Company, USA). The biochemical oxygen demand was assessed by standard BOD_5 test. TOC was measured using a Shimadzu 5050 TOC analyzer.

Experimental Procedure

The experiment was performed in a 450 mL high pressure stainless steel batch reactor manufactured by Parr Instrumental Company, U. S. A. 300 mL of the filtered wastewater was loaded into the reactor. When necessary, the catalyst was weighed and added to the wastewater. After the reactor was properly sealed, it was placed in the heating jacket and heated to the required reaction temperature. Oxygen was introduced into the reactor through the gas inlet when the set temperature was attained. The reaction medium was stirred thoroughly by the stirrer. Samples of the wastewater were taken during the experiment. The first sample was taken before the reactor was loaded. This was referred to as sample at t=-30 minutes. The second sample was drawn off immediately after preheating and before the oxygen valves were opened. That was sample at t=0. The rest of the samples were taken at times t=10, 20, 30, 60, 90 and 120 minutes after reaction had started and were analyzed. These analyses included COD, Biochemical oxygen demand (BOD), Total Organic Carbon (TOC), lignin/tannin, color and pH. Biodegradability (BOD/COD) was also determined for the wastewater.

Modelling of the WO System

Creation of General Model

Mathematical expressions were generated to represent the WO process. The general expression of the modeled response using linear model function is given as,

(1)

Where A, B, C, D, and E are the coefficients of the respective input variables which must be generated. Y is the response measured (COD, TOC, lignin/tannin, etc). T, P_{O2}, Cc and COD_{ini} are the temperature, oxygen pressure, catalyst concentration and initial COD concentration used during the WO study. The responses where measured at time t=0, 10, 20, 30, 60, 90 and 120 minutes. An auto-generated Laptop system which uses matlab 7.3.0 (R2006b) software was used to generate the coefficients at various times for various responses. Later, Microsoft Excel was used to model the coefficients at all times.

Discussion of Results

Effect of Increasing Temperature

The effect of increasing temperature from 120 ^oC to 180 ^oC on contaminants removal from the water can be summed up in figure 1.

The pH of debarked wastewater during WO is depicted against time in figure 1. The pHs decreased gradually from neutrality to acidity for all experiments. This may be as a result of toxic organic contaminants being decomposed into organic acids during the process. The rate at which the pollutants decompose depends on the conditions used.

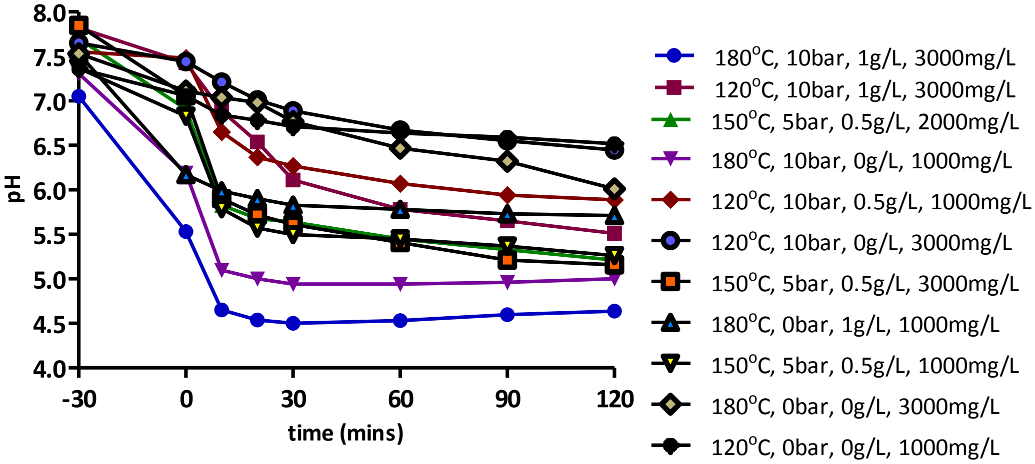

Figure 1: pH reduction against time

From figure 1, it can be observed that higher temperatures reduced pH greatly. Again, there is a sharp decrease in pH during the preheating period. This is because the organic pollutants decompose into organic acids immediately they are exposed to higher temperatures. Higher temperature exposure leads to higher rate of decomposition of organic contaminants.

From the study conducted, it was realized that the decomposition of organic pollutants into organic acids and inorganic minerals occurred at elevated temperatures. Lower temperatures gave least decomposition rates. This is so because oxygen must first diffuse into the liquid phase for WO reaction to occur, its solubility in water is critical since it depends on temperature. The higher the temperature, the more soluble the oxygen becomes in water and the higher the reaction rates. Increase in temperature between 120^{o}C and 180^{o}C improved reduction in COD, TOC, Color and Lignin/tannin concentrations as well as pH observed.

Effect of Increasing Catalyst Concentration

To study the effect of catalyst concentration on contaminants removal from the wastewater, the COD responses of some experiments are presented. Figure 2 shows COD removed (%) with time for four comparable experiments. Results of two of the experiments without catalyst addition, whose conditions are at 120 ^{o}C, 0 bar, 0 g/L, 1000 mg/L and 120 ^{o}C, 10 bar, 0 g/L and 3000mg/L showed closed COD reduction of 10.1 and 13.4% respectively. This means, they did not remove much of the organic pollutants in the wastewater. The other results (cases where catalyst were used) showed higher COD removal with the highest catalyst concentration used giving a COD removal of 38.5%.

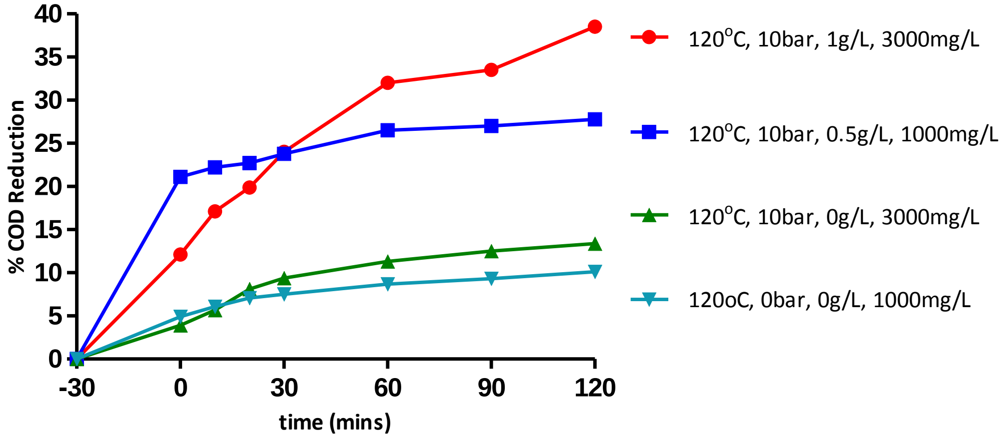

Figure 2: % COD removal against time

Effect of Increasing Oxygen Partial Pressure

Oxygen partial pressure helped in the removal of contaminants from the wastewater. To see how this affects the various outputs, some experimental runs where analyzed. The results are shown in figures 3 and 4 for % COD and % TOC respectively. It can be seen from these pictures that, oxygen partial pressure clearly differentiates the cases giving high TOC and COD reduction to 54% and 75% respectively within 2 hours.

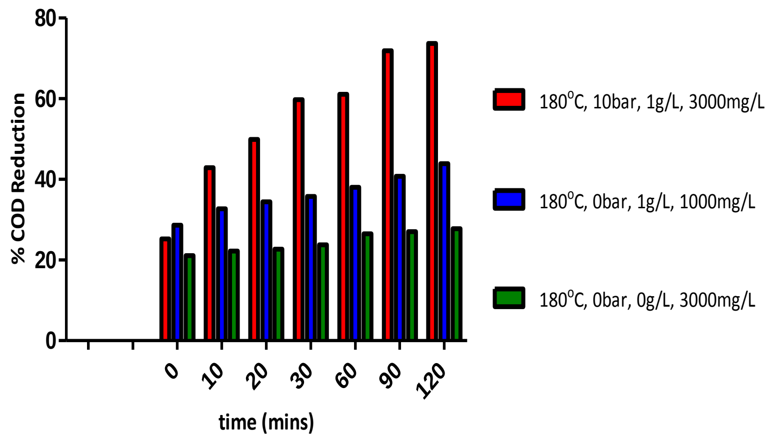

Figure 3: % COD removal against time

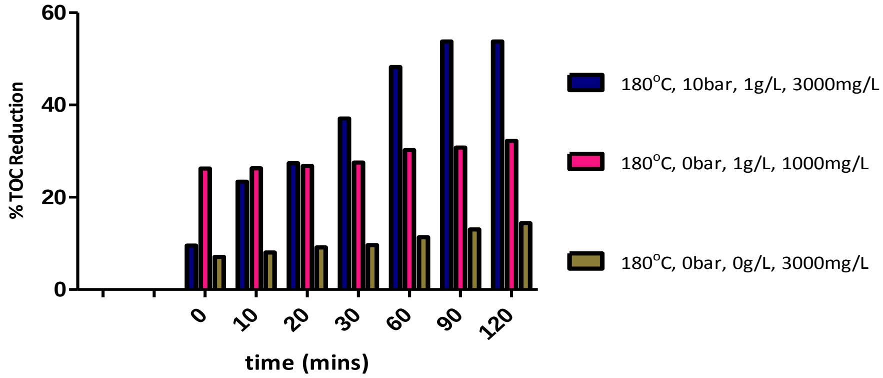

Figure 4: % TOC removal against time

The role of oxygen pressure is to maintain oxygen in the liquid phase. A higher pressure will increase the dissolved oxygen concentration which is important for wet oxidation whiles a lower pressure will liberate oxygen from the liquid phase.

Mathematical Models of the WO System

Using equation (1), the mathematical models describing the WO system for some responses are presented below.

COD(t)$=(-0.0889t^2+16.439t+580.34) + (0.0003t^2-0.0543t-3.2208)\times T + (0.004t^2-0.6729t-10.784)\ P_{O2} + (0.021t^2-4.6953t-225.33)\ Cc + (0.7664\times \exp(-0.0033t))\ C_{COD}$

TOC(t)$=(-0.058t^2+10.813t-106.85) + (0.0003t^2-0.0625t+0.9271)\ T +(0.0023t^2-0.4017t+3.1779)\ P_{O2} + (-8\times 10^{-7}t^5+0.0002t^4-0.0219t^3+0.7964t^2-8.5523t-174.11)\ Cc + (0.2973\times \exp(-0.0009t)) \times C_{COD}$

Forecasting the Behaviour of Input Variables

The models generated were used to predict the behavior of the input variables outside the experimental range. The analyses were done at the best experimental conditions (180°C, 10 bar, 1g/L and 3000mg/L) for 2 hours. The input variables were increased by 5, 10 and 20%. The results showed gradual reduction in the output (COD, TOC, Color, etc). Temperature increment will make the most impact by giving further 21% COD reduction if it is increased by 20%. Oxygen pressure demonstrates very little expected COD reduction after the suppose increment. The higher the oxygen pressure expected to be applied, the more the expected COD gets to zero. This could mean that the 10 bar pressure is enough for the WO system. Expected increment in catalyst concentration will lead to further reduction in the response.

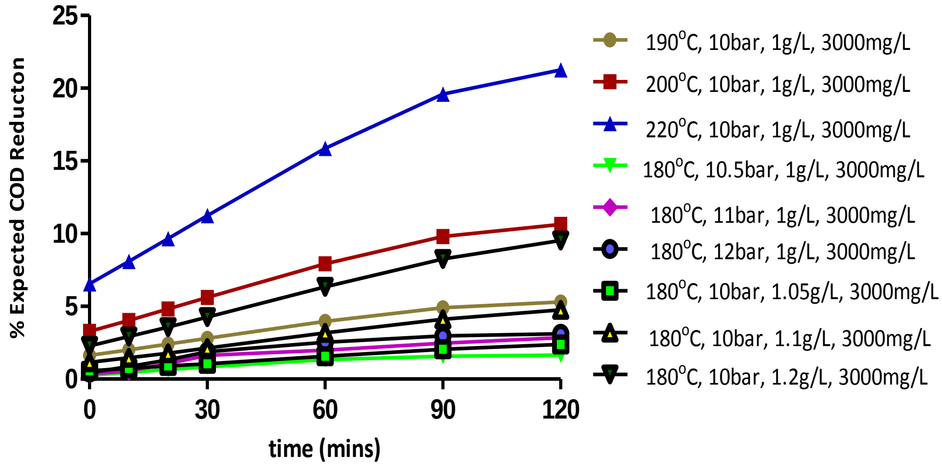

Figure 5: % Expected COD removal at the optimum conditions against time

Lessons

Increasing the input variables (temperature, oxygen pressure and catalyst concentration) during the WO process improved reduction in COD, TOC, Color and Lignin/tannin concentrations as well as pH observed of a debarked wastewater. Moreover, the WO system was modeled mathematically and the model was used in predicting the behavior of input variables outside the experimental range.

Recommendation and Conclusion

Wet oxidation process for the treatment of debarking wastewater can be improved by the use of catalyst and an optimization between temperature and oxygen partial pressure. Appreciable levels of contaminants such as COD, TOC, lignin/tannin, etc were removed from the debarked wastewater at every specific operating condition. Lignin/tannin was greatly removed. Increasing temperature between 120 ^{o}C and 180 ^{o}C favored higher CWO rate, allowing a faster oxidation of contaminants. Oxygen pressure increment between 0 and 10 bar resulted in the improvement of the CWO process. For catalyst concentration, higher oxidation rates of the organics were achieved by increasing catalyst concentration between 0 and 1g/L.

Mathematical models for describing the WO systems were developed and used in forecasting. It is expected that, increasing temperature and catalyst concentration will further aid in contaminants removal while oxygen pressure increment will have little effect.

Ageing of the catalyst, which was not taken into consideration, should be investigated in the future.

Acknowledgement

I sincerely wish to express my profound appreciation to Lappeenranta University of Technology for providing all the needed financial and material assistance for this research. Special thanks go to Professor Juha Kallas (now retired) for supervising this work.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Quality Drinking Water for Rural Communities: Technology Options

Edward Antwi, Edem Cudjoe Bensah, Julius Cudjoe Ahiekpor, Richard Arthur & Elijah Boadu

Abstract
Availability of water is very crucial for sustaining life. In Ghana, many rural communities and some urban dwellers depend so much on underground water to meet their basic water needs. Just as water is very important, the quality is equally important. Some wells in Ghana are prone to high levels of infection and contamination by heavy metal contaminants due to the poor management of waste, industrial activities, floods and natural causes such as rock formation. This paper looks at the treatment options of infected and contaminated wells in Ghana as a way of ensuring the provision of quality water for our people.

Introduction
Ghana's Water Situation
Surface water bodies dominate Ghana's water resources of which the Volta River is the largest, draining nearly 70% of the country. Aside this, other surface water bodies including major rivers like the Ankobra, Pra, Densu, Birim drain the remaining 30% [1]. Underground water resources have been associated with three major geological formations. The consolidated sedimentary and the crystalline igneous and metamorphic geological formation constitutes about 45% and 54% respectively while the mesozoic and cenozoic constitute just about 1% [1]. Put together, Ghana's total actual renewable water resources stands at about 53.2 km^3/year [2].

Portable water supplies to urban areas are mainly as a result of major impoundments in and around these major cities. For instance the Accra and Tema metropolis have been served by two major impoundments at Weija and Kpong. Residents of Kumasi on the other hand have been served with water from the Owabi and Barekese impoundments [3]. Population explosion in urban areas has placed undue pressure on these water supplies managed by the Ghana Water Company Limited. More often than not residents experience major disruption in the flow of water thus affecting their livelihood.

The water needs of people in rural areas have to some extent been catered for by the Community Water and Sanitation Agency (CWSA) under the National Community Water Supply Program (NCWSP). Over 95% of the water needs under this programme has been met with underground water resources either in the form of stand-alone wells or small isolated mini-supply for a small community [4]. In spite of these advances and programmes in place to make water accessible to the general population, many individuals still lack access to portable water. The problem has further been exacerbated by the rampant disruption in supply resulting in women and children queuing or walking long distances in search of water. Individuals in both urban and rural areas who live in the three main geological areas tend to sink their own wells to enjoy uninterrupted supply of water. Though good, legitimate concerns of the quality of the underground water have been raised, in that natural and environmental conditions tend to affect the quality of the water.

Sources of Underground Water Contamination

Water they say is life. In as much as this is true it is equally true that bad/unhygienic water leads to diseases which sometimes results in death. High quality water is thus needed. According to WHO [5] environmental factors such as unsafe drinking water among others is responsible for almost 24% of all diseases worldwide and 80% in developing countries. The main cause of diarrhoea the leading cause of illness, death and disability adjusted life years (DALY), accounting for nearly 1. 7 million deaths annually is caused mainly by lack of access to good drinking water, poor sanitation and unhygienic conditions [5]. In addition, 94% of all diarrhoea cases are attributable to unsafe drinking water, poor sanitation and hygiene [6]. Since water plays a very important role in both good sanitation and hygienic conditions, any effort to provide good quality water will go a long way to eliminate this potent threat.

Underground waters are usually safe for use as drinking water. However, in recent times environmental factors have led to the contamination of these otherwise safe underground waters [7]. Source of contamination of underground waters include leachate of minerals that are unsafely disposed off, pit latrines and general unhygienic conditions at the wells. Natural contamination of the underground water due to the rock formation like in the case of Bongo district where high fluoride contamination have been reported [1,8,9] and in so many areas where manganese and iron contamination are common [1]. Heavy metal contaminations such as Arsenic, Lead among others due to industrial activity have also been reported [10].

Some of the causes of underground water pollution are pit latrines, and waste dumping sites close to wells [11, 12, 13]. The presence of E-coli in underground water is mainly due to the presence of faecal matter in the water [12]. In rural communities the presence of pit latrines are very common and wide spread: 57.7% in Forest Areas, 43.6% in Coastal areas and 20% in Savannah areas [14]. Because the basement and the walls of the pit latrines are not lined, some of the faecal matter seeps into the soil [13]. During floods and heavy down pour, these pits often get full or overflow. The resulting seepage enters underground waters contaminating it. On the other hand overflowing pits flow directly into wells. In cases of heavy flooding, rivers break their banks carrying with them dirt, faecal matter and all sorts of waste straight into wells. The results are heavily polluted wells in the immediate vicinity. Dumping of waste in open fields is a common spectacle in rural areas where no proper waste management takes place [14]. Hazardous waste such as batteries, drugs and other chemical are mixed with household waste and dumped together. The leachate from the waste seeps into the underground waters contaminating it.

Effluents from some industrial activities like mining especially small-scale mining activities are known contaminants of water bodies. In most cases surface water bodies are the most affected however the possibility of spillage of chemicals on the soil cannot be ruled out. In such cases, these harmful chemicals will leach into the underground water bodies [12]. Since these activities are not regulated, such spillages are neither reported nor monitored, putting people in the immediate neighbourhood at risk. Other industrial setups like petrol stations and fuel storage sites often experience spillage of petroleum products that are not properly handled. The result is the leaching of the volatile organic compounds that are carcinogenic into underground waters. Extensive use of chemicals and pesticides for farming purposes also result in the leachate of harmful chemicals and pollutants into underground water bodies. The drinking water quality specification as provided by the Environmental Protection Agency (EPA) Ghana, and the World Health Organisation (WHO), are provided in table 1.

Table 1: EPA and WHO water quality standards

Parameter	EPA, Ghana	WHO
Manganese (mg/l)	-	0.4
Lead (mg/l)	0.1	0.01
Copper (mg/l)	-	2.0
Arsenic (mg/l)	1.0	0.01
Zinc (mg/l)	10	3.0
Mercury (ppb)	0.2	0.01
Iron (mg/l)	-	0.3
Cadmium (mg/l)	-	0.003
pH	6.5 – 8.5	6.5 – 8.5
Turbidity (NTU)	5	5
Electrical Conductivity (μS/cm)	-	-
Colour	15	15
Total dissolved solids (mg/l)	1000	1000

Treatment Options

Water Quality Not Just Availability

For a very long time, a lot of emphasis has been laid on water availability. Donor funding as well as government programmes have targeted increasing water access thus extending water supply to the remotest of places. Erroneously, underground waters have always been considered of very good quality because of the extensive filtering process the water undergoes. True as it may be, as has been pointed out both natural and environmental conditions most often than not make nonsense of this claim. To curb the incidence of water related diseases, water quality must be taken just as serious with adequate funding as water access and availability. In the next section proven methods of purifying the water are explored.

Disinfection of Wells

This section looks at how infected wells are treated for high levels of bacteria. Faecal contamination of wells leads to the aggregation of bacteria and other harmful germs. Periodic laboratory analysis of water quality checks needs to be carried out in all areas to ascertain the level of bacterial contamination. Disease causing bacteria such as e-coli, salmonella, vibrio cholerae among others must be the target of such investigation. When the level of contamination is determined to be unsafe for human consumption, the well has to be capped and disinfected before allowing the inhabitants to use it. In situations where the well cannot be capped due to the urgent need for water, residents must be advised to boil their water before drinking it. Chlorination is a very effective way of killing germs and disease causing bacteria. The quantity of hypochlorite used however depends on a number of factors:

- Quantity of water in the well
- Level of contamination.

The quantity of water in the well can be calculated using the formula in [15]

Where:
V = volume of water in the well
d = diameter of the well
h = water column height

This method is particularly good for boreholes and occasional contamination of wells like flooding. Where the contamination is coming from the walls of the well other methods will have to be employed. Assuming the water table is contaminated as a result of a pit latrine situated close to the well or leachate from dumpsites, then one time disinfection of the water in the well might not solve the problem. If the water table is contaminated then either the latrine is closed down which will most likely not be the case or the dump site is completely cleared which will also not materialize. In such a situation one solution is effective, an automatic hypochlorite dispensing machine placed on top of the well, which occasionally dispenses hypochlorite solution into the well in precisely measured quantities to kill germs and bacteria. Such a system will depend to a large extent on the rate of recovery of the well. The authors are working on a similar system powered by solar energy.

Removal of heavy metals

Treatment Using Lignocellulosic Materials

Treatment of contaminated water using dung and carbon prepared from animal bones by CWSA, though successful, has not been accepted due to cultural connotations. The use of agricultural waste to reduce heavy metal contaminants have also been reported to be successful by Harman *et* [16], even though the same success rate was not achieved with light metals like Mg^{2+} and K^{+}. Significant amounts of Mg^{2+} and K^{+} were not removed from the water. This was explained to mean that the heavier metals had more affinity for the cellulosic materials than the lighter metals. This means the heavier the metal the higher the affinity. Though this may be true as reported a careful selection of cellulosic material and the right environmental conditions like PH may be able to increase the removal of the lighter metals.

Activated Charcoal

The CWSA has also reported the successful removal of the heavy metals from ground water using activated charcoal in the MWACAFE filtration plant. They strongly believe that since charcoal is a household commodity cultural barriers leading to rejection will be greatly reduced, thus making it more acceptable. Initial reports indicate that high removal of manganese and iron was achieved using the MWACAFE plant [17]. Charcoal has a very high porosity which makes it a good absorber. When is it activated, its affinity for metallic ions increases, thus its ability to reduce the concentration of metallic ions in solution. The ability of the MWACAFE plant to remove other heavy metals has not been investigated.

Distillation

Distilled water is said to be the purest form of water. Though good, distillation is very expensive since a lot of energy is expended during the distillation process. Also the distillation receptacle is often expensive and thus beyond the economic reach of most people. The Centre for Energy, Environment and Sustainable Development, CEESD has demonstrated how solar energy can be utilized to remove distil water and make it safe for drinking. Solar water distillers virtually remove all contaminants and bacterial infections, thus making the water clean. A small unit installed in AnaafoBissi in the Bongo district was able to reduce the fluoride contaminants from 20 mg/l to about 0.7 mg/l which is way below the WHO standard [18].

Special areas that deserve particular attention with regards to underground water quality are discussed below.

Mining Town

Mining communities have long suffered from contamination of their surface water bodies by both multinational mining companies and local mining groups popularly called "galamsay". This has had both huge health and economic toll on the inhabitants of these areas. Because the activities of these companies and groups are not properly monitored, it is increasingly becoming alarming that underground water bodies may have been polluted as well. In an extensive survey by the Wassa Amenfi Communities Affected by Mining (WACAM) of underground waters in the Tarkwa and Oboasi Municipalities showed that most wells shown in figure 1 had higher heavy metal content than the EPA and WHO standards. This is very alarming given the health implications of ingesting heavy metals.

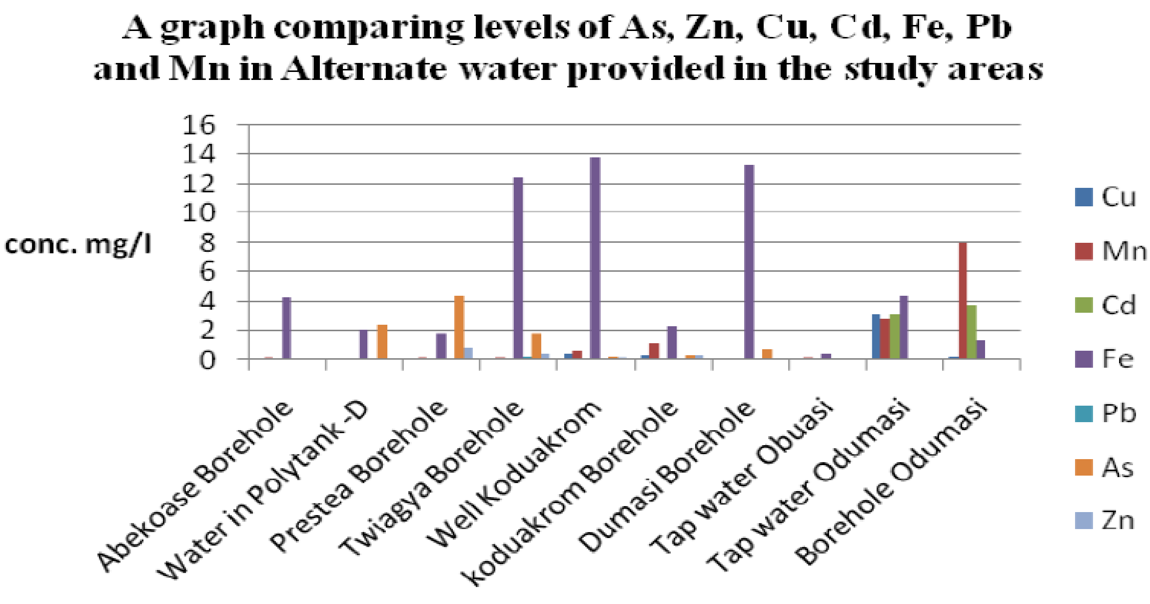

Figure 1: Results of heavy metal contaminants in mining areas
Source: Adapted from WACAM report [20]

Flood Prone Areas

During rainy seasons we often hear of floods in so many areas in Ghana. In 2009 and 2010, major floods in Ghana were attributed to the effect of climate change. As has already been pointed out, due to our poor waste management situation, the potential of flood waters carrying potentially harmful waste into already dug wells is very high. Besides that, leachate from waste dumping sites seeping into underground waters is a major concern. Due to these issues the quality of the water from the wells needs to be checked.

Areas Close To Dump Sites
In Ghana, there is only one engineered landfill site in Kumasi. All other cities and towns have dump sites. Due to the nature of our waste collection and dumping systems, mingled waste containing, organic, industrial, plastic and in some cases medical waste are dumped together on these open fields. All wells close to dumping sites must therefore have their water quality tested regularly.

Areas around Magazines and Heavy Industrial Setups
Fitting shops and magazines do not usually have mechanisms for treating their liquid waste. Dirty engine oils, other lubricants, fuels and greases are usually poured onto the bear ground. These petroleum products and synthetic oils often containing harmful chemicals seep into underground water bodies. Due to the movement of water molecules in the earth not just the immediate environment is affected, however, other areas further away from the magazine or fitting shop may also be affected.

All Wells
Aside these two special cases, the authors believe that all wells in the country should be checked periodically. Through preventive measures, contaminated and infested wells would be disinfected before any calamity occurs.

Conclusion
Wells have come to stay as an important source of water supply for especially people in rural areas, not only them; urban communities are increasingly depending on wells as well. The quality of water from many wells is questionable since it might contain high levels of metal contaminants and or bacterial infection due to several factors such as floods, poor waste management and poor hygiene. Several methods for removing metallic contaminants have been reviewed while a comprehensive disinfection of wells has also been explored. It is hoped that a system will be put in place to check the quality of water from wells periodically and a disinfection plan put in place. In the case of metallic contaminants, a cost effective method should be selected and promoted vigorously in areas known for high levels of contamination either with donor support or a special government programme.

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Quality water, contamination, sanitation, wells

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Cost of Rural and Small Town Water Service Delivery in the Bosomtwe District

E. Appiah-Effah, K.B. Nyarko, B. Dwumfour-Asare & P. Moriarty

Abstract

This paper uses the Life-Cycle Cost Approach (LCCA) to quantify the costs of providing sustainable water services and measures the actual water service received by the users in Bosomtwe district in the Ashanti region of Ghana. The study covered 28 water point systems (boreholes fitted with handpumps) in 10 communities and one small town piped system serving 5,462 inhabitants in the district. The water services received was assessed through household surveys covering 620 households with the following indicators: quantity, quality, accessibility, crowding and reliability. The paper discusses the cost of providing water services for the two main models of water supply (water point systems and piped schemes) using the Bosomtwe district. The study revealed that the cost of constructing the small towns water system is about twice that of the water point systems and the ongoing cost of operating and maintenance of the small towns is four times that of the water point system. The small town water system also provided acceptable service to 72% of the inhabitants compared to 34 % by the water point system. The paper concludes with some policy recommendations on the use of life cycle costing to improve decision making in water service delivery.

Introduction

In Ghana like other developing countries, the method of water supply to rural and small towns inhabitants are predominantly water point systems (boreholes with handpumps) and small town piped systems (mechanized water schemes). According to CWSA (2009a) 6,668,484 rural people (56%) have been served with handpumps as against 1,816,891 (62%) served under small-town piped water systems all in the 2008 year. However, provision of facilities is not enough and will not necessarily contribute to long term coverage statistics if operations are not based on sustainability.

WASHCost project partners have developed the Life-cycle cost approach (LCCA) methodology for costing sustainable water, sanitation and hygiene (WASH) services by assessing life-cycle costs and comparing them against levels of service provided. The approach has been tested in Ghana, Burkina Faso, Mozambique and Andhra Pradesh (India). The life-cycle costs approach is a robust tool to study cost effectiveness of service delivery. In Ghana, Kwame Nkrumah University of Science and Technology (KNUST), International Water and Sanitation Centre in Netherlands (IRC), and Community Water and Sanitation Agency (CWSA) are using the LCCA to identify the true costs of providing sustainable Water, Sanitation and Hygiene in rural and peri-urban areas.

This paper presents the cost of providing water services using the Life Cycle Cost Approach (LCCA based on ten (10) rural communities using water point sources and one (1) small town with a piped water scheme.

Study Area

Bosomtwe District is located at the central part of the Ashanti Region and has Kuntanase as the District Capital. The projected district population for 2009 was 187,499 using growth rate of 3.0 %. The district covers an area of approximately 68,179 square kilometers. The settlements of the district are mostly farmsteads. There is low standard of living in the district as the average households' per capita income is less than US$ 1 a month (Ghana Districts, 2006). The Figure 1 below is a map of Ghana showing the location of Bosomtwe district and study areas.

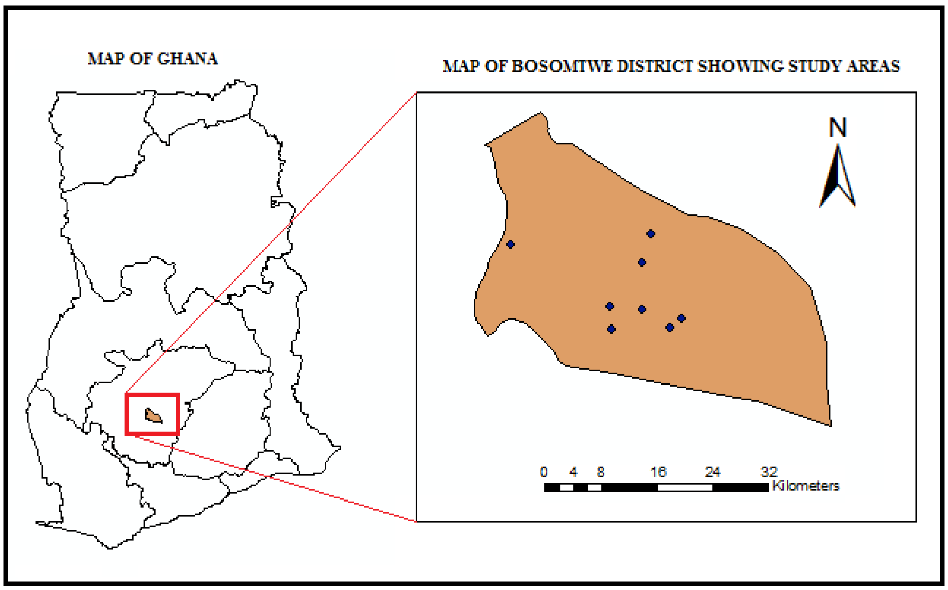

Figure 2: Bosomtwe district with some study communities

Methodology

Assessing Water Service Levels

The assessment of the level of service considers what beneficiaries receive rather than what the water system is designed to provide. The framework (see Table 1 below) is based on the CWSA norms for water quality, accessibility, reliability and crowding. The service is classified into five levels for all the indicators and the minimum acceptable in Ghana is the basic service (see Table 1 below). An acceptable or standard level of service is defined as a basic service or better.

Table 3: Framework for assessing water services

<table>
<tr><th rowspan="2">Service Levels</th><th colspan="3">Indicators</th></tr>
<tr><th>Water quantity accessed</th><th>Distance to water source</th><th>Crowding-with-reliability</th></tr>
<tr><td>High</td><td>60 [7]lcd and more</td><td rowspan="3">500 meters and/or less
(Standard)</td><td rowspan="3">300 persons and/or less per point-system or standpipe
(Standard)</td></tr>
<tr><td>Intermediate</td><td>From 40 to less than 60 lcd</td></tr>
<tr><td>Basic</td><td>From 20 to less than 40 lcd</td></tr>
<tr><td>Sub-standard</td><td>From 5 to less than 20 lcd</td><td rowspan="2">More than 500 meters
(Sub-standard)</td><td rowspan="2">More than 300 persons per point-system or standpipe
(Sub-standard)</td></tr>
<tr><td>No service</td><td>Less than 5lcd</td></tr>
</table>

Source: WASHCost Ghana, (2010).

When reading the table it is important to understand that to score standard for the overall service it is necessary to score standard on all of the indicators. Thus the overall score can be different from the individual scores for each indicator. The overall score gives a conservative estimate of access to services, based on an assumption that all indicators are equally important.

Quantifying Life-Cycle Costs (LCC)

Life-Cycle Costs (LCC) represent the aggregate costs of ensuring delivery of adequate, equitable and sustainable WASH services to a population in a specified area (Catarina et al, 2010). According to Moriarty et. al., (2011) the various components of life-cycle costs are listed below;

- Capital Expenditure: Initial costs of putting new services into place; 'hardware'' such as pipes, toilets and pumps and one-off ''software'' such as training and consultations.

- Cost of Capital: The cost of borrowing money or investing in the service instead of another opportunity. It also includes any profit of the service providers not reinvested. It has a direct impact on the ability to maintain a service financially.

- Operation and maintenance expenditure: Routine maintenance and operation costs crucial to keep services running, e.g. wages, fuel or any other regular purchases. Neglect has long-term consequences for service delivery, e.g. expensive capital (maintenance) expenditure and/or service failure.

- Capital Maintenance expenditure: Occasional large maintenance costs for the renewal, replacement and rehabilitation of a system. These essential expenditures are required before failure occurs to maintain a level of service and need to be planned in. This is one of the most frequently ''forgotten'' costs.

- Expenditure on direct support: Pre and post-construction support costs not directly related to implementation, e.g. training for community or private sector operators, users or user groups.

[7] Lcd means Litres per Capita per day

These costs are often forgotten in rural water and sanitation estimates but are necessary to achieve long-term functionality and scale.

- Expenditure on indirect support: The cost of planning and policy making at governmental level and capacity building of professional and technicians. These costs have a direct impact on long-term sustainability.

The cost data was collected for the water systems and adjusted to current year (2009) values using GDP deflators (World Bank Group, 2010) and then to the equivalent US Dollars using the average 2009 exchange rate of USD$ 1 is to GH¢ 1.4132 (BoG, 2009). The direct support cost data represents CWSA and DAs' (DWSTs) operational expenditure from annual reports and the per-capita cost calculated by dividing cost by the national rural population and district population for CWSA and district respectively.

Results and Discussions

The findings presented in this paper are based on the analysis of cost and household surveys (620) data collected in ten (10) rural communities and one (1) small town.

Water Service Levels

The overall water services received by both rural and small town inhabitants are shown in Figure 2 below. Clearly the small towns water systems provides acceptable water services to 72% of the population whilst the rural water points provide an acceptable service to only 34% of the population.

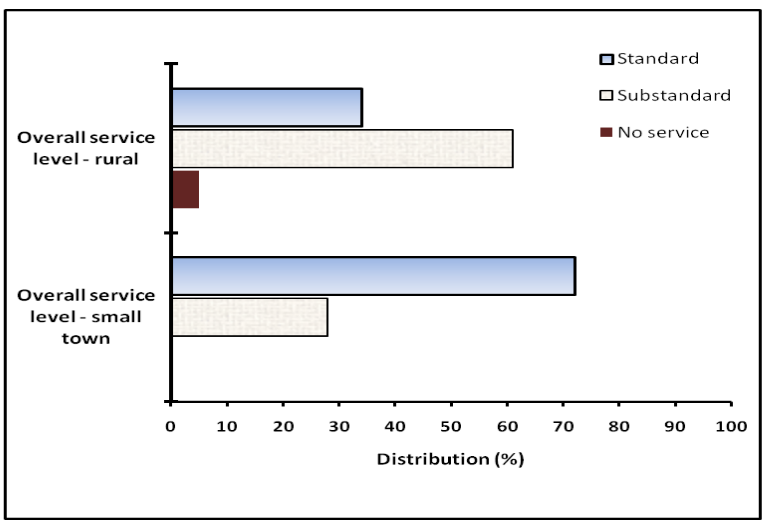

Figure 3: Overall water service levels received by users

The contribution of the individual service level indicators to overall water service levels are discussed below. Figure 3 shows the service levels by water quantity for the water systems. A significant number of users, 26% of the respondents in the small towns and 38% of respondents using the water point systems are receiving unacceptable quantities of water (less than 20l/c/d). They are largely relying on traditional water sources such as rivers, hand-dug wells, rainwater and a lake which does not guarantee the desired public health benefit and discouraged according to the national norms.

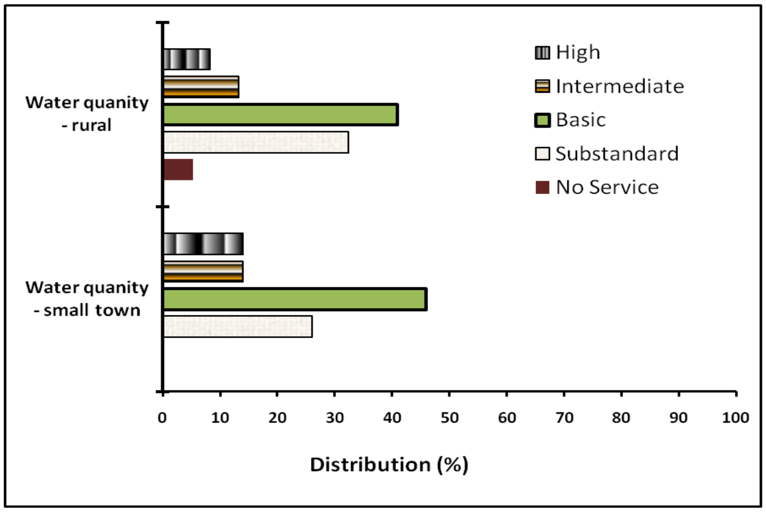

Figure 4: Water quantity service level

The results of the service level in terms of access by distance, and crowding-with-reliability is shown in Table 2 below. The accessibility measured by distance to water source for both the rural and small towns water system meets the standard of less than 500 m except a smaller fraction of users (2%) in the small towns where the houses are located in new areas springing up in town.

Table 4: Service level by access distance and crowding-with-reliability

Indicator	Description		Rural	Small town
			%	%
Access by distance	Standard	Distance to water source < 500m	100	98
	Substandard	Distance to water source > 500m	0	2
Crowding-with-reliability	Standard	<300 users per reliable facility	51	100
	Substandard	>300 users per reliable facility	49	0

The crowding-with-reliability indicator reveals that all the users in the small towns satisfy the crowding with reliability indicator of less than 300 users for a reliable standpipe. In the case of the rural water point systems, 3 of the 28 water systems were not reliable contributing to 49% of the systems serving more than 300 users.

Cost of Water Service

The life-cycle cost analysis was conducted for capital expenditure (CapEx), operational and minor maintenance (OpEx), capital maintenance and direct support cost. The data on cost of capital was not readily available for the individual water systems of the study.

The capital expenditure (CapEx) of the small town piped water system at current (2009) value is US$ 429, 151 (US$ 79 per capita). The capital expenditure (CapEx) of the 28 water systems is US$ 756,000 (based on data on 2 water point systems constructed in 1998). However, when more recent cost data for 387 water systems in two other regions is used the total capital expenditure is US$ 352,696 for the 28 facilities. Therefore the total capital expenditure at current cost is US$ 781,847 for a population of 15,584. With 15 % of the water point systems not functioning, the current value of the non functional systems investment is US$ 52,904.

The operational and minor maintenance expenditure (OpEx) available for 23 water point-systems gives cost range from US$ 0 to 102 per facility per year (median of US$ 43 per facility/yr). The operational and minor maintenance expenditure (OpEx) in terms of cost per capita based on observed population ranges from US$ 0 to US$2.0 (median, US$ 0.1). However, for the small town water system the average annual OpEx is US$ 12,427 representing US$ 2.3 per capita/yr. There was no cost data available on capital maintenance for WPS even though six (6) facilities had their handpumps replaced. For the small town system, the average annual capital maintenance (CapManEx) is US$ 4,948 representing US$ 1 per capita/yr. The total per capita direct support costs in the Bosomtwe district covering activities of CWSA and DWST is US$ 0.56 per capita/year. The direct support cost is low as both CWSA and the DWSTs have low budgets for monitoring and supporting the water service delivery in communities.

Conclusions and Recommendation

The water point systems cost US$ 42 per capita and a running cost of US$ 0.9 per capita/yr and delivers acceptable service to only 34 % of the populace. On the contrary, the small towns are more expensive, costing about twice that of the water point system and a running cost of about four times that of the water point system. The small town water system also provided acceptable service to 72 % of the inhabitants compared to 34 % by the water point system

The total investment at current cost for the 10 rural communities and 1 small town is US$ 781,847. The recurrent expenditures (direct support cost, operational and minor, and capital maintenance) are relatively low contributing to the non functional system which has a current value of US $ 52,904. The CWSA and DWST are under resourced adversely affecting their role in the post-construction support activities. Meanwhile, these routine expenditures are crucial for facilities' functionality and reliability for long term sustainable service delivery.

It is recommended that CWSA (regional) and DA (DWST) should be adequately resourced for post-construction monitoring of operations and maintenance especially with the WPS to achieve 100% functionality and reliability rates for sustainable services. Also there should be planned capital maintenance for especially very old rural water systems to replace the handpumps.

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Key Words

Life-cycle cost approach, rural water point systems, small town piped system, service levels

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Degradation of Water Resources and the Effect on Drinking Water Treatment in Ghana

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Abstract

Ghana Water Company Limited is the urban water provider in Ghana. It has been facing problems with some of its raw water resources due to environmental degradation such as illegal mining activities in the catchment areas. This has resulted in poor raw water quality as well as occasional and permanently drying up of some dams. Colour and turbidity are the worst affected water quality parameters. Degradation of the water catchment areas has resulted in increasing chemical cost of water treatment and also intermittent shut downs of some water treatment Plants. Key Stakeholders in the management of water resources need to have a common platform to discuss the way forward in managing pollution situations of water bodies.

Introduction

Water is a precious commodity that touches the life of every person on the planet. The availability and provision of clean water still proves to be a scarcity.

Ghana Water Company is responsible for the provision of potable water for the urban population in the country. The Company currently operates forty six [46] major surface Water Treatment Plants and is able to meet only about 59% of the demand of its customers nationwide. Within the last few years, our operations have been facing an unprecedented water treatment challenges arising from poor quality of the raw water abstracted from the river sources.

The water resources in Ghana have over the years experienced an escalating degradation. This degradation affects the water quality of the rivers making it difficult and sometimes unfit to treat for human usage. This situation has come about because of the continuous degradation of the environment with severe negative impact on catchment areas of raw water sources.

For instance a number of Water Treatment Plants sometimes have to be shut down on several occasions as a result of heavy pollution. These Plants have not been designed and built to process the current rate of deterioration of the raw water quality characteristics caused mainly by human activities such as inappropriate industrial and domestic waste disposal, poor sanitation, mining within catchments and in the beds of rivers, deforestation or removal of vegetation cover, fishing, farming, climate change etc.

The degradation resulted in dried up raw water sources for which some Water Treatment Plants have permanently closed down or occasionally shut down. Shut down of Treatment Plants denies **the people of regular supply of water. It has however been the only necessary precautionary** measures applied to avoid supplying communities with unsafe drinking water. Apart from the above stated problems, the cost of chemicals used to treat the water is a huge financial burden for which customers are often asked to pay.

Affected Water Treatment Plants

For the last two years especially from 2009, our operations have been facing an unprecedented water treatment challenges arising from heavy pollution of the raw water abstracted from the river sources. Climatic change and land degradation have caused some impounded reservoir sources of water to dry up permanently or seasonally. Flood water and soil erosion caused by rain storms, had negative impact on previously clean water supply sources. The Water Treatment Plants severely affected by the challenges stated above were indicated in the table 1 below.

Table 1

SYSTEMS	Nature of problem
Damango/ Yendi	Closed down source/Seasonal production reduction or shut down.
Osino/ Bunso/ Kibi/ Anyinam	Occasional shut down caused by mining activities
Axim/Inchaban	Occasional shut down/ production reduction
Daboase/ Sekyere Heman	Increased chemicals usage caused by mining in Pra River.
Kpong/ Weija	Increasing chemicals usage caused by catchment degradation

In Eastern Region the Water Treatment Plants, namely Osino, Bunso, Kibi and Anyinam that drew raw water from the Birim River had to be shut down on several occasions as a result of pollution. These Plants were not designed and built to process the rapidly deteriorating raw water quality characteristics caused mainly by mining activities. Shut down of treatment plants denied the people of regular supply of water. It was however the only necessary precautionary measures applied to avoid supplying communities with unsafe drinking water.

The Pra River which served Water Treatment Plants namely Sekyere-Heman and Daboase in Central and Western Regions respectively was also highly polluted by mining activities. The miners also created coffer dams/dykes within the river bed which restricted and diverted away the water flow to the intake point especially at Daboase. Cement–sand bags were made to build a coffer dam to redirect the water flow to the intake point.

Damongo System in the Northern Region had been closed down permanently since year 2000 as a result of dried up impounded reservoir. Yendi System experienced seasonal production reduction or shut down due to insufficient quantity of raw.

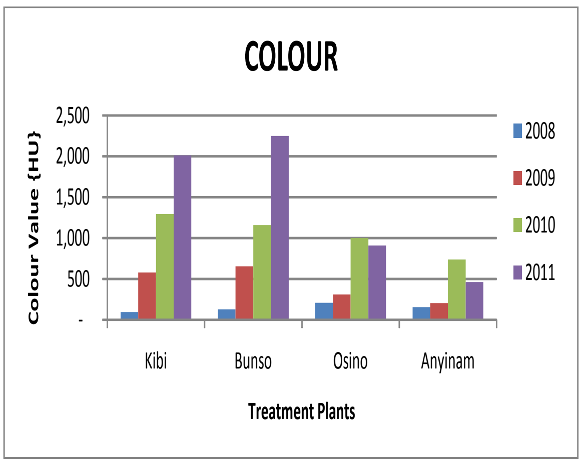
The Axim and Inchaban Systems in the Western Region experienced occasional shut downs or production reduction seasonally because of inadequate quantity of raw water.

In June 2009 Kpong System was shut down for twenty four hours to avoid supply unsafe water. The shutdown was necessary because the applicable filtration process alone could not reduce colour and turbidity values to acceptable limits. Water quality monitoring results indicated the possible use of a coagulant (e.g. Aluminium Sulphate) to treat the water in the near future.

Aesthetic Water Quality Results

The critical aesthetic water quality parameters namely, colour and turbidity of the raw water sources monitored to highlight the challenges were as given in graphical representation below to indicate clearly variations on yearly bases. These parameters are important in determining the visual appearance of water for its acceptability or objection be used for drinking and domestic purposes. The objectionable appearance calls for the need to transform the water to a state that is wholesome and attractive to users. The values of colour and turbidity determine the amount of coagulant chemical such as aluminium sulphate (Alum) needed to treat the water.

The results of the water quality analysis of the critical operational parameters of the raw water sources of some of the Systems under discussion were as presented graphically for the period 2008 to May 2011.



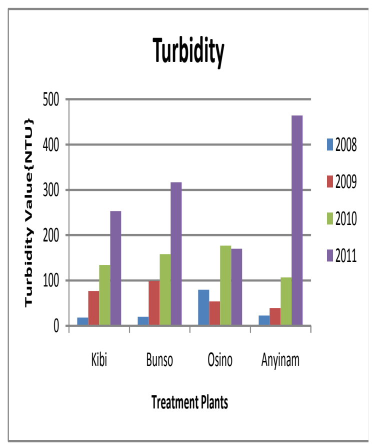
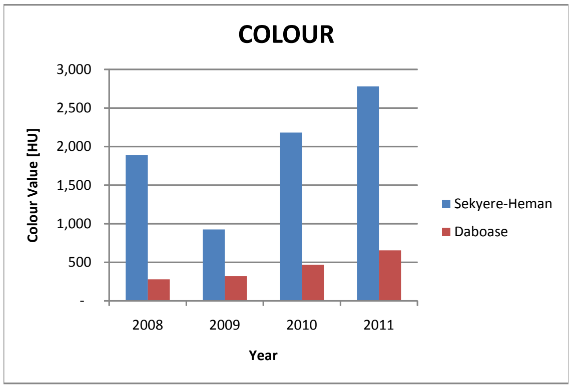


Figure 1: Birim River

Generally, both colour and turbidity values showed increasing trends from year to year as clearly indicated in figure 1. High values of colour and turbidity caused increase in coagulant chemical usage and the associated cost of water treatment. The Plants were occasionally shut down because of mining activities right at the raw water intake point. The situation needed some realistic measures to be put in place to control the mining activities within the catchment areas of the Birim River.



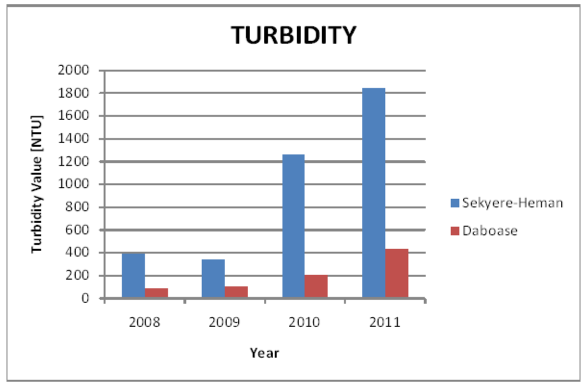


Figure 2: Pra River at Sekyere-Heman and Daboase.

The colour and turbidity values of the Pra River at Sekyere- Heman and Daboase Systems in the Central and Western Regions respectively were as represented by figure 2 showed increasing yearly trends. Changes at Sekyere-Heman were more pronounced than at Daboase. The intensive illegal mining activities took place close to the intake points.

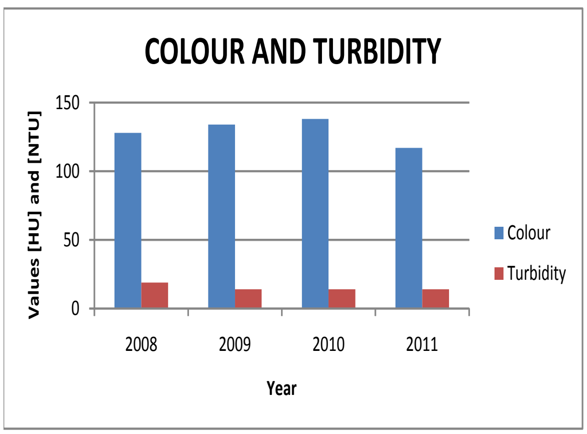


Figure 3: Densu River

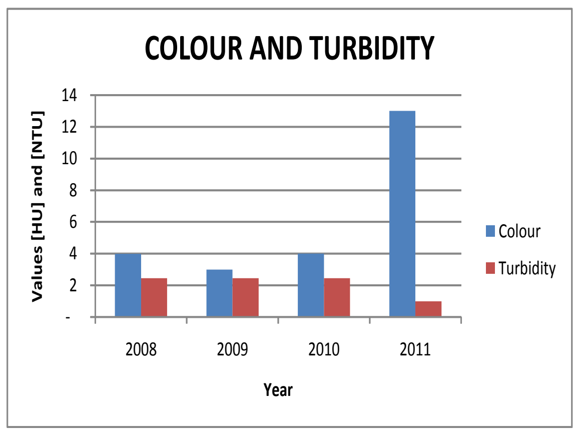


Figure 4: Volta River

The colour and turbidity values of the raw water of the Densu River at Weija were as represented by figure 3. The Station suffered algal bloom which required the use of high quantity of coagulant chemical Aluminium Sulphate. The algal bloom was caused by domestic and industrial waste discharges into the catchment area. The colour and turbidity values of the raw water of the Volta River at Kpong were as represented by figure 4. The raw water quality characteristics were so good that filtration, disinfection and pH Adjustment processes were only required. However, in June 2009 Kpong System was shut down for twenty four hours to avoid supply unsafe water. The situation was caused by extraordinary high values of colour [125HU) and turbidity (174NTU) such that the filtration process was ineffective. Investigation conducted revealed sand weaning activities in a portion of the catchment area close to the intake point. The trend of yearly colour measurements pointed to the fact that we may soon begin to use coagulant chemicals to remove colour and turbidity.

Major Concerns

One of the major components of water production is the chemicals cost apart from dried up raw water sources and occasional shut down of treatment plants. Deterioration of the raw water quality characteristics in terms of colour and turbidity increased the quantities of chemicals used to treat the water. What it means is that production cost will continue to increase at a faster rate and customers would be asked to pay higher tariffs if something is not done to minimize the pollution effects.

Recommendation

For reasons stated here and other factors, it is very important that Management of Ghana Water Company Limited should in collaboration with especially Water Resources Commission (WRC), initiate steps to create a common platform for key stakeholders to meet regularly and discuss the way forward in managing pollution situations of water bodies.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Promoting Decentralised Solar Water Purification Systems in Ghana: A Case Study at Bongo

Edem Cudjoe Bensah, Edward Antwi & Julius Cudjoe Ahiekpor

Abstract

Solar purification of water is a proven technology that can be used to produce clean water on decentralized basis to households in communities that face challenges with the quality of groundwater resources. Even though Ghana has quality groundwater resources, there are numerous localities whose groundwater systems are not potable due to high salinity, fluoride contamination, and other chemical and biological contaminants. Moreover, the risk of groundwater becoming contaminated from faecal matter from poorly constructed septic tanks is high especially in peri-urban communities. This paper assesses the potential of using solar stills to produce clean water from contaminated groundwater in Ghana. The paper highlights the success of using two solar stills to treat fluoride-contaminated water at Anaafo Biisi Primary School in the Bongo District of Ghana. Water quality analysis conducted showed a reduction of fluoride concentration from 20 mg/l to below 1 mg/l, which is acceptable under WHO standards. As a result of the ability of solar stills to mitigate the incidence of fluorosis in Bongo, it is envisaged that the project will receive the necessary support so that it can be expanded to cover over 100 households and three basic schools in Anaafo Biisi.

Introduction

Groundwater Quality in Ghana

Water resources in Ghana are decreasing at an alarming rate owing to several factors: population growth and urbanization, forest degradation, agricultural expansion, industrialization, pollution of water bodies, and destruction of wetlands, among others. Pollution of surface water bodies and the groundwater is a major developmental challenge [1]. Seepage of contaminants into groundwater systems from agriculture, mining and other industrial waste, and poor waste disposal practices are raising concerns regarding the quality of underground water. According to the fifth round of the Ghana Living Standards Survey (GLSS5), about 73 % of urban households have access to pipe-borne water compared to only 14 % of rural households [2]. The quality of groundwater resources in Ghana is generally good except for some cases of localised pollution and areas with high levels of iron, fluoride and other minerals [3]. Salinity in certain groundwater occurrences is also found especially in some coastal aquifers. Over 10,000 boreholes are known to have been dug in Ghana [1]. The number is likely to have been understated since a common trend observed in many cities and towns is the construction of wells and boreholes by estate delivers especially in new suburbs where pipe-borne water may not be available. City dwellers are increasingly using water from boreholes as a way of cutting down expenditure on pipe water.

Since most rural communities rely on groundwater resources, there is the need to promote interventions that safeguard the quality of local groundwater. However, in places where groundwater is naturally polluted with salts such as fluorides and chlorides as is the case in the groundwater of Bongo and Ada respectively, there is the need to promote technologies that can be used to purify water from such contaminants on decentralized basis. Solar distillation is one such technology. Solar purification of contaminated water could provide a leeway for local communities that depend on such water.

Solar Purification of Water

Solar purification of contaminated water involves the use of the sun energy to evaporate water into vapour and the subsequently condense the vapour formed into pure water. Water is separated from any dissolved matter such as salts, nitrates, dirt, pathogens, heavy metals, and arsenic [4]. The apparatus used for solar water purification is termed the solar still or solar water purifier. Since the solar still relies on the energy from the sun, a trapping medium such as plain silicate glass is used to transmit radiation onto an absorber such as a black surface in contact with the water. When the water is heated, it is vaporized. Since the glass is cooler since it is in contact with the surrounding air, the vapour condenses on the tilted glass cover and runs down into a channel which usually leads to a storage container for collection.

There are two main models of the solar still – single basin and multiple-effect basin stills. The single basin design has one compartment and is simple to construct. On the other hand, multiple-effect stills have more than one compartment and are arranged such that the condensing surface of the lower compartment becomes the floor of the upper compartment. The heat given off by the condensing vapour provides energy to vaporize the feed water above. It is costly compared to the single basin type [5].

Use of Solar Stills for Treatment of Fluoride Contaminated Water at Bongo

Incidence of Fluorosis at Bongo

Bongo is located on latitude 10°54′28″N and longitude 0°48′29″W, and is about 20 km from Bolgatanga, the capital of Upper East region. The district faces water problems caused by high concentrations of fluoride (more than 1.5 ppm) in most water from boreholes [4, 6]. Most boreholes have thus been rendered useless and people who drink water from the boreholes suffer from unpleasant teeth colorization due to the effects of dental fluorosis [7]. Children under the age of 5 years are the most vulnerable. Figure 1 shows school children affected by dental fluorosis. The prevalence rate of dental fluorosis among school children has been estimated at 33 % in Bongo and surrounding communities [8].

Figure 1: School children suffering from dental fluorosis in Bongo

Even though most boreholes have been shutdown as a result of this, people in some of the villages continue to consume water from hand-dug wells and even capped boreholes because there are no alternative sources of safe drinking water. Anaafo Biisi is one of such villages in Bongo. Dental fluorosis has reached extremely high levels – as high as 80 % of entire population. A water quality analysis conducted on a sample of water from a borehole is shown in Table 1.

Table 1: Results of water quality analysis of water from the solar still

Parameter	Value
TDS	138.0 mg/l
Total Hardness ($CaCO_3$)	90.0 mg/l
Calcium	23.0 mg/l
Magnesium	7.8 mg/l
Fluoride	20.65 mg/l
Chloride	11.0 mg/l
pH	6.73
Turbidity	0.1

Source: [4]

Attempts have been made by the Bongo district assembly, government, local and international non-governmental organizations to find a lasting solution to the problem. The use of fluoride removal methods such as precipitation and ion exchange has been tried by several organizations to no avail due to the relatively high cost of such systems and problems with availability of chemicals and equipment.

Intervention by the Centre for Energy, Environment and Sustainable Development (CEESD)

In an attempt to find a sustainable means of treating contaminated water at Bongo, the Centre for Energy, Environment and Sustainable Development (CEESD), a local non-profit organization, assessed the water problem at Bongo in August 2010. Based on the findings from the survey, CEESD was convinced that the solar still would be an appropriate technology for purifying fluoride contaminated water at Bongo.

CEESD Solar Stills

Two solar water distillers (Figure 2) have been designed and installed at Anaafo Biisi primary school by CEESD. Figure 3 shows a picture of the solar still constructed at Anaafo Biisi. The value of the solar insolation for Navrongo was used in the design of the stills since Navrongo is the closest town to Bongo for which such information is available. The two models could deliver up to 25 litres of clean water daily. The stills were constructed readily available materials at Bongo with the exception of the glazing which consisted of plain silicate glass.

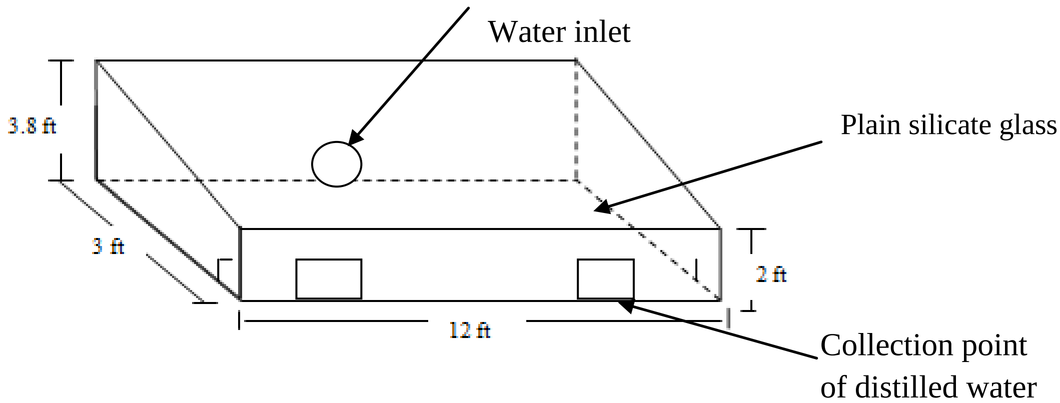

Figure 2: Diagram of solar still

Figure 3: Solar stills constructed at Anaafo Biisi Primary School in Bongo

Results and Discussion

Samples of purified water produced from the stills were analysed at the laboratories of Ghana Water Company Limited and Department of Civil Engineering of Kwame Nkrumah University of Science and Technology. Analysis of the solar purified water collected on five different days indicates that the fluoride level in the raw borehole water had reduced significantly by about 96 %, from 20.65 mg/l to an average of 0.76 mg/l which falls below the WHO figure of 1.5 mg/l (Figure 4).

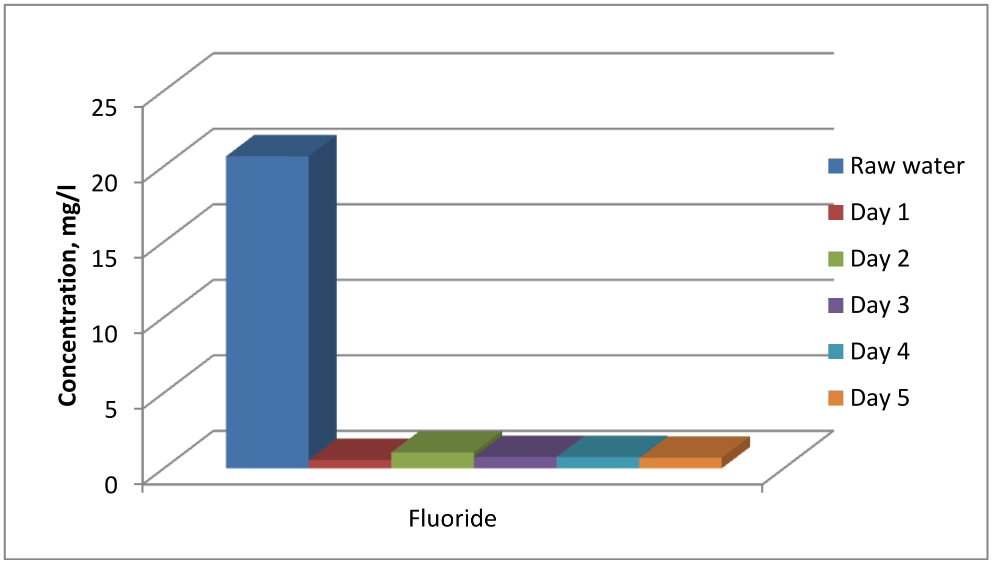

Figure 4: Fluoride concentration of the water sample before and after treatment with solar energy.

Lessons

The success of this project is a manifestation of how simple but appropriate technologies could be used to provide clean water for communities facing groundwater quality challenges in Ghana. The total cost of the two stills was GH¢ 380 which shows that such systems could be replicated in many communities in Bongo with the support of donors. More importantly, job opportunities could be created if the youth is trained in the design, installation and marketing of solar stills in Ghana.

Conclusion and Recommendations

The challenge of providing clean water to Ghana's growing population is daunting. While efforts are being made by Government to expand water services to all Ghanaians, there is also the need to promote appropriate technologies such as solar stills that can be used to treat water from contaminants such as salts and dirt on decentralized basis. CEESD's solar still demonstration units at Bongo are a demonstration of how simple but appropriate technologies could be used to solve major developmental challenges in the water sector.

As a result of the success of the installed stills, CEESD intends to expand the facility by installing 100 units of solar water purifiers in 120 selected households and three basic schools in the 6 communities that make up Anaafo Biisi. The entire units are expected to provide over 2500 litres per day of fluoride free water. Emphasis will be placed on the need for beneficiary households to give premium to children under the age of 10 years in the usage of the distilled water. In order to ensure the sustainability of the project, CEESD will build capacity of 60 local people from all six communities in the design, construction, and maintenance of solar water purifiers. This will create sustainable livelihoods for the local people who will be trained.

Acknowledgements

CEESD acknowledges the financial support received from Vodafone Foundation Ghana through its World of Difference programme. The service of Frank Mensah, a trainee under the World of

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Supply Constraints of Utility Water Services to Newly Developing Private Estates in Accra

Hector Emmanuel Adjetey Boye

Abstract

The ramifications of the elements of "private, peripheral location and sheer size" of newly emerging private housing estates in peri-urban areas raise questions concerning availability and quality of public water services and how these issues are overcome. Against this background, this paper examines the policies, existing institutional arrangements and constraints associated with the delivery of water services to newly developing estates in Ghana and to develop recommendations aimed at addressing the identified bottlenecks. By analyzing the various roles played by potable water service providers and estate developers, the lack of coordination amongst and between the various stakeholders in land use and engineering planning for potable water services in peri-urban regions of Accra and the Ghana Water Company Limited capacity constraint are identified as key problems. The paper recommends measures to address current problems associated with public water supply including amongst others the need for regular flow of information amongst the various stakeholders so that they move in tandem. The recommendations give some directions for planning, financing, public and/or private provision and operation of water service infrastructure. The paper particularly recommends promulgation and enforcement of legislation requiring estate development of peri-urban Accra to be directionally zoned periodically.

Introduction

Statement of the Problem

The elements of "private, peripheral location and sheer size" collectively contribute to the inadequacy of water supply services to estate housing sites. The inadequate capacity of the government water agencies to service these estates therefore compel tenants and/or developers to look for alternative arrangements and/or sources of water supply, which sometimes are not of good quality. Four (4) estates respectively located to the east, north, northwest and west of Accra are investigated in the light of the afore-mentioned. It is also noted that housing development in Ghana is bereft of direct guidance through legislation. Indirect guidance has however been provided through various land laws and planning-related legislation. Some of the policies are: The Town and Country Planning Ordinance 1945 (Chapter 84); The State Lands Act, 1962 (Act 125); The State Lands Regulation, 1962 (L.I. 230); The Local Government Act, 1993 (Act 462)

Aim and Objectives

The Ghana Water and Sewerage Corporation (GWSC) was established in 1965 under an Act of Parliament (Act 310) as a legal public utility entity to (1) provide, distribute, conserve and supply water in Ghana for public, domestic, commercial and industrial purposes; and (2) establish, operate and control sewerage systems for such purposes. Under the Statutory Corporations Act (Act 461), which enabled government to convert hitherto public-owned statutory corporations into limited liability companies in anticipation of privatization, GWSC was renamed the Ghana Water Company Limited (GWCL) and registered in July 1999. In December 1998 the Community Water and Sanitation Agency (CWSA) was formed by Act 564 to assist District Assemblies and communities to provide water supply services to rural and small towns. With the capacity-constrained GWCL primarily focused on urban areas, a policy gap is indicated for peri-urban areas. This paper examines the policies, existing institutional arrangements and constraints associated with the delivery of potable water supply to newly developing estates in Ghana, which are often situated in peri-urban areas. In specific terms, the paper's objectives are to:

1. Investigate the processes that estate developers go through to acquire water utility service,

2. Identify the problems associated with the processes,

3. Make recommendations to inform policy formulation in respect of supply of water utility service for promotion of real estate development.

Application processes, delivery time and the question of shared responsibility amongst the various parties concerned are investigated. This generally informs recommendations that are made to enhance collaboration amongst the stakeholders and to reduce the problems associated with water supply to peri-urban areas.

Key Issues and Challenges

There are a number of key development policy issues and challenges associated with appropriate development of water supply infrastructure in peri-urban areas of Ghana.

1. The primal status of Accra has resulted in the city experiencing urban sprawl in all its major forms; namely:-
    - low-density continuous development,
    - ribbon development and
    - leap frog development.

2. Whilst institutions involved in water supply arguably have their distinct roles to play in urban or rural settings, the indication and reality is that there is a problem of poor coordination and sometimes-conflicting roles in peri-urban areas. This is evidenced for instance by the current situation where CWSA operates in peri-urban areas to the north of Accra previously served by GWCL.

3. It is noted that enforcement of existing legislation (Chapter 84) by local authorities could have provided a platform for the requisite coordination of the various agencies involved. This is presently lacking, resulting in estate developers accessing land anywhere for development without considering implications for water utility service.

Analysis of Utility Water Supply Constraints

Water Mains Extension Process

Relevant issues pertaining to application and design in the process for supplying water to some peri-urban locations are indicated in Table 1.

Table 1: Process-related Issues for Water Mains Supply to Study Locations

ISSUES	ESTATES (Lashibi)	ESTATES (Oyibi)	ESTATES (Kwabenya)	ESTATES (Amanfro)
APPLICATION	Letter with registered site plan and estate layout (before design)	Letter with registered site plan.	Letter with registered site plan (before design)	Letter with registered site plan (before design)
DESIGN	GWCL	GWCL	GWCL	GWCL
RESPONSE TIME FROM GWCL	4 weeks with many follow-ups	*20 weeks with many follow-ups	4 weeks few follow-ups	2 weeks with many follow-ups
EXTENSION	400m	300m	50m	1,000m

Source: Author's Survey

*GWCL had expected to effect supplies from groundwater sources in Dodowa through infrastructure put in place earlier for a planned industrial enterprise. These sources had however been exclusively committed to Adenta. Part of the installed infrastructure is currently incorporated in a water supply system provided by CWSA from an underground source in Oyibi and community-managed by the Oyibi Water and Sanitation Development Board (WSDB).

Table 2: Other Process-related Issues for Water Mains Supply to Study Locations

ISSUES	ESTATES (Lashibi)	ESTATES (Oyibi)	ESTATES (Kwabenya)	ESTATES (Amanfro)
FUNDING	Developer	-	Developer	Developer/GWCL
MATERIALS PURCHASING	Developer	-	Private Contractor	GWCL
PIPE-LAYING & FIXING OF VALVES	Private Contractor under developer supervision	-	Private Contractor under developer supervision	Private Contractor under GWCL supervision
CONSTRUCTION TIME	3 weeks	-	2 weeks	10 weeks
CONNECTION FEE	5% of supply and installation costs	-	5% of supply and installation costs	5% of supply and installation costs
SUPPLY CONNECTION	GWCL	Oyibi Water & Sanitation Development Board	GWCL	GWCL

Source: Author's Survey

[O] Developer paid for earthworks by taking advantage of ongoing GWCL 3km pipeline project supplying water to Kokrobite to negotiate cost-sharing arrangement.

Summary of Findings

Planning for Utilities

- Lack of planning and minimal coordination amongst and between water service providers, estate developers and land supply agencies is indicated.

Key Water Supply Issues/Problems

- The key problem for water supply to newly developing estates in Accra stems from the GWCL capacity constraint. Groundwater supplies appeared to be the most viable alternative available to private developers.

- Operational conflicts between GWCL and CWSA exist in certain peri-urban areas.

- Mobilising funds for the huge capital outlay involved for water supply in site and services schemes in which housing utility infrastructure is installed prior to actual building of houses, is difficult for developers; who are likely to immediately bear all physical infrastructure extension costs prior to transferring the costs to house buyers.

Related Issues

- Private estate developers, in supplying and installing water mains infrastructure to their peri-urban housing sites also tend to be at the forefront of acquisition of land and compensation for the required right-of- way for mains extensions through undeveloped lands. In taking-over developer-installed physical infrastructure for service operations, the water utilities do not coordinate with the land agencies to secure and protect the previously acquired rights-of-way.

Recommendations and Conclusions

Recommendations

In the light of the key findings, some recommendations are suggested at two levels.

Short-Term Proposals to Address Water Supply Problems

Estate Developers

- Developers should endeavour to ensure that private design consultants take cognizance of the spatial variations in the supply constraint of GWCL water in and around Accra.

- Developers should be made aware of the need to involve the Water Resources Commission in any plans for groundwater abstraction.

Service Providers

- GWCL must increase its water supply capacity and introduce electronic operations in distribution.

- Government needs to immediately address the policy gap in water supply operations in peri-urban areas.

Long-Term Proposals to Address Water Supply Problems

Planning and Financing

- Physical plans of the metropolis ought to be updated for subsequent harmonization with Master Plans of utility water agencies.

- There should be promulgation and enforcement of legislation requiring estate development of peri-urban Accra to be directionally zoned periodically.

- Collaboration between water utilities and private sector organizations such as estate developers should be better promoted. The Ministry of Water Resources, Works and Housing should create a Department of Private Estate Development under which GREDA could be promoted as a public-private partnership and made to collaborate with the District and/or Municipal Assemblies.

Provision of Infrastructure

- Limited liability companies formed through partnerships with the utilities should be made responsible for the entire process of providing service to newly developing estates commencing with planning, through financing, installation, operation and maintenance.

Service Operations

- Developers should be encouraged with long-term financing and management arrangements to collaborate with trained and certified contractors for dedicated services (bulk supply) and associated water utilities management (operation and maintenance) within their estates.

- Studies must be concluded on the effect of private finance of public water utility network extensions on tariffs and in fairness any rebates ought to be credited to house owners and/or residents. This exercise should be spearheaded by the PURC.

- Modern technology such as Geographic Information Systems and Remote Sensing Service operations should be introduced into monitoring and supervision of water service networks.

Conclusion

A coordination problem was identified as key in planning for public water utilities as well as for adequate designs for water supply to peri-urban Accra. There is also a policy gap in water service delivery to peri-urban communities. In order to market their estates however, developers go to great lengths to service their estates with water supply resulting in increased housing delivery costs, but oblivious to buyers. The price quoted by the developer includes exhorbitant costs incurred for ensuring utility water provision.

In the short term, through planning, the water utilities are advised to enhance their operational efficiencies with modern technology whilst government is advised to bridge the policy gap in water service delivery in peri-urban areas. In the long-term, legislation to geographically and cardinally direct spatial development is recommended along with creation in the Ministry of Water Resources, Works and Housing, a Department of Private Estate Development under which GREDA could be promoted as a public-private partnership entity.

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Prof. S. K. Afrane of the Kwame Nkrumah University of Science and Technology (KNUST). His outstanding and constructive suggestions gave meaning to the original work.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Characterisation and Adsorption Potential of Kpong Water Treatment Plant Filter Media

R. Buamah & A. Yakubu

Abstract

The Kpong Water Treatment Plant (KWTP), one of the two major Water treatment plants supplying the Accra/Tema Metropolitan cities, services about 3.4 million people. Lately, the filtering media at KWTP has been observed to develop a black coating within three to four years of operation. This appearance results in more water than necessary being used for backwashing the filters. The composition, toxicity and impact of the black coating is unknown and raises concern among the plant operators.

This study investigated the characteristics of black coating on the KWTP filtering media and its effect on the filter performance. Laboratory scale experiments and batch reactor tests were conducted to characterize the coating and determine the effect of the coating on the filter performance with respect to iron removal.

The chemical components of the black coating of the KWTP filter media were found to be mainly iron, manganese, sulphates and sulphides. Other components like copper, lead, mercury occurred in trace concentrations. The black coating has a limiting effect on the iron removal capacity of the coated KWTP filter media.

Introduction

The Ghana Water Company presently operates 84 urban water supply systems in the country whiles Community Water and Sanitation Agency (CWSA) tends the rural water supply systems. The effective urban water coverage in the country at the moment stands at 59%. The Kpong water treatment plant, one of two major water treatment plants servicing the Accra and Tema metropolitan cities supplies averagely 44 million gallons a day to about 3.5 million people (Kpong, 2010; Brinkhoff, 2010). The treatment scheme of the Kpong treatment headworks include the following units shown in the figure 1 below.

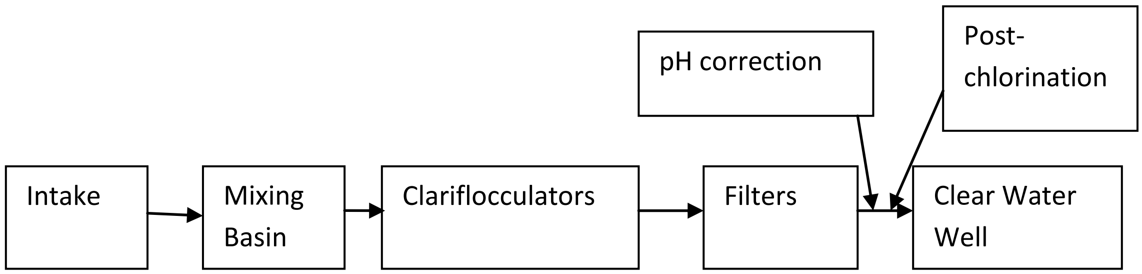


Figure 1: Water treatment scheme at the Kpong Water Treatment Plant

The headworks takes its raw water from the Volta Lake and its intake point is sited at a point, 17 km downstream of the Akosombo dam. The Volta Lake water quality is relatively good compared with most of the surface water bodies from which various water treatment plants abstract water for treatment in the country. As a result, the treatment scheme in operation at Kpong is less laborious and less expensive than the other treatment systems in the country. Recent developments at the Kpong headworks with respect to the appearance of the filter grains in the filters however, have raised concern about the quality of the raw water. There are causes to believe that the raw water is being polluted. The source of the pollution however is not known. The filter media at the Kpong headworks has developed a black coating media instead of the normal dark brown coloration common to most filtering media of water treatment in the neighbourhood (Figure 2), e.g. VRA-WTP located at 400 meters upstream of the Akosombo hydro dam; and moreover the filter run time appears to be declining. The black colouration has led to more water being used in backwashing than normal. The appearance tends to give impression of the deposition of dirt thus the need to do extra minutes of backwashing (operations manager, 2009)

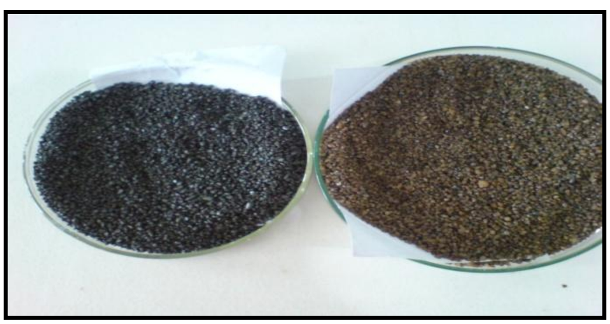


Figure 2

Other concern is the composition and toxicity of the black coating and the possibility of the compound leaching back into the treated water after sometime.

This study focused on characterising the black coating of the filter media and determining the effect of the coating on the filter performance of the filter media. In addition a comparison of the characteristics was made with filter media taken from the VRA – water treatment plant that takes it raw water source upstream of the Volta Lake. Both the Kpong and VRA water treatment plants use similar water treatment schemes.

The Adsorption Phenomenon

In the treatment of water, filtration is one of the unit operations that is employed in the physico-chemical and bacteriological separation of mainly suspended and colloidal particles from the raw water. To some extent dissolved compounds like ammonium can also be removed in the filters if biomass like nitrosomonas and nitrobacter species have developed within the filters. In the filters, other combination of processes such as sedimentation, straining, adsorption, biochemical activities occur (Buamah, 2009). When colloidal or dissolved particles have sizes below 1 micrometer the removal process predominantly employed in the filter is adsorption.

Adsorption process involves the accumulation of particles from one medium onto the surface of another medium. The particle(s) being accumulated is referred to as the adsorbate whiles the medium on which the particle(s) is being gathered is called the adsorbent. When particles are adsorbed based on weak van der Waals forces and weak electrostatic forces the adsorption is termed to be physical adsorption. Such adsorption process is normally reversible. In contrast if the adhesion between the adsorbate and the adsorbent involves strong electrostatic forces the adsorption is termed as chemi-sorption. The adsorption process is normally affected by factors such as pH, temperature, organic matter, particle size of the adsorbent, dissolved ionic concentration. The potential of a filter media to remove contaminants, to a larger extent depend upon its capacity to adsorb dissolved particles.

Black Colouring Compounds

Compounds capable of forming black solutions or black precipitates include sulphides of ions like iron, copper, mercury, lead. Oxides of copper and iron could also generate some black coloration in solutions (Brown, 1985).

Methodology

Characterizing the Black Coating of the Kpong and VRA Filter Media

To determine the composition of the black coating on the KWTP filter media, one gram samples of filter media were taken from each of the filter beds at Kpong and VRA-WTP. The samples were placed in round bottom flasks containing 100 ml of 18.5% HCl and allowed to stay overnight. The solutions were digested by heating on a hot plate for about 1 hour to ensure complete dissolution of the coating material (Standard methods, 2005). The solutions were then analyzed for the following metals and non-metals: manganese, copper, lead, zinc, mercury and sulphates and sulphides. For the metallic ions the Buck Scientific atomic absorption spectrophotometer VGP 210 was used. The sulphates and sulphides were assayed for using the Hach spectrometer DR 2010 with appropriate reagent powder pillows – sulphaver 4

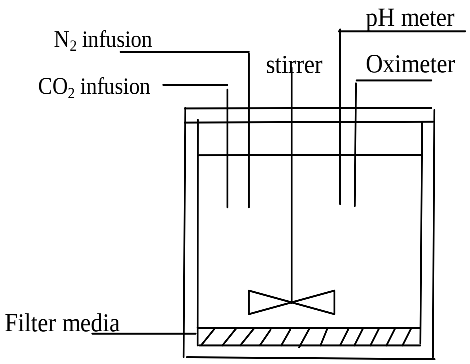
Batch Experiments

The adsorptive performance of the four filter media, i.e. KWTP filter media, the de-coated KWTP filter media, the VRA-WTP filter media and then a fresh filter media from Dakyebi Company Limited were investigated using batch reactor experiments. The Dakyebi company limited supplies fresh filter media to the KWTP to be used in their filters. The fresh filter media, coated and de-coated KWTP filter media and the VRA-WTP filter media were washed separately with de-mineralised water and dried at room temperature for 24hours.

Batch Experimental Procedure

A two litres batch reactor was filled with 1.5-litres of de-mineralized water and dosed with 0.045g/l of $NaHCO_3$, 0.017g/l of $MgSO_4$, and 0.017g/l of $CaCl_2$ to prepare a solution simulating the conditions that prevails in the raw water (i.e. the Volta lake) abstracted by the KWTP for treatment. The top cover of the reactor is equipped with ports for pH meter and oximeter electrodes (Figure 3). The content of the reactor was stirred continuously with a mechanical stirrer at a rate of 100rpm. Nitrogen gas was infused into the solution till anaerobic condition was obtained. The pH of the solution was adjusted by infusing carbon dioxide gas to 6.9 ± 0.1 (pH of the Volta Lake). Iron was then dosed to obtain a 0.2mgFe^{2+}/l solution; and stirred continuously for 15 minutes to ensure complete mixing.

Fifteen millilitre of the solution was fetched from the reactor and immediately acidified with hydrochloric acid (time zero sample). This was followed immediately by the addition of 1.0g of the coated filter media. Water samples (10 ml) of the solution were withdrawn at: 15min, 30min, 1hr, 2hr, 4hr, 6hr, 8hrand 12h; acidified with hydrochloric acid and their respective iron(II) concentration determined using Buick Scientific Atomic Absorption Spectrophotometer. The experiment was repeated for the de-coated KWTP filter media and the VRA-WTP filter media.



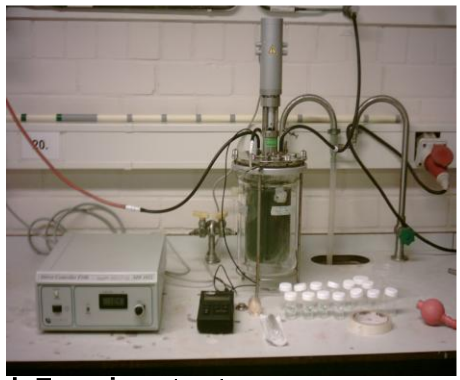


Figure 3: Batch Experiment set up

Results and Discussions

Chemical Composition of the Black Coating

The Table 1 below shows the average values obtained for the constituents of the outer coating of the various filter media after the characterization experiments.

Table1: Results of analyses of filter media coating

Parameter	VRA WTP (mg/g)	Kpong WTP (mg/g)	Increasing factor
Iron	2.71	5.96	2 times
Manganese	0.12	2.06	17 times
Copper	0.12	0.32	3 times
Zinc	0.002	0.02	10 times
Mercury	0.00001	0.00024	24 times
Lead	0.02	0.03	-
Sulphide	0.00010	0.0005	5 times
Sulphate	0.00704	0.00798	-

All the ions analysed for were higher in the coating of KWTP filter media than in the VRA WTP filter media. The predominant metals present were found to be iron and manganese. In terms of magnitude the iron occurrence was higher but the remarkable feature is the tremendous increase in the amount of manganese on the KWTP filter media. This is an indication that activities occurring within the lake at the area stretching from the location of the VRA-WTP to the KWTP contribute appreciable amount of manganese to the lake. With the high concentrations of the sulphides recorded (Table 1), it shows that most of the black coating material is predominantly manganese sulphides. Iron sulphate and / or sulphides may also be present. These results point to the fact that there may be sources of these contaminants other than the raw water from the Volta Lake, thus the need to analyse the discharges from the riparian industries. Mercury was found in trace quantities however the sharp increase observed for the KWTP filter media raises concern about the source and the need to trace it. Mercury is toxic and noted for bioaccumulation in aquatic species.

In the case of the anions, sulphate happens to be higher in concentration compared with the sulphide. It can be inferred that the sulphide interacts with the iron or the manganese to get it oxidized to the sulphate. Iron oxide and manganese oxides are known potential catalyst (Buamah et al., 2009).

Adsorption of Iron by Filter Media

To investigate the iron removal potential of the black coated filter media of KWTP, laboratory scale experiments were conducted using model water dosed with 0.2mg Fe^{2+}/L at a pH 6.9 (Figure 2). The experiment was conducted using four different filter media (i.e. black coated, de-coated, fresh and VRA WTP filter media). From Figure 4, the Fe^{2+} adsorption trends of the coated, de-coated fresh and VRA filter media indicate the VRA filter media having the highest iron (II) adsorption capacity within the tested period of 12 hours (i.e. 720 minutes). The de-coated filter media had the least adsorption capacity. All things being equal, the KWTP filter media having been in use for about fifteen years now, was expected to exhibit a higher adsorption capacity than VRA filter media, which has been in use for only ten years. Generally, filters that have been in operation for longer periods do have denser coating material on the sand grains and higher occurrence of iron oxides in the coating. The iron oxides enhance the adsorption capacity of the sand grains for iron (II) in the raw water. A higher adsorption capacity exhibited by the VRA filter media is an indication that the black coating on the KWTP is limiting the full adsorption potential of the coated filter media. The VRA filter media, although fed with the same source is not coated black.

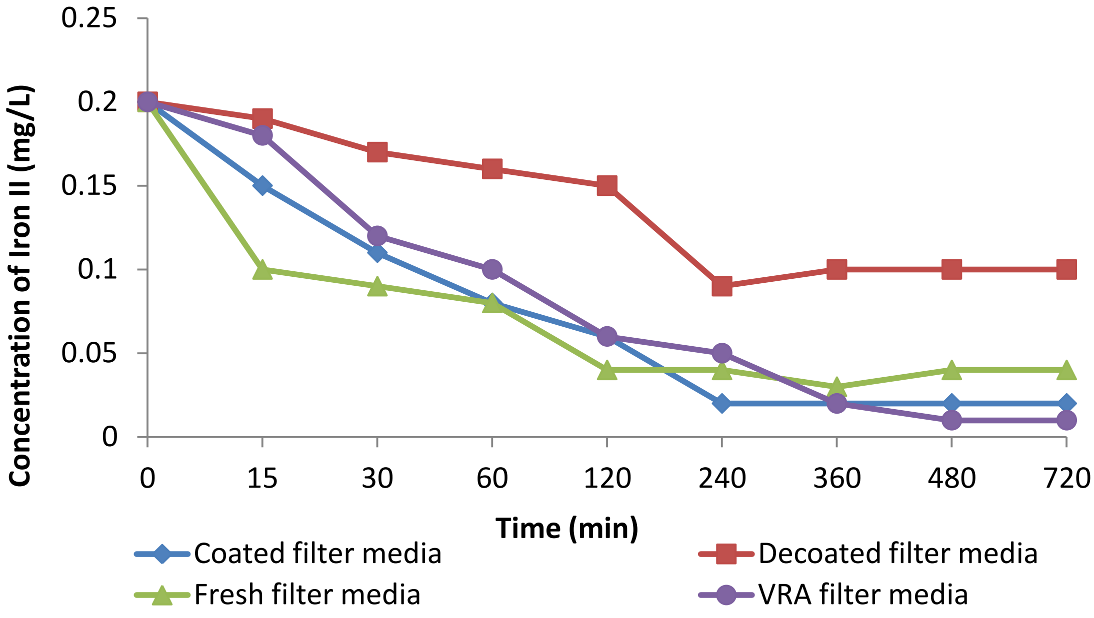


Figure 4: Performance of the various filter media in iron (II) adsorption at pH 6.9

Conclusions

1. The chemical components of the black coating of the Kpong filter media are mainly iron, manganese, sulphates and sulphides. Other components like copper, lead, mercury occurred in trace concentrations.

2. The blackening of the filter media at KWTP is probably due to manganese and iron sulphates or sulphides. Iron oxides may also be a contributory factor.

3. The black coating is limiting iron removal capacity of the Kpong filter media.

Recommendations

1. Discharges from riparian industries and communities located within the area between the VRA-WTP and KWTP must be sampled to trace the source of the manganese, iron, sulphate or sulphide and mercury that eventually coats the KWTP filter media.

2. Further works using columns must be carried out to determine the effect of the coating on the filter run time.

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Keywords

Black coated media, adsorption, filter

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Comparative Study of the Physico-Chemical and Bacteriological Quality of Drinking Water in Kumasi and Ho Metropolitan Areas

Philip Dwamena-Boateng, Bright Kofi Bansah, Oppong Manu Michael & Raphael K .Klake

Abstract

Physico-Chemical and Bacteriological analyses were performed on water supplied by Ghana Water Company Limited (GWCL) in Ho and Kumasi, water stored in Tanks in the Ho Municipality, and Commercial Drinking water (sachet and bottled waters) from various manufacturers. The results were compared with Ghana Drinking Water Standards (GDWS) and WHO Guideline values to ascertain whether they meet the above guideline values and also to find out if they differ from each other. The Commercial drinking waters and GWCL water quality were found to be within the GDWS and WHO guideline values and therefore suitable for drinking. The quality of the water from storage tanks depended on whether the tanks were covered or not. For the tanks that were covered, the water quality compared with the GWCL water was of suitable quality for drinking. For tanks that were not covered, there were colour, turbidity problems and bacteriological contamination. This deterioration in quality can be attributed to irregular or no cleaning of tanks and improper maintenance.

Introduction

The main purpose of the study is to ascertain the claims by some consumers that water supplied by GWCL is of poorer quality as compared with bottled and sachet waters and to investigate the source of any possible contamination.

To achieve the purpose of the study, the following specific objectives were pursued.

i. To conduct quality analysis on GWCL treated water samples, water from GWCL distribution systems and water from overhead storage tanks as well as Commercial drinking waters (Sachet and bottled water).

ii. To compare the results with Ghana Drinking Water Standards and WHO guideline values.

iii. To verify whether there is contamination in any of the sources and recommend solutions.

The essence of this project is to help ensure and maintain consumer confidence and improve storage services. Currently, the use of overhead storage tanks is inevitable due to intermittent supply of water to the consumers.

Methodology

Sampling Points

In all, fifteen (15) samples were taken from the various overhead storage tanks; thus the Ho-Polytechnic (central Hall and main entrance house 2), Residency (1,3,5,7,10), lands commission office, OLA HSE 1, OLA HSE2, Regional Hospital Gate, Nurses training school, Mawuli S.H.S, Mawuko Girls (hostel), Corn oil filling station, eleven (11) bottled water samples, ten (10) sachet water samples as well as GWCL treated water samples from Ho and Kumasi.

Sampling Procedure

For the physico-chemical analysis, 1-Litre plastic containers were used. Before filling, each container was rinsed three times with the sample of water to be taken. The pH was measured in the field. Samples for bacteriological analysis were however taken in polypropylene bottles. All samples analyses were performed within 24 hours.

Analyses of Samples

Physico-chemistry: pH was measured with the Horiba Compact B-122 and Inolab 7300 Conductivity/TDS portable meters. Colour, turbidity and total iron were also measured by spectrophotometry using Hach DR/2500 following Standard Methods (APHA, 1998). Alkalinity and chloride were performed by Titration Methods (APHA, 1998).

Bacteriology: Faecal coliform (E-coli) was measured with the traditional Multiple Tube Fermentation method proposed in Standard Methods (APHA, 1998). All equipments used were first pre-sterilised using an autoclave and 95% ethanol.

Discussion

The results of the physico-chemical and bacteriological analyses are shown in Tables 1, 2 and 3.

pH

The pH of Ghana Water Company Water from Ho and Kumasi and all the water from the storage tanks as well as the sachet water were all within the GDWS and WHO guideline values. However, some bottled water samples (Amrita, Everpure, Adeshe Nsuo and Icecool) showed pH levels below the above standards.

Turbidity

All the water samples showed turbidity of zero with some stored water samples showing turbidities of 0.2 and 0.3 NTU. Overall, all showed turbidity values below the guideline value.

Colour

All the water samples showed colour of zero with some stored water samples showing colour of 8 and 7 Pt.CO which are above the GDWS but below the WHO guideline value.

Total Iron

The GWCL water and all the Commercial drinking water samples showed values below the GDWS and WHO guideline value. The total iron values were also low for stored water with the exception of site NA1 which is a partially covered tank and PH2 which is uncovered. This is probably due to the fact that the two tanks are galvanized and have corroded.

Bacteriology

The study indicated that there was no bacteriological contamination (faecal coliform or E. coli) in the selected brands of bottled water, sachet and tap water per every 100 ml analyzed.

However the partially covered and uncovered sources showed high faecal counts. This can be attributed to contamination due to exposure.

Conclusions and Recommendations

- Results obtained from the analysis show that all the Sachet, bottled and GWCL waters were within the guideline values.
- The iron levels in some of the stored water were higher than the guideline values and this has been attributed to the make of the tanks (galvanized).
- Faecal contamination was only found in uncovered and partially covered storage tanks which is as a result of contamination through exposure.

Lessons Learnt

- The quality of GWCL treated waters from Ho and Kumasi if taken directly from the taps is comparable to the Commercial Drinking water in both physic-chemical and bacteriological quality.
- Contamination of GWCL waters normally takes place when the storage tank is partially covered or uncovered.
- The chemical composition of the material used in storing water has direct impact on the quality of the water that is being stored.
- Proper handling and maintenance of storage tanks can help in preserving the quality of water stored in them.

Recommendations

- More extensive surveillance of bottled and Sachet water industries and more stringent regulations should be developed.
- The Food and Drugs Board (FDB) of Ghana, as the regulatory authority should insist on official registration of all producers of Sachet and bottled water.
- Routine tests should be conducted on these products and consumers alerted about those products that are unwholesome.
- Workshops should be conducted to educate producers and vendors on how to maintain quality.
- Overhead storage tanks must have tight covers to prevent contamination.
- GWCL should educate consumers on the proper maintenance and inspection of their overhead storage tanks to avoid contamination.

- GWCL should encourage the consumer to do regular cleaning and disinfection of overhead storage tanks.

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Table 1: Physico-chemical and bacteriological results of sachet drinking water.

Parameter	Tap Water (Ho)	Tap Water (Kumasi)	Woezor	I am Ok	Mount Zion	Eli	Medels	Constant	Sela	Hydroplus	Kristar	Rose	GDWS	WHO
pH	7.4	7	7.4	7.2	7.5	7.2	6.7	7.6	8.2	7.2	8.2	7.3	6.5-8.5	6.5-8.5
Turbidity (NTU)	0	0	0	0	0	0	0	0	0	0	0	0	5	5
Colour (Pt.Co)	0	0	0	0	0	0	0	0	0	0	0	0	5	15
Total Iron mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3
Faecal Coliform (MPN/100ml)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2: Physico-chemical and bacteriological results of bottled drinking water.

Parameter	Tap Water (Ho)	Tap Water (Kumasi)	Mobile Water	Amrita	Grafton	Everpure	Aquasplash	Ecospa	Voltic	Adeshe Nsuo	Safina	Aqua fill	Icecool	GDWS	WHO
pH	7.4	7	6.5	6.1	6.5	6.1	6.3	6.7	6.7	6	6.8	6.9	6.1	6.5-8.5	6.5-8.5
Turbidity (NTU)	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
Colour (Pt.Co)	0	0	0	0	0	0	0	0	0	0	0	0	0	5	15
Total Iron mg/L	0	0	0.01	0	0	0.01	0.01	0	0	0	0.01	0.01	0.01	0.3	0.3
Faecal Coliform (MPN/100ml)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3: Physico-chemical and bacteriological results of stored drinking water.

Parameter	Tap Water (Ho)	Tap Water (Kumasi)	CO (C)	R1 (C)	R3 (PC)	R5 (C)	R7 (C)	R10 (C) GALV.	OH1 (PC)	OH2 (U)	RHG (PC)	NST (C)	PC (C)	PH2 (G)	MSH (PC)	MG (U)	LCO (C)	GDWS	WHO
pH	7.4	7	7.2	7	7.1	7	7.1	7.1	6.5	7.2	7	7.1	7	7.2	6.9	8.5	7	6.5-8.5	6.5-8.5
Turbidity (NTU)	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0.3	0	0	0	5	5
Colour (Pt.Co)	0	0	0	0	0	0	4	8	0	0	0	0	0	7	0	0	0	5	15
Total Iron mg/L	0	0	0.02	0.03	0.03	0.02	0.03	0.4	0.35	0.03	0.03	0.02	0.01	0.45	0.02	0.03	0.03	0.3	0.3
Faecal Coliform (MPN/100ml)	0	0	0	0	5.1	0	0	>16	9.2	0	5.1	0	0	>16	2.2	2.2	0	0	0

Evaluating the Implications of Future Water Resource Development under Current and Projected Climate in the Volta Basin

Gerald Forkuor, Matthew McCartney & Barnabas Amisigo

Abstract

This study combines climate change (CC), hydrological and water resource evaluation models to assess the impact of one downscaled mid-range CC scenario (A1B) on the performance of existing and planned irrigation and hydropower schemes in the Volta basin. The models were run (1983-2100) to simulate the CC scenario in combination with three development scenarios, each reflecting different levels of water resource development in the basin. Results indicate a general trend of declining rainfall and increasing potential evapotranspiration in the basin. This trend was found to have caused: i) a significant reduction in flows at key stream gauge locations; ii) an increase in average basin-wide per hectare irrigation requirement and iii) a significant reduction in the percentage of the potential hydropower that could be generated in the basin. This has the tendency to undermine the economic development of the riparian countries unless due consideration is given to these impacts and suitable adaptation measures introduced.

Introduction

The Volta basin is an important source of water for the inhabitants of the six riparian countries it drains. It plays a vital role in the economic prosperity of the people. Agriculture, which employs majority of the basin's inhabitant and generates about 40% of the basin's economic output, is heavily reliant on it (Biney, 2010). Water is also used to generate cheap hydropower which supports major industries (i.e. mining, aluminium, etc.) in Ghana and is also exported to neighbouring countries (Owusu et al. 2008). Other uses include livestock rearing, fisheries, recreation and tourism.

Water resources in the basin have come under increasing pressure in recent years. Massive population growth in the two main countries - Ghana and Burkina Faso – has resulted in larger abstractions to meet increasing demand (Van de Giesen et al., 2001). The basin's population is projected to reach 34million in 2025, up from 18.6 in 2000 (Biney, 2010). Despite the existing pressure on the resource, there are plans to build more dams to increase electricity production and expand irrigation in the basin. In addition, CC and the uncertainty associated with it, will further complicate the management of the basin's water resources. Signs of a probable CC (i.e. shorter rainy seasons and increased temperature), which could have dire consequences for future development in the basin, have been reported (Jung and Kunstmann, 2007).

Previous studies have assessed the implications of CC and the ongoing development of dams/reservoirs on the water resources in the basin (e.g. Andah et al. 2004; de Condappa et al., 2009). It has been predicted that CC similar to that which has been observed in recent years will have a greater impact on

Lake Volta than the continued construction of small reservoirs in the upstream portion of the basin (de Condappa et al., 2009).

This paper reports the findings of research conducted to determine the impact of one specific CC scenario on the performance of existing and planned irrigation and hydropower schemes in the Volta basin. The scenario selected for analyses was the IPCC SRES-AR4 A1B emissions scenario. This scenario is distinguished from other scenarios by the technological emphasis on a balance between fossil intensive and non-fossil energy sources (IPCC, 2000). The research was conducted by combining CC, hydrological and water resource evaluation models. Simulations were conducted between the period 1983 and 2100. In order to systematically assess the impact of growing water demand on the basin's water resources, three development scenarios were identified and modelled:

- Current Development – this simulated present water withdrawals/demand. Irrigation and hydropower schemes in this scenario were the ones that are currently operating.

- Intermediate Development – this simulated possible expansion of existing irrigation schemes as well as new hydropower and irrigation schemes that are likely to come on line by approximately 2025.

- Full Development – this simulated expansion of the near-future schemes and additional new schemes that may come on line by 2050.

Study Area

The Volta Basin is drained by four major river systems: the Black (147,000km^2), White (106,000km^2), Oti (72,000km^2) and Lower Volta (73,000km^2) systems (Figure 1). The total annual runoff is estimated to be 40.4 Bm^3 (Andah et al. 2004). Climatically, the southern part of the basin is tropical, with a bi-modal rainfall distribution that reaches about 1500mmy^{-1}. The northern part has a semi-arid climate with a uni-modal distribution of about 500mmy^{-1}. The amount and distribution of rainfall varies significantly from year to year and also seasonally (van de Giesen et al. 2001).

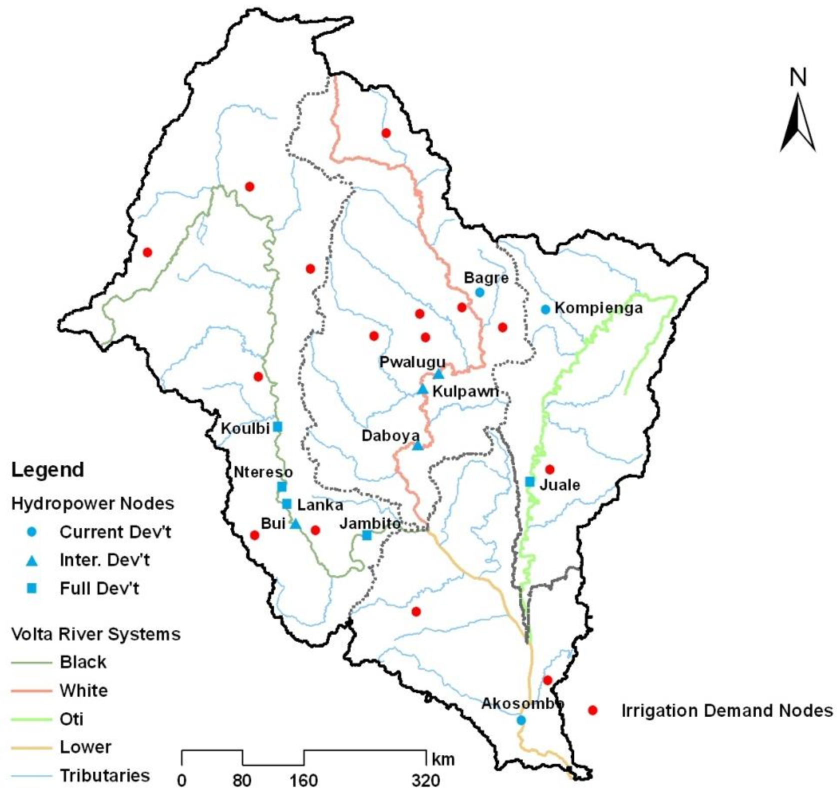


Figure 1: Volta Basin showing hydropower and irrigation demand points

Current Water Resource Development

The most significant development in the basin so far is the construction of the Akosombo dam on Lake Volta primarily for hydropower production. The Lake reservoir has a surface area of 8,500km^2, an average depth of 18.8m and a storage capacity of 148 Bm^3 (Barry et al. 2005). Current installed generating capacity is 1,020 MW. Other hydropower stations are Kompienga and Bagre in Burkina Faso which have total volumes of 2.03 Bm^3 and 1.7 Bm^3 and installed generating capacities of 14 MW and 10 MW respectively.

A number of small, medium and large reservoirs have been constructed in the basin primarily for irrigation. The total storage volume of these reservoirs (excluding the hydropower schemes) is about 1.4 Bm$^{3.}$ These are mainly formal irrigation schemes. Total area under these formal schemes is 30,500 ha. Informal irrigation practice is widespread, but information on it is scanty despite attempts to compile it (Drechsel et al. 2006).

Future Water Resource Development

Major developments planned for the basin focus primarily on hydropower generation and irrigation development. In Ghana, for instance, the Volta River Authority has identified potential sites for hydropower generation in the Black and White Volta as well as the Oti (Figure 1). All together, these planned schemes, including the Bui scheme which is currently under construction, will have a generating capacity of approximately 900MW. At the time of writing, information on similar planned schemes in the other riparian countries were not available.

Expansion in the irrigated area of existing schemes and construction of new ones is expected to increase irrigated area in the basin by close to 33,000 ha. This includes 30,000 ha of irrigation under the Bui scheme. The Ghana Irrigation Development Authority (GIDA) plans to develop an additional 22,590 ha of small or micro scale irrigation and drainage schemes within five years in five regions of Ghana (including the three northern regions). Again, information on future irrigation development in Burkina Faso was not readily available.

Method

In this study, the Water Evaluation and Planning System (WEAP) was used to evaluate the effects of CC on water resources in the face of increasing water demand for irrigation, domestic and hydropower generation in the Volta basin. Modelling was performed in 18 sub-basins. The Soil and Water Assessment Tool (SWAT) was used to simulate flows (supply resources) in each sub-basin, with the downscaled CC (A1B) scenario as input. By using SWAT and WEAP in combination it was possible to simulate the amalgamated impacts of both increasing future demands and changed water availability resulting from CC. Table 1 below gives brief details about the models used.

Table 1: Models used to evaluate the implications of climate change on existing and future water resource development in the Volta Basin

Climate Modelling
COSMO-CLM (CCLM) is a dynamic, non-hydrostatic regional climate model (Davin et al. 2011). The data used for this study were taken from COSMO_4.0_CLM simulations, run for the African continent with grid dimension of 165 x 162 and grid spacing of 0.5^o. It has 32 vertical layers and 10 soil layers. The simulations comprised 30 years of daily control runs using ECHAM5-OM (1971-2000) and 100 years of transient scenario runs using ECHAM5, A1B climate scenarios (2001-2100). The initial and boundary conditions were taken from the ECMWF Re-Analysis (ERA40)
Hydrological Modelling
The Soil and Water Assessment Tool (SWAT) is a rainfall-runoff model (Arnold et al., 1998). It operates on a daily time step on sub-basins identified using a digital elevation model. In this case 31 sub-basins were identified. Similar land-use, soil characteristics and topography (slope) within each sub-basin are lumped together into hydrological response units (HRUs). The model was first set up using observed daily climate data for the period 1968-1980 derived from fourteen meteorological stations located within the basin. Historic flow records at eight stations were used to calibrate and six were used to validate the model. Output from the model comprised, potential and actual evapotranspiration as well as flow and groundwater recharge for each sub-basin. Results were combined to provide data for the 18 sub-catchments used in WEAP.
Water Resource Modelling
The Water Evaluation and Planning (WEAP) model is used to evaluate planning and management issues associated with water resource development. It calculates a mass balance of flow sequentially down a river system, making allowance for human induced abstractions and inflows. It is typically used to simulate alternative scenarios comprising different development and management options. In this study the model was configured to simulate the 18 major sub-catchments of the basin. It was used with flows generated by the SWAT model for the period 1983-2100. Rainfall and evapotranspiration data, required for irrigation schemes and reservoirs, were also taken from the SWAT model output, and varied depending on which sub-basin they were located in. The WEAP model was calibrated and validated by simulating the recent past and comparing simulated and observed flows at Bamboi, Nawuni and Sabari, on the Black, White and Oti basins respectively.

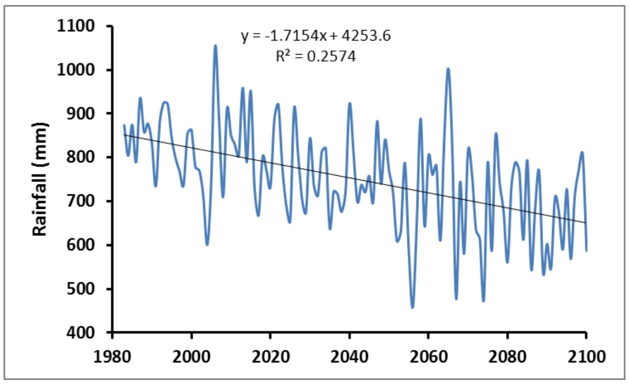
As earlier stated, three separate development scenarios were modelled. Table 2 compares total reservoir storage, irrigated area and installed hydropower generating capacity for the three scenarios. To facilitate comparison between the scenarios, results were summarized over three periods: 1983-2012, 2071-2050 and 2071-2100. Basin average results were computed from sub-basin results by computing the arithmetic mean of the results from individual basins.

Table 2: Water resource development scenarios

Scenario	**Total reservoir storage (Mm^3)**	**Irrigated Area (ha)**	**Installed hydroelectricity generating capacity (MW)**
Current Development	153,124	30,468	1,020
Intermediate Development	180,124	63,253	1,547
Full Development	203,437	65,207	1,916

Results

Figure 2 and Table 3 summarize changes in key hydrological variables (i.e. basin average rainfall, potential and actual evapotranspiration and groundwater recharge) over the period 1983 to 2100 as derived from the CCLM and SWAT models. Although there is some spatial variability, the models predict that for the A1B scenario, averaged across the basin, there will be: i) a decline in rainfall; ii) an increase in potential evapotranspiration iii) a decrease in actual evapotranspiration and iv) a decrease in groundwater recharge. Potential evapotranspiration increases mainly due to rising temperatures. Actual evapotranspiration, on the other hand, decrease because rainfall reduces, leading to drier conditions. Thus, although there's rise in temperatures, less water is available for evaporation due to the decline in rainfall.



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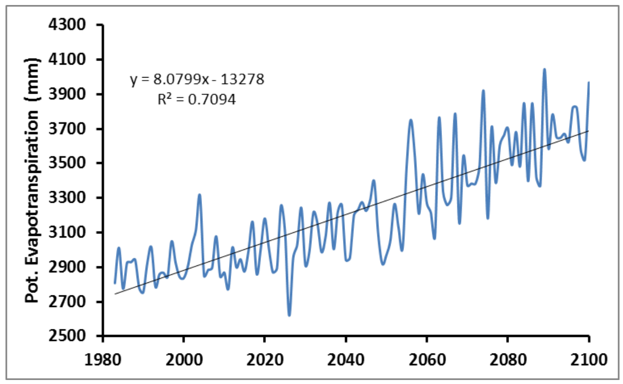

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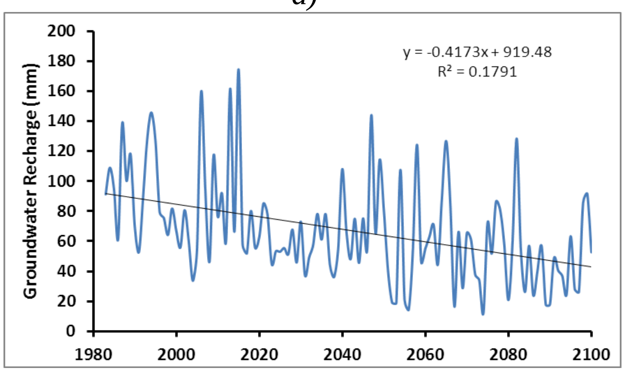

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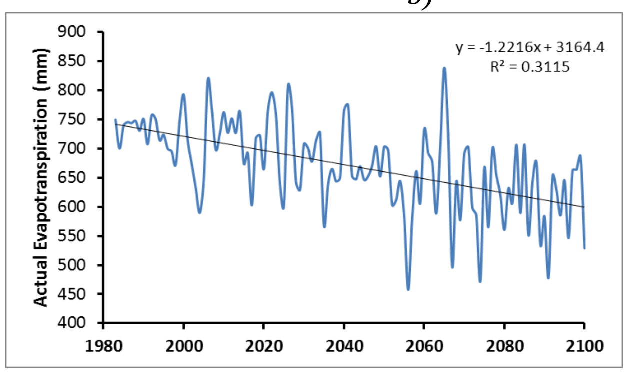

d)

Figure 2: Basin average annual climate variables (1983-2100): a) rainfall; b) potential evapotranspiration; c) groundwater recharge and d) actual evapotranspiration

Table 3: Basin averaged hydrological variables for the periods: 1983-2012; 2021-2050 and 2071-2100

	Rainfall (mm)	**Potential Evapotranspiration (mm)**	**Actual Evapotranspiration (mm)**	**Groundwater Recharge (mm)**
1983-2012	827	2915	722	88
2021-2050	767	3085	688	66
2071-2100	674	3623	614	50

Irrigation

Figure 3 and Table 4 compare irrigation water demand and unmet demand for the three development scenarios. Unmet demand shows an increasing trend due to (i) increase in irrigated areas, (2) decrease in rainfall and increase in evapotranspiration, and (3) increased per hectare water demand.

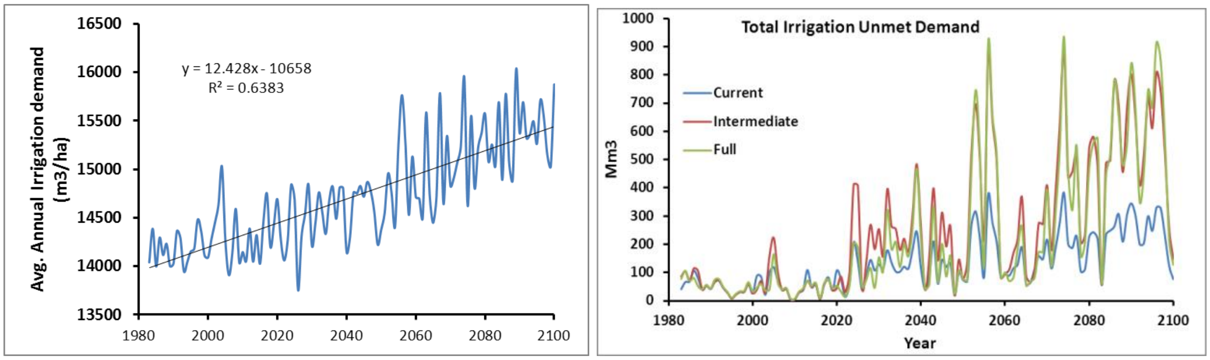

Figure 3: a) Predicted average irrigation demand for the basin; b) Unmet irrigation demand for the three development scenarios

Table 4: Changes in total irrigation demand and unmet demand and in each of the three development scenarios

		1983-2012	2021-2050	2071-2100
Basin avg. irrigation demand (m^3ha^{-1})		14234	14527	15328
Current Development	**Water Demand (Mm^3)**	356	376	394
	Unmet Demand (Mm^3)	51	113	227
	% demand delivered	86	70	42
Intermediate Development	**Water Demand (Mm^3)**	786	817	855
	Unmet Demand (Mm^3)	60	212	513
	% demand delivered	92	74	40
Full Development	**Water Demand (Mm^3)**	824	856	896
	Unmet Demand (Mm^3)	51	144	505
	% demand delivered	94	83	44

Hydropower

Figure 4 and Table 5 show the decreasing trend in hydroelectricity production and the reverse trend in total unmet potential in the basin for each of the scenarios. The results show a very significant increase in hydroelectricity produced as a consequence of the increased generating capacity between current and full development. They also show that reduced river flows, arising as a consequence of climate change, will significantly reduce the amount of power generated in comparison to the potential, particularly in the second half of the century. This could affect significantly the economic gains of the riparian countries, especially as they move towards industrialization.

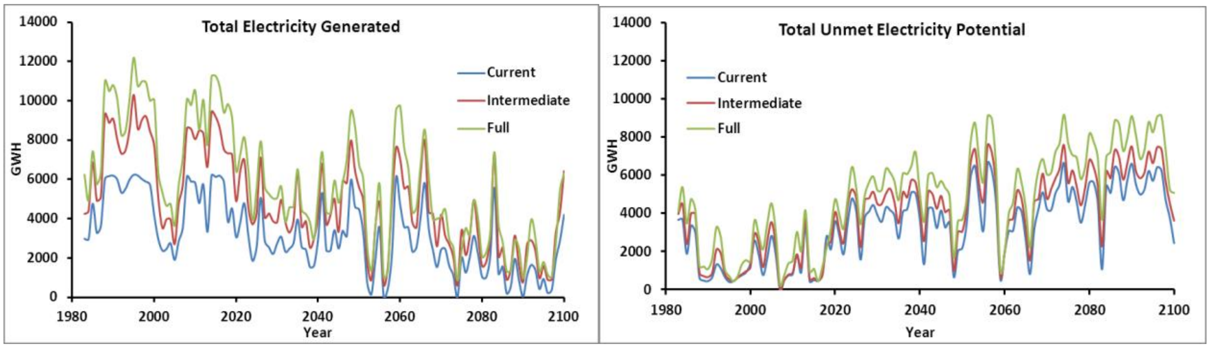

Figure 4: a) Hydroelectricity generated; b) Unmet hydroelectricity potential in the Volta basin

River Flow

Table 6 shows the impact of development and CC on the flows of key streams in the basin. All stations indicate significant changes in flow. The situation at Sabari is slightly different to the other locations because the change is driven solely by CC as there is relatively little water resource development on the Oti. Slight increases in flows at some stations between intermediate and full development (e.g. Nawuni) can be attributed to intensification of upstream storage, i.e. through the construction of reservoirs. The flow downstream of Akosombo is estimated to decline by 80% (i.e. from 1,207 to 290 m^3s^{-1}) as a consequence of the combined impact of CC and upstream development.

Table 5: Changes in hydroelectricity generated and percentage of the total potential in each of the three development scenarios

	Current Development		**Intermediate Development**		**Full Development**	
	Hydroelectricity generated ($GWhy^{-1}$)	**% of total potential**	**Hydroelectricity generated ($GWhy^{-1}$)**	**% of total potential**	**Hydroelectricity generated ($GWhy^{-1}$)**	**% of total potential**
1983-2012	4678	77	6975	80	8378	79
2021-2050	3159	48	4779	53	5684	53
2071-2100	1569	24	2599	30	2946	29

Table 6: Changes in river flows (m^3s^{-1}) at four locations in the basin for the development scenarios.

	River	1983-2012	2021-2050	2071-2100
Current Development	Bamboi	288	251	160
	Nawuni	218	155	140
	Sabari	300	173	167
	Akosombo	1,207	808	408
Intermediate Development	Bamboi	243	217	136
	Nawuni	182	111	94
	Sabari	300	173	167
	Akosombo	1,140	739	346
Full Development	Bamboi	229	202	120
	Nawuni	184	107	93
	Sabari	300	174	168
	Akosombo	1,096	676	290

Conclusion

Effective water resources management is critical for successful adaptation to climate change. Although there remains great uncertainty about how climate change will impact the water resources of the basin it is clear that even under a mid-range scenario, the performance of existing and planned irrigation and hydropower schemes in Ghana could be severely constrained. Efforts for economic development will be undermined unless due consideration is given to the possible impacts of climate change and suitable adaptation measures introduced.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Capacity Development Tools for Improving Solid Waste Management Services Delivery in Metropolitan, Municipal and District Assemblies in Ghana

Kodwo Beedu Keelson

Abstract

The WastePro Software is suite of computer modeling tools that is currently being developed at the Kaaf University College in Ghana. The modeling capabilities of this desktop software application make it a suitable choice as a capacity development tool for waste management departments in developing countries. The Revised Environmental Sanitation Policy 2009 for Ghana identifies capacity development as a critical element for improving environmental sanitation services. Furthermore, it recognizes that there has been a decline in the coverage of services from the late 1970's which has continued and worsened. To overcome this deficit and make progress requires that there is urgent and scaled up capacity enhancement within the sector. This paper presents a technical description of the WastePro Software package and discusses how the various computer modeling tools can be used for institutional capacity development at the local government level in Ghana.

Introduction

The WastePro Software is being developed under the framework of the Waste Informatics Research Project at the Kaaf University College. This privately funded research project seeks to investigate and promote the use of information technology and information systems to support water and sanitation services delivery at the local governmental level.

The use of information technology in water management is now a common feature in both advanced and developing countries. Several Windows–based software applications such as MOUSE, HEC-RAS and SWMM have proved useful in the engineering design and rehabilitation of large urban water infrastructure projects. However, the use of ICT systems and tools in the environmental sanitation sector is very limited in spite of the potential benefits that could be realized especially in developing countries. The need to bridge this technological and knowledge gap has led to the development of the WastePro Software. This software package has been envisioned as a user friendly desktop application that can be used by researchers, practitioners and educators to deal with emerging challenges in the environmental sanitation sector.

This paper presents a technical description of this software package and discusses how the various computer modeling tools can be used for institutional capacity development to improve solid waste management services delivery at the local government level.

Technical Description

Software Structure

The WastePro software package is a suite of computer modeling tools which have been programmed in the Microsoft Excel 2003 environment. The software modules in the current version WastePro 2.0 (WastePro, 2010) include:

- WastePro Municipal Waste Manager Software
- WastePro Waste Generation Software
- WastePro Waste Haulage EDM Software
- WastePro Decision Makers ISWM Toolbox

Each computer modeling tool is an Excel workbook consisting of a specific number of worksheets. The worksheets consist of sections called Cell Blocks. The cell blocks in each worksheet are for data input or visualization of simulation results.

Graphical User Interface

The WastePro Software package has a Microsoft Excel interface that offers comprehensive functions for data handling and visualization. The cell blocks in all the worksheets are colour-coded in three different font colours to serve as a guide for the user as to what data needs to be provided, and what data is automatically calculated by the software module. The simulation results are presented in bar charts, scatter plots and pie charts which can be edited by any user who is familiar with Microsoft Excel spreadsheets. Some of the cell blocks are programmed to return an error message when input data for certain modeling parameters are not specified correctly.

Modeling Tools

<u>WastePro Municipal Waste Manager Software</u>

This solid waste cycle modeling tool simulates waste material flows through the various stages of the waste cycle i.e. waste collection, waste collection and transfer, waste treatment and waste disposal for a typical urban waste management system.

BOLAKROM WASTE STORAGE ANALYSIS | RESET | PRINT

Location	Waste Category	Design Population	Proportion (%)	Collection Efficiency (%)	Waste Generation (l/wk)	Available Storage Volume (l)	Removal Freq per week	Evaluation of Storage
Elekrovej	RESIDENTIAL	900	9%	89%	8,100	3,600	2	INADEQUATE
Tommerup	RESIDENTIAL	1,500	14%	71%	13,500	4,800	2	INADEQUATE
Kaastrup	RESIDENTIAL	800	8%	100%	7,200	3,600	2	ADEQUATE
Holte	RESIDENTIAL	1,400	13%	76%	12,600	4,800	2	INADEQUATE
Norrebro	RESIDENTIAL	700	7%	100%	6,300	3,600	2	EXCESS
Kongens	RESIDENTIAL	500	5%	100%	4,500	2,400	2	EXCESS
Naerum	RESIDENTIAL	950	9%	100%	8,550	4,800	2	EXCESS
Gentofte	RESIDENTIAL	450	4%	100%	4,050	2,400	2	EXCESS
Baekevang	RESIDENTIAL	2,300	22%	58%	20,700	6,000	2	INADEQUATE
Osterport	RESIDENTIAL	1,000	10%	100%	9,000	4,800	2	EXCESS
TOTAL		10,500	100%		94,500	40,800		O.K.

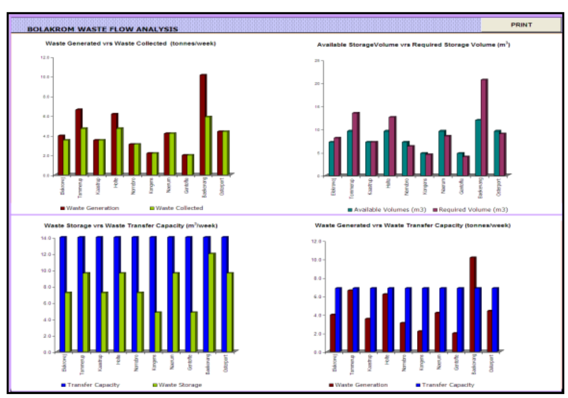

Figure 1: Municipal Waste Manager Software cell blocks for data input and visualization of results

Figure 2: Waste Generation Software cell blocks for data input and visualization of results

The software makes it possible for the user to estimate waste quantities, storage container sizes, collection frequencies, waste transport capacity as well as annual waste management revenues and expenditures. Figure 1 shows screenshots of cell blocks used for data entry and visualization of results in various Municipal Waste Manager Software worksheets.

<u>WastePro Waste Generation Software</u>

This sophisticated modeling tool performs the following functions:

- Waste stream/characterization analysis for five waste categories i.e. residential, commercial, construction/demolition, industrial and street cleansing waste.

- Waste generation forecasting for both steady state and non-steady state conditions based on location-specific demographic data.

Figure 2 shows screenshots of cell blocks used for data entry and visualization of results in various Waste Generation Software worksheets.

<u>WastePro Waste Haulage EDM Software</u>

This modeling tool allows the user to simulate waste haulage operations in an urban environment. It can also store and organize waste haulage services data in a standalone Microsoft Access database module to perform a range of design tasks including:

- Route Development – plan collection routes and prepare daily haulage schedules.

- Collection System Design – determine haulage volumes and WCV requirements.

- Business Performance Analysis – determine haulage revenues and disposal costs for specific collection days, haulage routes or service areas.

Figure 3 shows screenshots of data input cell blocks used for route development and collection system design respectively in various Waste Haulage EDM worksheets.

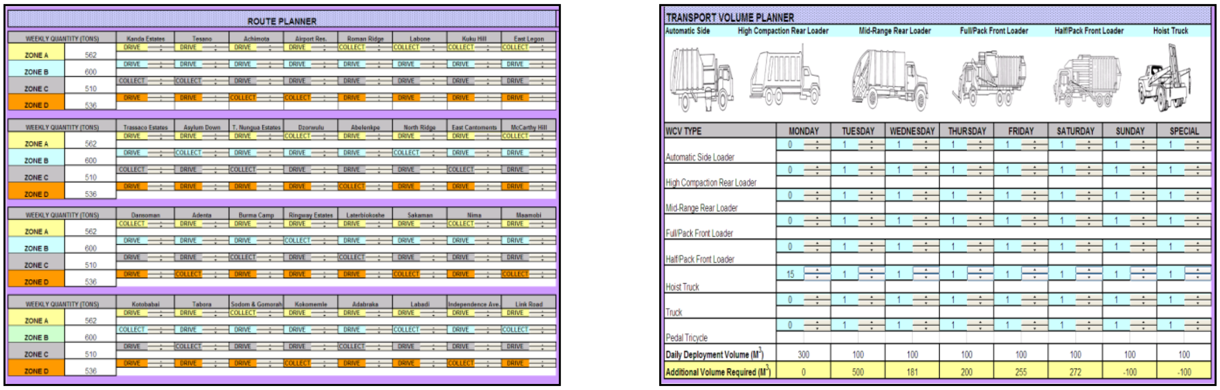

Figure 3: Waste Haulage EDM Software cell blocks for data input

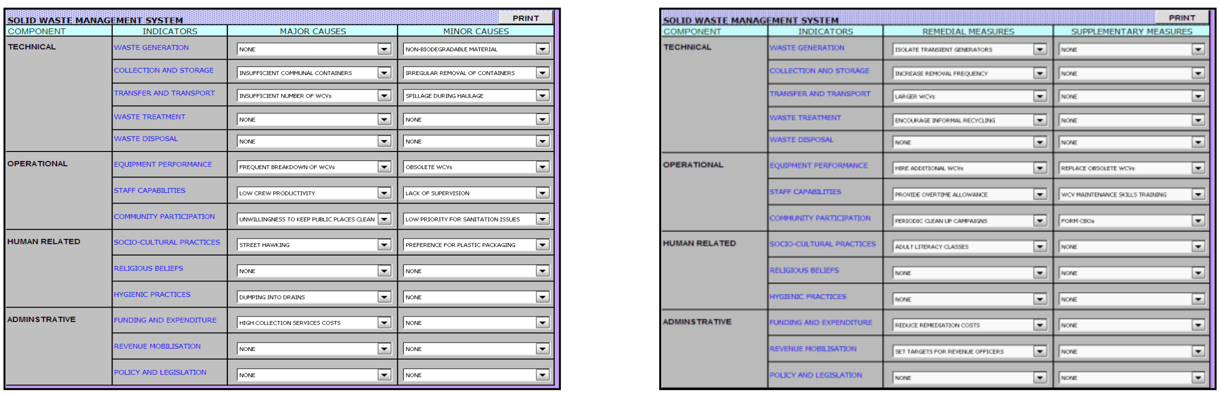

Figure 4: User interface for Decision Makers ISWM Toolbox

<u>Waste Pro Decision Makers ISWM Toolbox</u>

This is a rapid assessment tool which allows the user to adopt a strategic planning approach (Wilson et al., 2001) in evaluating urban waste management systems by considering a wide range of contributory factors i.e. technical, operational, institutional, financial and socio-cultural. It can also be used to administer a computerized aptitude test for waste management professionals to evaluate their knowledge and appreciation of integrated solid waste management concepts. Figure 4 shows screenshots of the user interface for the Decision Makers ISWM Toolbox.

Capacity Development for Improving Solid Waste Management Services Delivery

The Revised Environmental Sanitation Policy identifies capacity development (MLGRD, 2010) as a critical element for improving environmental sanitation services. Furthermore, it recognizes that there has been a decline in coverage of services from the late 1970's which has continued and worsened. To overcome this deficit and make progress requires that there is urgent and scaled up capacity enhancement within the sector.

The modeling capabilities of the WastePro software package make it a suitable choice as a capacity development tool for improving environmental sanitation services delivery in the metropolitan, municipal and district assemblies. Areas of application include:

- Training and aptitude testing for administrative and technical personnel in MMDAs.
- Decision support tools for planning, monitoring and evaluation of environmental sanitation services by waste management departments.
- Waste Information Systems for solid waste management planners and policy makers at the local, regional and national level.

Training and Aptitude Testing

The WastePro Software package can be used as a teaching and training tool (Kuschke et al., 2005) to deepen the knowledge of MMDA administrators and technical personnel in the field of solid waste technology and management. Administrators used in this context refer to MMDA chief executives and coordinating directors, whereas technical personnel refer to engineers, town planners and environmental health officers.

The Decision Makers ISWM Toolbox can be used for the training of MMDA administrators on new concepts such as *Materials in Transition* (MINT) that have been outlined in the National Environmental Strategy and Action Plan. This toolbox can also be used to administer a purposely designed computerized aptitude test, the Basic/Expanded ISWM Aptitude Test, for MMDA staff before and after a training or refresher course to assess its impact. It can also be used as a screening tool for potential employees being considered for appointments in MMDA waste management departments.

The Municipal Waste Manager software can be used as a teaching material (Davinson and Porrit, 1999) in institutions of higher learning and professional training such as the Kwame Nkrumah University of Science and Technology, Institute of Local Government Studies, Management Productivity and Development Institute etc. for continuous professional development courses in solid waste engineering and management either through on-campus or distance learning modes. A well illustrated 155-page Tutorial Manual provides comprehensive guidance on how to use this particular software application to model urban solid waste management systems.

Decision Support Tools

The WastePro software modules such as the Waste Generation Software, Municipal Waste Manager Software and the Waste Haulage EDM Software can be coupled as shown in Figure 5 to form a suite of decision support tools (Thorneloe et al., 2007) for MMDA waste management departments to design new waste management systems as well as the evaluation of alternative planning scenarios for solid waste management services delivery.

Figure 5: Coupling of modules for decision support at MMDA waste management departments

The increasing private sector participation in solid waste management services provision means that the MMDAs should be well resourced with requisite monitoring and evaluation systems (Cointreau–Levine and Coad, 2000) to be able regulate their activities. The Integrated Solid Waste Management Series, which is a set of technical reference manuals, have been purposely developed to assist MMDA waste management departments in using the WastePro software package to perform their solid waste management planning functions.

Waste Information Systems

Waste Information Systems (WIS) are now being adopted in many transition and developing countries. Typical examples include Slovakia (Hrebicek et al., 2001) and South Africa (City of Cape Town, 2004). The city of Cape Town, for example, has knowledge based waste management planning system incorporating a waste generation model that makes it possible to set waste reduction targets up to the year 2030.

The WastePro software modules such as the Waste Generation Software, Municipal Waste Manager Software and the Waste Haulage EDM Software can be used to set up local level WIS in the various MMDAs. Each MMDA-WIS will contain updated information on all the elements of the local waste management systems including equipment, facilities, level of services etc. The MMDA-WIS will facilitate the preparation of District-level Environmental Strategy and Action Plans (DESSAPs) by the various MMDAs (MLGRD, 2007) which are informed by a proper knowledge based system. It will also ensure the reporting of annual waste statistics in a standardized format that allows the creation of regional and national databases by the relevant state agencies such as the Environmental Protection Agency and the Environmental Health and Sanitation Directorate of the Ministry of Local Government and Rural Development.

Conclusion

This paper has presented a technical description and the potential applications of the WastePro Software package in improving solid waste management service delivery in the metropolitan, municipal and district assemblies in Ghana. The first stable version WastePro 2.0, which was programmed in the Excel 2003 environment, has been released. A number of field tests using this software package are being planned in the first quarter of 2012 for some selected MMDAs in the Greater Accra and Central regions. Future work will involve migration unto the Excel 2007 platform and the integration of open source GIS software modules into the waste haulage simulation tools.

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Keywords
Capacity development, information systems, decision support, teaching and training

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Rainwater Harvesting (RWH) as a Complementary Approach to Improving Water Supply in Ghana

Jemila Mashood, Joseph Ampadu-Boakye & Nii Odai Anidaso Laryea

Abstract

At the 2006 Climate Change Convention in Nairobi, Rainwater Harvesting (RWH) was recognised as a viable option to addressing the current water needs and providing security against future droughts in many African countries. This paper demonstrates that while RWH is a viable option for water supply, it has not received the required support for adoption and scaling up in Ghana The paper examines the reasons for the low interest and adoption of RWH in Ghana and concludes that the RWH technology can, in most cases be introduced as part of an integrated water supply system especially in areas where existing water supply sources are intermittent, unreliable and cannot provide all year round water supply. The paper recommends strategies to strengthen institutional support, adoption, scaling up and sustainability of RWH as an appropriate technology for water service delivery in Ghana.

Introduction

Rainwater harvesting is an old practice which has evolved over time and presently adopted in many countries of the world including Brazil, Togo, India, Kenya, China, and Germany among others. Rainwater harvesting means capturing the rain where it falls or capturing the runoff and taking measures to store that water for domestic use and other purposes. In Africa, countries such as Kenya by 1994 had more than 10,000 people who had already benefited from rainwater harvesting and many more facilities have been built since then (Mbugua, 2005). Several global and regional declarations have recognised rainwater harvesting (RWH) as a viable option for addressing water supply needs in many Sub Saharan African countries and to provide security against future droughts. Notable among these declarations are the 2007 Brazzaville Declaration by the African Ministerial Council on Water; the 2006 Climate Change Convention in Nairobi and the United Nations UNEP General Assembly of 2005 to the Commission on Sustainable Development. Governments that have endorsed RWH include Benin, Egypt, Ghana, Guinea, Kenya, Mauritania, Rwanda, South Africa, Swaziland and Zimbabwe (Partners for Sustainable Development, 2005).

The purpose of this paper is to assess the prospects as well as current levels of adoption of RWH as a water supply technology in Ghana, challenges with the adoption of RWH and to propose measures to scale up RWH as a viable water supply technology option in Ghana.

Prospects for Rainwater Harvesting

The national coverage rate for drinking water in Ghana for 2009 was estimated at 58.98% (Republic of Ghana, 2010). On account of this, about 38.26% of the existing population was yet to be served with potable water as at the end of 2009 especially in rural areas, low income urban communities and peri-urban areas. With an anticipated increase in population especially in urban areas, additional water supply resources are needed to meet the current supply gap and future increase in demand for water supply.

The National Water Policy and the Ghana Shared Growth and Development Agenda (2010-2013) affirm the Ghana Government's interest in developing alternative water supply sources including rainwater harvesting. However, despite these commitments, the level of adoption of rainwater harvesting as a water supply option has been minimal. The Ghana Statistical Service reported that only 0.6% of households (0.2% in urban areas and 1% in rural areas) used rainwater harvesting as a source of drinking water. There is currently no indication in the Strategic Investment Plan of the Community Water and Sanitation Agency (CWSA) to utilise rainwater harvesting as an option for drinking water supply in rural areas. In all, investments in rainwater harvesting under the National Community Water and Sanitation Programme (NCWSP) has been lower as compared to other water supply technology options such as boreholes, hand dug wells and piped schemes. In 2006 for instance, CWSA facilitated the construction of only 8 rainwater harvesting tanks as compared to over 1,300 boreholes in the same year (Republic of Ghana, 2008).

Ironically, Ghana has a fairly good amount of annual rainfall. Generally, Ghana's annual rainfall decreases from the south-west of the country (2,000 mm/year) towards the north (950 mm/year) and the southeast (800 mm/year) (WRC, 2010). Besides, rainwater harvesting serves as an alternative source of water supply in rural areas especially in areas that do not have conventional water supply systems. It is an ancient technology that is still relevant and in use for the supply of water in rural communities (Siabi et al., 2008). It is also reported that about 12,000 people in 42 communities in the Volta and Eastern Regions of Ghana were served with rainwater harvesting facilities under the DANIDA financed water and sanitation interventions facilitated by CWSA (ibid). The implication is that rainwater harvesting could be a viable water supply technology option in these areas and in other parts of Ghana which have challenges with surface and groundwater sources.

A number of reasons account for the low level of adoption of rainwater harvesting technology. First, it has been established that the initial capital investment for rainwater harvesting is relatively high. According to Siabi, W. et al (2008), about seven (7) rainwater harvest tanks will have to be provided as compared to only one (1) borehole to meet the water supply needs of a community of 300 persons with per capita water demand of 20 litres /person/day.

Table 1: Comparable investment cost for rainwater and boreholes in small communities.[8]

Community sizes (Population)	150	250	300	400	500
Expected number of 50m^3 rainwater tanks required for 100% water coverage	4	6	7	10	12
Expected number of boreholes required according to population size.	1	1	1	2	2
Cost of rainwater facilities required to achieve 100% water coverage (million cedis)	208	312	364	520	624
Cost of boreholes required to achieve 100% water coverage (million cedis)	70	70	70	140	140

[8] Siabi et. al. (2008)

NB: *One 50m^3 rainwater concrete tank cost 55 million cedis.*
A borehole fitted with hand pump cost 70 million cedis.

The investment is however less risky as compared to investment in groundwater supply. Besides, given the lifespan, and operation and maintenance cost of the rainwater harvesting tank and the borehole or hand dug well, the rainwater harvest tank is cheaper in the long term.

Other reasons include the low level of adoption of rainwater harvesting technology, limited demonstration facilities, the perception that rainwater quality is suspect as compared to groundwater and treated surface water sources, inadequate financing and inadequate building regulatory framework to support rainwater harvesting.

Key Lessons

- Rainwater harvesting facilities are currently being used in selected regions in Ghana as a water supply service and could serve as a basis of assessing prospects for scaling up the technology option for household and communal use.

- Rainwater harvesting has comparatively high initial investment cost but given the lifespan, and operation and maintenance cost of the technology, it is comparatively cheaper in the long term than groundwater sources.

- Given the initial investment requirement, it is more feasible to promote rainwater harvesting at the household level in the short term and to focus on communal level use in the long term

Recommendations and Conclusions

- The Ministry of Water Resources, Works and Housing should support CWSA to assess the prospects of using rainwater harvesting for water service delivery in areas where surface water and groundwater resources are not readily available and difficult to access. This strategy should culminate in a review of the CWSA Strategic Investment Plan (SIP) to include rainwater harvesting technology option. The strategy should be backed by a comprehensive nationwide awareness creation on the benefits of rainwater harvesting as a water supply technology option.

- The Ministry of Water Resources, Works and Housing through CWSA and GWCL should develop guidelines for rainwater harvesting as a drinking water supply system. This should be supported by providing training for Planners, Architects and Contractors on the need to include rainwater harvesting facilities in the designs of buildings. Existing and prospective real estate developers should also be encouraged to provide gutters in the roofs of building designs to enable harvesting of rainwater into receptacles for use by occupants.

- Extensive public education should be provided for households on the need to harvest rainwater in water receptacles/storage tanks as the starting point. This should be accompanied by simple household level water treatment methods. In the long term, a more sustainable approach should be shared investment for communal use with consideration for models that focus on cost reduction.

- There is currently lack of information on knowledge levels and skills in rainwater harvesting at the national, regional and district levels in both the public and the private sectors. This would require a detailed assessment of the human resource capacity at all levels to establish existing capacity needs that would be required to support the promotion, operation and maintenance of rainwater harvesting as a technology for water service delivery.

- The Ghana Government should demonstrate commitment by adopting an innovative financing arrangement for the provision of RWH facilities both at the community level through CWSA and at the household level by providing seed money for micro finance for households who adopt RWH.

- An Inter-Ministerial dialogue process should be initiated by the Ministry of Water Resources, Works and Housing and should include the Ministries of Finance and Economic Planning, Local Government and Rural Development, Education and Health. The dialogue process should review modalities and approaches that will ensure implementation of the policy measure that "due consideration be given to water harvesting as a source of water supply in building regulations" (Ghana National Water Policy 2007 page 28)

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Decentralised Water Supply for Low Income Urban Areas: Institutional Arrangements and Forms of Agreement

Kwabena Nyarko & Tim Hayward

Abstract

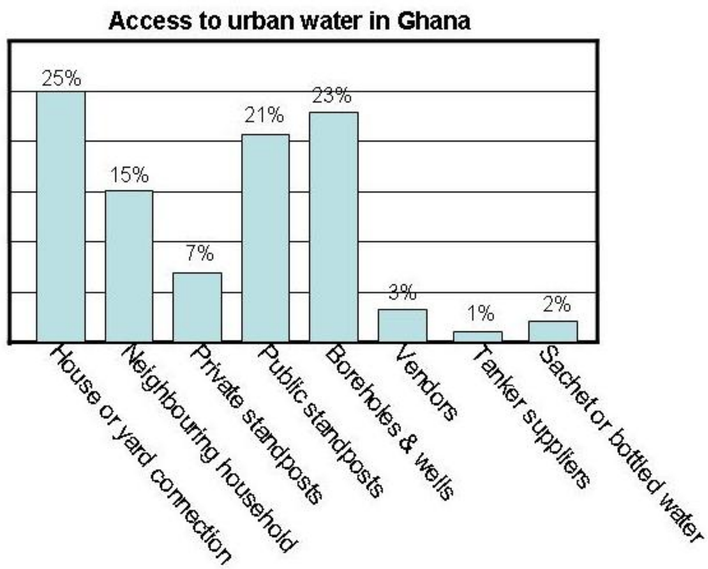
Water and Sanitation for the Urban Poor (WSUP) has been working on the development of community and private sector approaches that address the inadequate water and sanitation services in low income urban areas in Ghana. The paper is based on WSUP's experience of implementing the USAID-funded OWAS project in Kotei, Kumasi, and also the CHF project in Avenor, Accra. It explains the challenges faced by GWCL in increasing water supply provision to under-served urban areas and highlights some alternative service delivery approaches that are being trialed by WSUP and CHF. It focuses on the process of close consultation that WSUP has taken with Ghana Water Company Limited (GWCL), traditional leaders and a Community Management Committee that has been established by WSUP and it describes the institutional model that has now been agreed upon by all parties. The paper discusses the challenges faced and compares and contrasts the Kotei model with other similar initiatives currently taking place in Ghana. The paper concludes with some comments and recommendations on the general applicability of such an approach in Ghana and the implications for current policy and practice if scale up of a decentralised approach to service delivery is to be achieved in Ghana.

Introduction

In many developing countries, including Ghana, a major characteristic of urban water service delivery is that the urban poor, most of whom live in low income settlements and peri-urban areas, are usually the last to be served (Addo-Yobo and Njiru, 2006). Consequently large proportions of the urban poor are not served directly by formal utilities and are compelled to resort to unsafe and/or expensive sources of water.

In Ghana, the formal urban water utility provider, Ghana Water Company Limited (GWCL) estimates coverage to be only 59% based on water production and the estimated water demand (MWRWH, 2010). The fifth round of the Ghana Living Standards Survey revealed that people living in urban areas access water from eight different sources as indicated in the diagram below (GSS, 2008). The diagram also illustrates that a significant proportion of urban dwellers do not have access to GWCL services. A consultative citizens report card conducted in Accra by the World Bank (World Bank, 2010) revealed that a greater proportion of the households with lower household incomes lack a connection to the GWCL system compared to the households with high income. Consequently, the worst affected by inadequate GWCL services are the urban poor and the lack of access to the urban poor is one of the major challenges identified in the national water policy which calls for the development of strategies to serve them better (GOG, 2007).

In response to this, Water and Sanitation for the Urban Poor (WSUP), a not-for-profit partnership between NGOs, the private sector and academia has been working in Kumasi with GWCL and the Kumasi Metropolitan Authority (KMA) since 2009 on the development of financially viable community and private sector approaches to improve water and sanitation services in low income urban areas. WSUP supports local service providers[9] to design and implement water and sanitation solutions that serve the needs of the urban poor in developing countries.



This paper presents the experiences and lessons learnt from providing decentralised borehole fed water services to the urban community of Kotei, in Kumasi, based on the work that WSUP has been supporting, and makes recommendations for adopting these approaches elsewhere in Ghana. A key aspect of the work in Kotei is the design of an appropriate institutional arrangement, a sound business plan and clear forms of contract for the efficient management of the water system. The paper begins with the status of water supply service delivery to the urban poor and WSUP's experience in supporting the delivery of water services to the community of Kotei. It concludes with a discussion of lessons learnt and identifies a number of policy recommendations.

Water Service Delivery for the Urban Poor in Ghana

Water supply delivery in Ghana is classified as either urban or community in the national water policy (GOG, 2007). Urban water supply delivery refers to water supply by Ghana Water Company Limited (GWCL) which is responsible for 82 systems supplying water to urban areas in Ghana. Community water supply refers to the rural and small town systems that are the responsibility of the District Assemblies. These systems follow a Community Ownership and Management (COM) approach, where the community representative, the Water and Sanitation Development Board (WSDB), is responsible for managing the water system. The community members are responsible for all the operations and maintenance of the water system through the tariffs, but formal ownership of assets rests with District Assemblies.

GWCL has the mandate to deliver water supply to all urban residents but their services fail to reach all especially the urban poor. Low income urban communities are characterised by unplanned and informal settlements, insecure tenure to land, irregular income and weak social networks (Addo-Yobo and Njiru, 2006). The policy of GWCL is to lay pipes according to the approved street layout but there are many inhabited areas without approved layouts. The danger of extending GWCL services in such areas is that GWCL could be liable for the cost of relocating the network to suit future layouts. GWCL has been able

[9] The term Local Service Provider (LSP) includes water utilities, municipal service authorities, and small independent providers such as private water operators, suppliers of sanitation products and services, community based organisations and water trusts and associations.

to provide water to some areas without approved layout by working closely with the Districts Assemblies to agree on the location of the road. Currently, the formal water sector lacks the capacity to improve water supplies to the poor and un-served in urban Ghana (AMCOW/WSP, 2010). As recommended in the national water policy, new methods and approaches to addressing their needs are therefore required as the formal utility business model does not currently target the urban poor.

The urban water utility regulator, Public Utilities Regulatory Commission (PURC), has started focussing on the provision of water to the urban poor, in line with its mandate to protect the interests of both consumers and providers of utility services. PURC has been piloting interventions that involve community management of bulk water supply to generate lessons to guide replication in regulatory decisions and future policy whilst bringing benefits to the urban poor. PURC pilot interventions have been based on extension of GWCL's network or use of water tankers to supply to communities. In all the pilots, the community representative (water boards) was responsible for the management of the water schemes.

In addition to the pilots by PURC, there are other initiatives. CHF[10], with funding from USAID, has extended the GWCL network to the community of Avenor in Accra and provided house connections, water kiosks and standpipes to the residents. The management model is direct community management whereby the community representatives, through a water and sanitation board, are responsible for operation and maintenance as well as bill collection. The water board has an arrangement with GWCL to carry out repairs and maintenance for a fee.

The challenge of providing urban water services to the poor is summarised in the national water policy as "achieving equity in access to water supply for peri-urban and urban poor to meet their basic needs at affordable cost" and calls for an understanding of the needs of the poor and designing interventions to suit their supply and payment choices (GOG, 2007). Furthermore, the policy encourages cooperation between private operators and small-scale independent providers, rather than grant exclusivity to either party, to facilitate adequate and affordable provision of safe drinking water to un-served and underserved areas. The experience in Kotei and Avenor indicate that shared responsibilities between the community and GWCL present promising approaches to scaling urban water service delivery which are also closely aligned with the national water policy directives.

WSUP Supported Process of Improving Urban Water Service Delivery in Kotei, Kumasi.

WSUP is supporting efforts of local service providers in Kotei, which is part of the Oforikrom Constituency, to improve access to potable water and sanitation services by local residents. Kotei is a suburb of Kumasi located about 10 kilometres southeast of the central business district. Prior to WSUP's intervention 86 % of the residents in Kotei old township (project site) were relying on water supply either from their neighbours or hand dug wells and boreholes (CARE, 2007). Currently water sells at Ghs 2.8 per m^3 (5 Gps per 18 litre bucket) compared to GWCL residential tariff of 80 Gp per m^3 for the first 20 m^3 or Ghc 1.20 per m^3 for consumption more than 20 m^3.

WSUP works by harnessing both local and global expertise to deliver improved water and sanitation services to the urban poor and by developing innovative management models. WSUP's approach is to improve the interface between low income communities and local service providers (LSPs), to increase

[10] The aim of all CHF's work is to build the capacity of local partners, governments and the private sector to create communities who are economically, socially and environmentally self-sufficient.

the capacity of the users to demand for greater accountability and for local service providers to provide improved levels of service to the urban poor.

WSUP started by facilitating the establishment of the Kotei Community Management Committee (CMC) which will be responsible by contract for the management of the water supply and sanitation facilities for the community. The CMC takes their legal authority from the Oforikrom Sub-Metropolitan Council[11] and are governed by a constitution. Representation on the CMC is by nomination from traditional leaders, opinion leaders, women's groups, the youth club, the Oforikrom sub-metropolitan council, GWCL and the Assemblyman for the area. The members serve a term of four years and are eligible for two consecutive terms.

In close consultation with the CMC, GWCL and the Oforikrom sub-metropolitan council three institutional management models were considered for the water supply system. The system is made up of mechanised boreholes with an overhead reservoir and a network of pipes and standpipes for a population of approximately 4,000 people. All of the assets will be owned by GWCL.

The three models were:

1. Direct GWCL Management

Complete handover of the Kotei water systems to GWCL. The water system would be integrated into the GWCL system and would be fully managed by GWCL. The advantage of this model is that GWCL has the requisite technical expertise and the tariff levels would be the lowest. The main challenge could be GWCL's ability to deliver a good quality of service and tariff collection from the community which could be difficult for GWCL.

2. Community-Utility Partnership

An arrangement between GWCL and the CMC for managing the water system. There may be variations on this depending on how the risk is shared between GWCL and the CMC but in practice, two options were considered. These approaches have the advantage of combining the strengths of both GWCL and the CMC but there is a greater risk of the mismanagement of funds.

Option A – GWCL management contract with the CMC for technical and commercial aspects such as operation and maintenance and revenue collection. The CMC may choose to delegate all this to a private operator to execute the task on its behalf

Option B – GWCL service contract with the CMC only for revenue collection. GWCL would take responsibility for all the technical aspects such as operations, maintenance and replacement of assets whilst the CMC takes responsibility for the collection of tariffs and pays a bulk water tariff to GWCL. The CMC would use their skills and knowledge to manage relevant aspects of the water supply operations to ensure a high level of revenue collection and that it is operated in the best interests of the community and GWCL

3. Direct Community Management

The community would take overall responsibility for the water system including water production, distribution, billing and collection as well as operations, maintenance and assets management. In this case tariffs are not guided by the PURC tariffs and would be much higher due to dis-economies of scale.

[11] Under Local Government Act 462 the Metropolitan Assembly has the authority to delegate functions, other than legislative, to "a sub-metropolitan council…or any other body …determined by the Assembly".

Another disadvantage of this model is that in the future when GWCL's network services become available an independent system would collapse due to the availability of cheaper alternative services. However there would be a high sense of ownership by the community.

The choice of the institutional model was based on community involvement in the delivery of services, arrangements that strengthen GWCL to deliver services to the poor and innovative models that may be relevant to other urban areas in Ghana. At a stakeholder workshop the Utility-Community Partnership Option B was endorsed. Thus GWCL will own the assets and take responsibility for operations, maintenance and capital maintenance, and the CMC will hire vendors to manage the standpipes, take responsibility for tariff collection, payment of vendors, payment of GWCL water bill and act as an interface between the utility and the community.

Initially the community had been in favor of direct community management due to their mistrust of GWCL. However, during the stakeholder consultation process GWCL made a significant contribution in offering to drill the boreholes at their cost. GWCL also oversaw the technical design of the water system. The financial model also indicated that direct community management would have the highest tariff. The stakeholders endorsed the utility-community partnership because it was seen as a "win win" situation for both parties.

Following the selection of the institutional model, contracts have been drawn showing clear delegation of responsibilities for smooth and efficient delivery of water services. There is one agreement between the CMC and the water vendors and another agreement between the CMC and GWCL. All parties were consulted during the writing of the contracts.

This approach for improving water services is also in line with PURC's strategy for involving communities in the delivery of services to the urban poor and also has similarities with other pro-poor initiatives. All the pro-poor initiatives are using the community representatives (Water Boards or Community Management Committees) in the management of the water system. The Avenor model contrasts with the model in Kotei where GWCL is responsible for all the technical aspect of the water system whilst the CMC takes responsibility for bill collection. The implication of the Avenor model is that the bulk water tariffs should be less than the PURC approved tariffs for standpipes or lifeline to compensate for the water boards responsibility for the technical aspects such as repairs and maintenance.

Lessons in Implementing Water Services for the Urban Poor

The experience discussed above of implementing water service delivery in Kotei has provided a number of lessons.

The involvement of the community, i.e. the users, is important for designing an appropriate model that meets the expectation of the community. All the pro-poor interventions were implemented with the active involvement of the communities to provide context specific solutions to the community needs. The process must therefore involve consultation with the community and local service providers in order to develop viable sustainable solutions. However, WSUP's experience reveals that GWCL does not have specific officers with the skills to liaise between the utility and the communities to address pro-poor concerns.

The appropriate bulk water tariff is currently unclear and not regulated. The experience of CHF has revealed a lack of clarity on the issue of bulk water tariffs for communities that take responsibility for operation and maintenance of a water system. For example, in Avenor bulk water tariffs are still being discussed and in Kotei the tariffs at the tapstands will be the GWCL approved tariffs. Clear guidance on bulk water tariffs from PURC is required.

Scaling up pro-poor interventions country wide requires financing and cost reflective tariffs to extend distribution systems into un-served and underserved urban areas. In Kotei the project is funded by USAID and GWCL contributed by drilling two boreholes. However, financial modeling showed that for the system to run independently of GWCL a cost recovery tariff (i.e. a tariff that covers all capital and maintenance costs) five times higher than standard PURC-approved tariffs would be required. Therefore urban poor users would be paying higher tariffs than regular GWCL customers. This underlines the need for a holistic review of urban water tariff policy. GWCL as the urban water monopoly provider benefits from economies of scale to provide services at the cheapest cost. Yet still the urban poor are clearly not getting the full benefit of GWCL's services. Therefore, strategies for GWCL to use their existing business to leverage funding to extend services to achieve universal service obligation should be examined. For example the use of the tariff structure to generate dedicated funding to serve the urban poor could be explored by GWCL and PURC.

Conclusions and Recommendations

The partnership between GWCL and the CMC in Kotei for delivering water services is promising as it employs the strengths of both GWCL and the CMC to ensure sustainable service delivery beyond the provision of the water infrastructure. The experience gained in Kotei and other pilots leads to the following recommendations if large scale improvements to the delivery of urban water services are to be achieved in Ghana:

- GWCL should use its monopoly power to leverage funding to deliver services to all. Furthermore, PURC should require GWCL to provide a plan with cost implications of ensuring universal service coverage including services to the urban poor.

- PURC should review the current tariff structure and provide clear guidance on bulk water tariffs when GWCL supplies bulk water for community management.

- A framework and guidance for community-utility partnerships based on ongoing pilots should be developed by the Ministry of Water Resources Works and Housing to guide future supplies to low income urban areas of Ghana.

- Given the wide recognition of the importance of community engagement GWCL should establish a specific team with staff of appropriate skills to support this and to develop and promote the importance of pro-poor service expansion/universal service within the company.

Acknowledgement

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Performance of a Multi-District Water Supply Scheme in Ghana – Case Study of the Three District Water Supply Scheme

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Abstract
In Ghana, small town water systems have increasingly become a popular method of water service delivery in rural and small town communities. Meanwhile the performances of most small town water' schemes are unknown and not sufficiently understood. The study examines the performance of the first complex multi-district small town water supply scheme, the 3-DWSS managed by three local authorities and a private operator. Based on key informants' interviews with local authorities, Community Water and Sanitation Agency (CWSA) and Private Operator (PO); focus group discussions (FGD) with management team, WATSANs and WSDB members; and household surveys with the users, technical and financial performances of the scheme. In addition household survey was conducted with 305 household to measure customer satisfaction to supplement the quantitative performance indicators. The findings of the study revealed that the 3-DWSS is performing well with respect to the CWSA technical and financial indicator targets. The household survey revealed a high customer satisfaction of the service, which confirms the good performance obtained by the objective indicators.

Introduction
The small towns piped system currently serves 1,816,891 inhabitants (CWSA 2009). Increasingly, multi-village piped schemes are being implemented for cluster of towns/villages when there are water resource constraints in the individual communities. The Community Water and Sanitation Agency (CWSA) has recently facilitated the construction of the three district water supply systems (3-DWSS), which is presently the biggest small town water supply scheme in Ghana, serving a population of about 115,092 in 130 communities and 18 institutions (Maple Consult, 2008).

The performances of most small town water' schemes in Ghana are unknown and not sufficiently understood. The performances of the water systems in relation to the CWSA norms are important to inform decision making for sustainable water service delivery. Performance measurement can be defined as an approach to determine how effectively and efficiently a local body delivers the required service (Gupta, 2006). There are a number of performance indicators that can be used to measure the performance of the water systems. Some of the indicators used by WSP (2006) to measure the efficiency of water supply systems are investment, financial, billing and collection, water quality, costs and staffing, metering, unaccounted for water (UFW), production/consumption, coverage etc. Owusu (2010) indicate that performance measurement of water systems for service delivery requires the views of the users on level of satisfaction.

This paper assesses the performance of water service delivery of the three-District Water Supply Scheme (3-DWSS) which is considered the biggest and most complex small town water supply system currently in the country with respect to technical, financial and customer satisfaction.

Methodology

The assessment of the system performance was based on analysis of historical data, key informant interviews and household surveys carried out from August 2010 to November 2010.

The analysis of historical data was from monitoring reports from operating teams and the Water and Sanitation Development Boards (WSDBs), and annual and quarterly technical and financial reports from the Private Operator/District Assemblies. The performance indicators used and their targets set by CWSA are shown in Table 1. In addition, key informant interviews were conducted with the private operator, staff of the three beneficiary District Assemblies (Dangme East, Dangme West and the North Tongu Districts), WSDBs and Greater Accra regional CWSA staff for explanation of the trends in the indicators.

Table 1: Performance Indicators used for the study

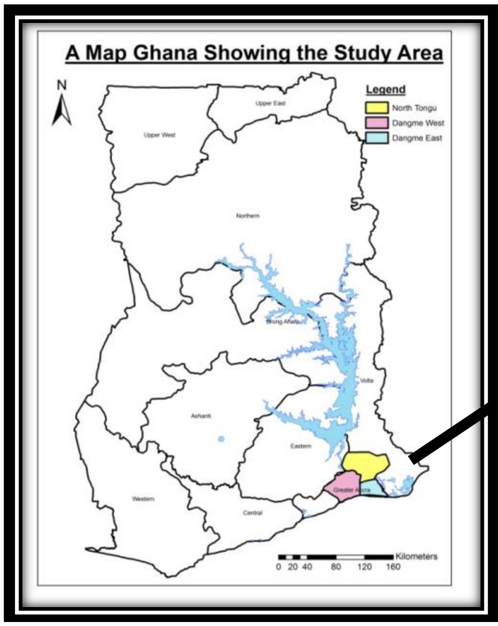
Indicator	Targets (%)	Indicator	Targets (%)
Unaccounted for Water	UFW<15%	Reliability	RE>95%
Self Financing Ratio	SFR>100%	Revenue collection efficiency	RCE>75%
Water quality monitoring	At least twice per year	Accountability:	
		Internal auditing	At least quarterly
		Reading of reports to communities	At least twice per year

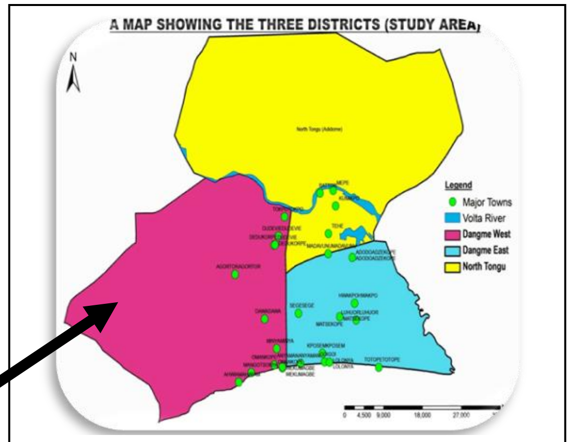
Source: CWSA (2005)

The household surveys were conducted in 305 households in 32 out of 120 communities on customer satisfaction. The survey covered the following aspects water quality, quality of service, impression of tariff and service continuity.

Description of the Study Area and the 3-DWSS

The three-district water supply scheme (3-DWSS) involves three different districts namely Dangme East, Dangme West and the North Tongu. While Dangme East and West are found in the Greater Accra region, the North Tongu is in the Volta region. The Districts are predominantly rural (82%) with crop farming, fishing and livestock rearing as their major means of livelihood. The Figure 1 below shows the three districts and some locations of major towns benefiting from the scheme.





District	No. of com.	Pop.	No of SP
Dangme East	54	52,987	147
Dangme West	41	28,135	81
North Tongu	31	24,907	72

Figure 1: The map of Ghana showing the study areas (the 3 Districts).

The 3-DWSS has its energy source from the national power grid, a standby Baifa diesel generator (100KVA); a booster station with 400 cubic metres ground tank; and fifteen high and low lift pumps. Also there are eight high level tanks with a total capacity of 1,450 cubic metres, Slow Sand Filtration (SSF) installations (3,600 cubic metres capacity), pipe network of a total length of approximately 400 kilometres and other facilities and installations such as 109 private connection chambers, hydrants, access chambers, valve chambers and etc.

Results and Discussions

These results are presented under subheadings technical, financial and customer service satisfaction assessments.

Technical Performance

Technical performance gives a clear indication on how the water system is performing in terms of the operational functions. The key technical performance indicators assessed were water quality and monitoring, unaccounted for water and service reliability.

The assessment of water quality was done with respect to the frequency of monitoring and the water quality test. The result reveals that the scheme satisfies the CWSA water testing monitoring requirement which is at least twice a year. On the water quality assessment, the scheme satisfies both the physico-chemical and bacteriological quality standards of Ghana Standards and CWSA guidelines for drinking water. Thus 3-DWSS meets the standard water quality testing and monitoring requirements unlike systems like the Mim and the Wenchi without any water quality monitoring compliance with reported colour (iron) problems (Owusu, 2010).

The unaccounted for water (UFW) set target in the contract document and the CWSA guideline value of less than 15%. UFW is the actual losses due to physical leakages, illegal connections and unbilled authorised consumption like water for cleaning reservoirs and fire-fighting. The vast nature of the scheme made it difficult for the PO to disaggregate UFW especially to give physical losses only. However, the management believes that most of the UFW is due to physical leakages on the main pipeline (especially the 2 Km stretch within Dedukorpe and Sege) since there is no record of illegal connections and hardly used fire hydrants. Also leakages within settled areas are not reported by community members early instead they fetch the water for free.

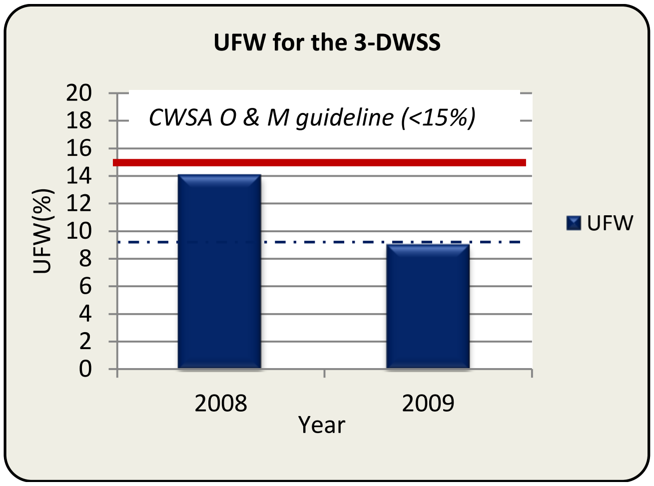


Figure 2: Annual unaccounted for water

The results of UFW meets the CWSA guidelines for the first two years of operation (see Figure 2). The high percentage of UFW in 2008 is attributed to seven recorded cases of cattle herdsmen who pouched pipelines for their cattle to drink. Most of such cases were within non settlement areas which were difficult to detect early. The number reduced to one case in 2009 and no case reported in 2010 after the water board and the DAs sounded a strong warning to the Fulani herdsmen. According to the management team, measures are being put into place to reduce UFW to avoid wastages and increase profit margin. The DAs are educating community members to report leakages early enough and instead of fetching for free.

CWSA guidelines (CWSA, 2005) propose that the service reliability should be greater than 95% in order to achieve the public health benefit. CWSA defines service reliability here as the ratio of the number of operational days to the total number of days per year normally expressed as a percentage (CWSA, 2005). Figure 3 below shows the service reliability as reported by Private Operator (PO) for 2008 and 2009 and confirmed by WSDB and WATSANs.

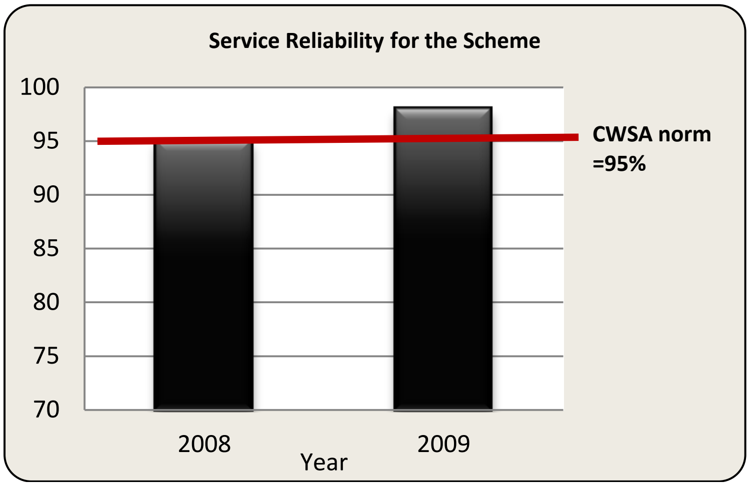


Figure 3: Service Reliability for 3-DWSS

The relatively low service reliability in 2008 is attributed to the high frequent power cuts within that year. According to the operating team, the fuel (diesel) needed to run the gen sets (as standby energy source) was expensive and could not afford it all the time because of the schemes' wider coverage requiring lot of energy. For the 2010 year the team expected service reliability of about 95% (less than 2009) because the scheme for the past two months had been running on three (3) high lift pumps instead of the six provided (three damaged)making it impossible to run every day.

Financial Performance

The financial performance of the scheme is assessed using revenue collection efficiency and cost recovery. At the start of operations, the revenue collection efficiency (RCE) was 30% when the WATSANs were in-charge for the revenue mobilization from the vendors for 5 months. When the PO was put in-charge after the WATSANs' poor performance, the efficiency shot up to 99%. Though the change over has resulted in poor working relations between the WATSANs and the operator, it has prevented huge revenue losses from users. Also the revenue collection efficiency with the private institutions and individuals is 100%. However, the collection efficiency with government institutions is poor because of delays in payment where in a particular instant over a year bill had not been settled by the ministry.

According to management of the scheme, the larger consumer is community users (over 95%) and higher RCE (99%) with this group is positive for the whole system. Though the overall RCE looks good but for long term sustainability, RCE should be 100% by instituting effective mechanisms to improve efficiency with the government institutions. 100% RCE is more recommendable in terms of sustainability even though from the CWSA Operations and Maintenance guidelines (CWSA, 2005), the RCE should be 75% or more.

CWSA uses the self financing ratio (SFR) for cost recovery assessment and satisfactory SFR should be greater than 100%. The SFR of the operator is approximately 102% (see Box 1 below) based on the 2009 records. The result indicates a satisfactory cost recovery for the system using the CWSA norm though figures used in the computation exclude revenue from institutions and commercial businesses. The private operator believes subsequent years will follow similar self financing ratio.

Box 1

Customer Satisfaction

The customer satisfaction analysis is based on water quality, quality of service provided, impression on water tariffs, need for continuity of the service (see Figure 4).

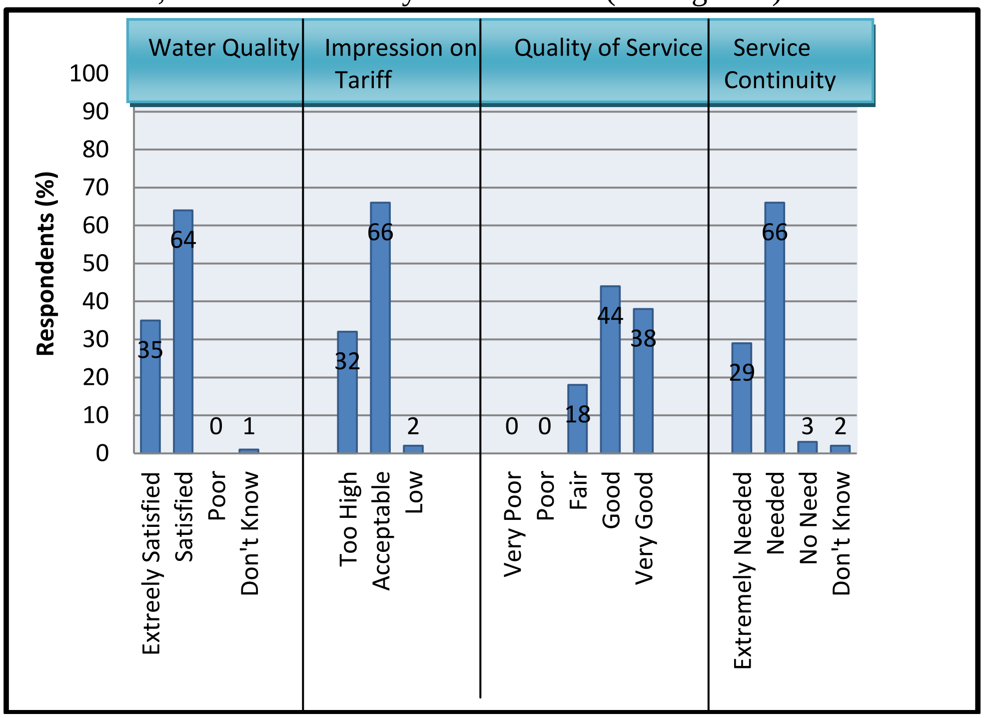


Figure 4: Customer satisfaction ratings

Approximately 99% of respondents are satisfied with the water quality and indicated they drink water from the water system though this study did not perform any water quality test.

Majority of the respondents (66%) were of the view that the water tariffs levels are acceptable and the rest (33 %) felt the tariffs are expensive. Currently users pay GH¢0.05 (US$ 0.035) for 18 litres (34 cm size bucket) instead of GH¢0.02 (US$ 0.014) per the 18 litre as a means for communities to complete their outstanding 5% capital cost contribution towards the water scheme construction. It is understood that upon the complete payment of the capital cost contribution the tariffs will be reverted back to the GH¢0.02 per 18 litre. The system does not have special tariff provision for poor and vulnerable consumers. In summary, majority of consumers (82%) are pleased with the quality of service received from the water scheme. On the basis of service continuity, most respondents (95%) want the services being provided so far to continue.

Conclusions

The three district water supply system is performing very well after two years of operation. Based on the CWSA Key Performance Indicators analysed, the 3-DWSS meets the requirement of water quality standards (water quality testing and monitoring frequency), self financing ratio, un-accounted for water (UFW), service reliability and revenue collection efficiency. Furthermore, the consumers are satisfied with the service. Thus the overall performance of the 3-DWSS is good from technical, financial and customer satisfaction assessments. The water system is operated by the private operator who has the incentive to improve performance since their management fee is linked to quantity of water that is delivered to the users.

For the purpose of long term sustainability, performance could be improved especially by addressing the few challenges such as delays in payment of bills by government institutions; frequent pumps breakdowns, frequent power fluctuations, delays in the detection of leakages, etc. Further studies are recommended on the scheme for performance monitoring with time as the system becomes old and also on partnership performance between the District Assemblies and the Private Operator to get a complete story for similar water schemes.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Cancer Health Risk Assessment of Resident Adults and Children from Exposure to Arsenic in Contaminated Water Bodies in Obuasi Municipality

S. Obiri, A. F. Armah & A. P. Awuah

Abstract

Cancer health risk was assessed for resident adults and children from exposure to borehole, tap and surface water in the Obuasi Municipality in line with USEPA's (US Environmental Protection Agency) Human Health Risk Assessment guidelines. The results of cancer health risk for resident adults in Obuasi exposed to arsenic in their tap water for both Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME) parameters respectively are 6.6 x 10^{-4} and 5.5 x 10^{-6}, which means that approximately 7 out of 10,000 resident adults in Obuasi who are exposed to arsenic in tap water are likely to develop cancer related diseases by CTE parameters and 6 out of every 1,000,000 resident adults are also likely to develop cancer related diseases by ingesting arsenic in the tap water per RME parameters. For resident children, we had 4.3 x 10^{-3} and 4.6 x 10^{-3} by both CTE and RME parameters respectively. That is, 4 and 5 resident children out of every 1,000 children are likely to suffer from cancer related diseases by both CTE and RME parameters respectively, which is above USEPA's acceptable cancer risk range of 1 x 10^{-6} to 1 x 10^{-4}, i.e., 1 case of cancer out of 1,000,000 people to 1 case of cancer out of 10,000 people.

Introduction

Surface water in most mining communities in Ghana have become unfit for human consumption due to chemical contamination from gold mining and processing activities such as roasting of arsenopyrites ores and cyanide heap leach methods (Obiri, 2007). Obuasi municipality, the primary focus of this paper has a long history of gold mining which dates as far back as AD 1896. Studies conducted by several scientists has revealed that most water bodies in the study area as well as other gold mining communities have high levels of inorganic arsenic (Adimadoo and Amegbey, 2003; Carbo and Serfor–Armah, 1997).

Oral and dermal exposure to arsenic in water causes a lot of diseases among which include gastrointestinal symptoms such as nausea, diarrhoea, loss of water, central and peripheral neuropathy, cancer of the skin, lung, liver and blood, skin pigmentation such as hyperkerotosis, melanosis, blackfoot disease, reproductive toxicity (see figure 1 below for pictures of patients with symptoms of arsenic related diseases).

Figure 1: Pictures of residents suffering from arsenic induced hyper pigmentation and black foot disease.

However, no work has been done in the area of assessing and quantifying the cancer health risk. It is against this background that this study was undertaken to address concerns faced by residents of Obuasi municipality and Ghanaians in general over exposure to carcinogenic chemicals in tap, borehole and surface water. The study seeks to answer two fundamental questions that residents in the Obuasi municipality have posed time without number:

1. What are the risks associated with exposure to carcinogenic chemicals in tap, borehole and surface water?

2. How serious are they in terms of their levels and prevalence?

Answers to these questions have their roots in cancer and non–cancer human health risk assessment and hence provides a strong justification for a study of this nature. The main thrust of this paper is to:

1. Calculate cancer health hazards associated with exposure to arsenic in tap, borehole and surface water in the study area by resident children and adults

2. Recommend to government and other stakeholders ways of reducing cancer health risk associated with ingestion and dermal contact with arsenic in tap, borehole and surface water in the study area

Risk assessment is defined as a process used to identify in qualitative sense, and then to quantify scientifically, the risk associated with a given exposure. It is also a process used to estimate health effects that might result from exposure to carcinogenic and non – carcinogenic chemicals (Asante–Duah, 1996; Obiri et al., 2006; USEPA, 2001). Risk assessment of toxic chemicals involves as proposed by the USEPA, four basic steps, which will be followed in this study. The steps are:

1. Hazard identification—this is the first step of the risk assessment process that is used to establish a link between toxic chemicals identified ad their health effects on residents in the study area.

2. Exposure assessment—is used to identify the chemicals of concern and to estimate the magnitude of human exposure to the chemicals of concern.

3. Toxicity assessment—identifies the toxicity criteria to be used to evaluate human risk associated with each carcinogenic and non-carcinogenic chemical in the study area.

4. Risk characterization/estimation—incorporates information gathered from hazard identification, exposure assessment and toxicity assessment to evaluate the potential health risk residents in the study area face.

Random sampling techniques were adopted in the collection of sixty water samples from rivers, boreholes and tap water in the study area between March 2006 and June 2006. The samples were stored under 4°C and conveyed to CSIR–Water Research Institute for the analysis of total arsenic and pH. The results of the concentration of arsenic in the samples have been shown in table 1.0 below and were used as input parameters for the calculation of the cancer health risk.

An exposure assessment is used to identify and evaluate the pathways through which constituents of concern (COC's) enter the human body, and to estimate the magnitude of human exposure to arsenic. In this scenario, ingestion and dermal contact of tap, borehole and surface water in the study area by resident adults and children were evaluated based on both Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME) parameters respectively. CTE exposure parameters were used so that health risks associated with typical or average exposures to the COC's can be calculated. RME parameters were also used so that health risks associated with high–end exposures can be calculated.

The potential receptors evaluated in this study are resident adults and children aged between 20 – 80 years and 2 – 19 years respectively.

The USEPA has provided oral cancer slope factor (CSF_{oral}) values in its online toxicity database file for use in assessing cancer health risk from exposure to arsenic in tap, borehole and surface water. Default values were used from RISC 4.02 software for CSF_{dermal} respectively for assessing health risks associated with exposure to arsenic in drinking water.

Cancer health risks were evaluated using RISC 4.02 human health risk software. The results of the analytical concentration of arsenic in the water samples in table 1.0 below were used to calculate excess cancer risk using the RISC 4.02 software.

Results and Discussions

The results of concentration of arsenic in the water samples, pH and cancer health risks for both resident adults and children from exposure to arsenic in tap, borehole and surface water in the Obuasi Municipality have been presented in Tables 1 and 2 below.

Table 1: Mean concentration of arsenic and pH of water samples from Obuasi Municipality

Sample Location	pH	Mean arsenic concentration-mg/L	Percentage (%) of how the arsenic concentration in the samples exceeds the permissible guidelines values		
			GEPA	WHO	USEPA
Borehole at Odumasi	5.56	0.048	4.8	480	480
Tap Water at Odumasi	5.59	0.025	2.5	250	250
Tap Water at Obumasi	6.8	0.0050	0.5	50	50
River Kaw	5.12	2.20	220	220,000	220,000
River Kwabrafo	4.43	32.7	3,270	327,000	327,000
River Pompo	5.23	30.6	3,060	306,000	306,000
River Akapori	6.08	0.79	79	7,900	7,900
River Jimi	5.91	7.34	734	73,400	73,400
Ghana Environmental Protection Agency (GEPA)	6.5 – 8.5	1.0			
USEPA	6.5 – 8.5	0.01			
WHO	6.5 – 8.5	0.01			

Arsenic concentration in water samples from the study area ranged from 0.005 mg/L (for tap water in Obuasi) to 32.7 mg/L (for River Kwabrafo). A comparison of the levels of total arsenic concentration with Ghana Environmental Protection Agency permissible guidelines reveals that it is above GEPA figures from as low as 0.5% to as high as 3,270%. Similar comparison with WHO and USEPA permissible guidelines also revealed that the levels of arsenic recorded in this study were above the permissible limits set by both WHO and USEPA. With the exception of the tap water from Obuasi, all the water samples analyzed for pH in this study exceeded the recommended GEPA, WHO and USEPA guideline values.

Table 2: Cancer health risks results faced by both resident children and adults from exposure to arsenic in the study area.

Sampling point	Exposure media	Exposure route	Cancer health risks			
			CTE Adults	**RME Adults**	**CTE Children**	**RME Children**
Borehole at Odumasi	Water	Ingestion Dermal	3.7×10^{-2} 2.8×10^{-3}	5.6×10^{-2} 1.9×10^{-3}	4.7×10^{-2} 3.2×10^{-3}	6.7×10^{-2} 5.1×10^{-3}
Tap water at Odumasi	Water	Ingestion Dermal	9.8×10^{-3} 1.8×10^{-4}	2.9×10^{-3} 1.4×10^{-4}	7.6×10^{-4} 5.2×10^{-4}	2.7×10^{-3} 4.0×10^{-4}
Tap water at Obumasi	Water	Ingestion Dermal	6.6×10^{-4} 2.9×10^{-5}	5.5×10^{-6} 2.0×10^{-5}	4.3×10^{-4} 3.1×10^{-5}	4.6×10^{-4} 6.0×10^{-5}
Kaw	Water	Ingestion Dermal	8.6×10^{-4} 1.6×10^{-4}	2.5×10^{-3} 1.2×10^{4}	6.7×10^{-5} 4.6×10^{-5}	2.4×10^{-4} 3.5×10^{-5}
Kwabrafo	Water	Ingestion Dermal	5.4×10^{-3} 2.5×10^{-3}	4.1×10^{-3} 1.9×10^{-3}	7.1×10^{-2} 3.7×10^{-3}	3.8×10^{-2} 5.5×10^{-3}
Pompo	Water	Ingestion Dermal	9.3×10^{-2} 1.7×10^{-3}	2.8×10^{-1} 1.3×10^{-2}	7.2×10^{-3} 4.9×10^{-3}	2.6×10^{-3} 3.8×10^{-3}
Akapori	Water	Ingestion Dermal	2.7×10^{-6} 5.0×10^{-6}	8.1×10^{-5} 3.9×10^{-5}	2.1×10^{-5} 1.4×10^{-5}	7.6×10^{-5} 1.1×10^{-5}
Jimi	Water	Ingestion Dermal	1.4×10^{-3} 2.5×10^{-3}	4.1×10^{-3} 1.9×10^{-3}	6.1×10^{-3} 7.2×10^{-3}	3.8×10^{-3} 3.8×10^{-3}

Cancer health risk is defined as the incremental probability that an individual would develop cancer during his or her lifetime due to chemical exposure under specific exposure scenarios evaluated. The term ‘incremental’ means the risk is above the background cancer risk by individuals in the course of life. For example, in the USA, approximately one out of four individuals die of cancer, in this case, the cancer background risk is 0.25 or 250,000 in 1,000,000 Americans would die of cancer related diseases (ACS, 2000).

From Table 2 above, the results of estimated lifetime cancer risk for adult receptors (20 – 80) resident in Odumasi who are exposed to water from the borehole is 3.7×10^{-2} and 5.6×10^{-2} for oral ingestion route based on CTE and RME parameters respectively. This means that on the average, 4 and 6 cases of cancer are likely to be recorded via oral exposure pathway in every 100 resident adults in Odumasi by CTE and RME parameters respectively. For dermal exposure route, we have 2.8×10^{-3} and 1.9×10^{-3} based on CTE and RME parameters respectively.

Similarly, the cancer health risk from ingestion and dermal contact with water samples from River Jimi is as follows; for resident adults, we have 1.4×10^{-3} and 2.5×10^{-3} by CTE parameters for oral and dermal contact, which means approximately 1 and 3 cases of cancers may be reported among resident who are exposed to arsenic ions in River Jimi. In the case of children, 6.1×10^{-3} and 7.2×10^{-3} for oral and dermal contact by CTE parameters respectively. This means that for every 1000 children that are exposed to arsenic ions in River Jimi, approximately 6 and 7 of them are likely to suffer cancer related disease via oral and dermal contact respectively.

Key Lessons Learnt

From the discussion above, it is important to take note of the following:

1. The long history of gold mining operations in the study area has impacted negatively on the quality of water bodies in the study area.

2. Elevated levels of arsenic were found in most of the water bodies sampled in this study with the exception of tap water in Obuasi which had arsenic concentration of 0.0050 mg/L. Also low pH values were recorded for the water bodies sampled in this study. A comparison of arsenic levels in the water bodies sampled in this study with WHO and USEPA permissible guideline values shows that they exceeded the limits by 5–327,000%.

3. Ingestion and dermal contact of the arsenic contaminated water bodies in the study area is responsible for the high levels of cancer health risk results faced by resident adults and children. The cancer health risk results obtained in this study were found to be above the USEPA acceptable cancer risk range of 1×10^{-4} to 1×10^{-6}.

4. It calls for a strict enforcement of all regulations governing health and environmental quality of the mining sector.

Conclusion

Given that only total arsenic was measured in this study and the fact that it is not only arsenic that is present in water bodies, soil, air and food crops in the study area for which resident adults and children might be exposed, it follows that considerable uncertainty exists regarding the actual toxicities of the various forms of toxic chemicals in water bodies for which resident adults and children might be exposed to. Similarly, arsenic is noted to cause non–cancer diseases such as diabetes mellitus, nausea, blackfoot disease, keratosis, etc which were not considered in this study.

The results of cancer health risk indicates high prevalence of diseases associated with exposure to arsenic via oral and dermal contact with tap, borehole and surface water in the study area. The cancer health risk results obtained from Obuasi Municipality in most cases exceeded USEPA acceptable cancer health risk range of 1×10^{-4} to 1×10^{-6}, i.e., one case of cancer in every 10,000 to 1,000,000 people and acceptable hazard index of 1.0 (USEPA, 1989, 1997).

Comparing the cancer health risk results obtained in this study to the average life expectancy figures of 55.4 years for men and 58.6 years for women in Ghana, it can be inferred that resident adults and children in the study area would have reduced life expectancy figures (GLSS, 2003). Government and other stakeholders responsible for providing potable water should act accordingly to provide clean and safe drinking water for residents in the Obuasi Municipality.

Recommendations

1. A similar study should be conducted in different regions or mining communities to assess the health impacts of exposure to toxic chemicals used in mining operations by both small scale mining and mining companies.

2. Civil society organisations working in the sector should advocate for the establishment and resourcing of the Agency for Toxic Substances and Disease Registry in all mining communities which should be mandated to carry out further medical examination of some diseases such as diarrhoea, nausea, etc which have other causative agents. This will help government and all stakeholders to have a firm knowledge about the impacts of mining operations on human health of residents of mining communities in Ghana.

3. Government, CSOs, Ghana Health Service, EPA, Minerals Commission, CHRAJ and other stakeholders should continuously educate residents of mining communities on (a) content of EIS of mining companies prepared by mining companies (b) "galamsey" operators to desist from smelting of the gold amalgam in the communities.

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Suitability of the Private Finance Initiative (PFI) System for Adoption in Ghana's Water Sector

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Abstract

Despite successive intervention programmes, Ghana's water sector continues to cause concern. Large areas of Ghana do not have access to safe drinking water. In most cases, supply of water is rationed, sometimes for days. The quality of water produced in most cases is poor. The dire situation of Ghana's water supply system is a result, among other reasons, of a lack of investment in the water supply system for several decades. The government continues to be the major financier of the network, however, with lots of other competing priorities; the water sector has suffered decades of underinvestment leading to the deterioration of Ghana's water infrastructure. To improve the current state of Ghana's water supply system, urgent efforts are required to mobilise funds to invest in the network. This requires innovative approaches to the management and financing of infrastructure which reduces the over-dependence on the government as the main financier and with responsibility for asset development. This paper explores the suitability of the Private Finance Initiative (PFI) system for adoption in Ghana's water sector. An assessment of the current situation of water supply is made. Alternatives to the current system for developing, financing and maintaining infrastructure are explored. Drawing lessons from current best practice, the paper makes recommendations on the way forward for Ghana's water sector.

Introduction

The need to provide infrastructure for the urban water sector to meet the needs of Ghana's population is a major challenge. According to the Ghana's National Water Policy, the Ghana Water Company Limited (GWCL) produces just about 45% of daily demand with only 41.4% of people living in urban areas having piped water in their homes (Water Resources Commission, 2008). Insufficient water supply in urban and peri-urban centres is attributed to the worsening financial situation of the utility, low levels of investment in the sector as well as poor managerial and implementation capacity. With the current state of operation where about 50% of the water supplied is unaccounted for due to leakages, illegal connections and inefficient distribution infrastructure, poor revenue mobilisation, the current system of operation can be described as inefficient (Water Aid, 2008).

Apart from problems such as political interference and poor management of Ghana's urban water sector through the years, competition from different sectors for government resources limits investment in infrastructure to about a third of what is actually required to meet the growing demand (Water Aid, 2008). Whilst the Government of Ghana (GoG) has shown interest in a greater role by the private sector in the provision of public services previously exclusively provided by governmental agencies including some new works, the involvement of the private sector in the water sector is mainly in the form of small businesses operating as suppliers to areas not connected to the network (PURC, 2005). In 2005, the water sector had its first exposure to international private participation through a Management Contract with Aqua Vitens Rand Limited (AVRL) in which AVRL was responsible for operations and customer service whilst GWCL remained the asset holder with responsibility for developing and expanding infrastructure (Agblevor, 2011). However, following the final review of the AVRL's Management Contract by an independent Consultant appointed by the Government of Ghana and the World Bank, it emerged that AVRL failed to meet vital targets such the water quality service standard; delays in Customer Accounts Receivables as well as the unimpressive targets for Treatment Plant Operating. Management of Ghana's urban water sector has been entrusted to an interim Special Purpose Vehicle (SPV), Ghana Urban Water Ltd for a period of 12 months with GWCL still responsible for the assets (Agblevor, 2011). Given that AVRL was brought in to address the perceived shortcomings of GWCL, there is concern as to the future direction of Ghana's water services.

This paper explores alternatives to the current structure, organisation and management of Ghana's water sector. The potential for the Private Finance Initiative (PFI), a public private partnership system of procurement is explored. Recommendations are made as to the way forward for Ghana's water sector.

Explanation of Key Terms

Public-Private Partnerships (PPPs)

Merna and Smith (1999) describe a situation where projects are not sufficiently robust to be procured by total private finance funding, in which case the gap between commercial and private funding can be closed by some type of public sector involvement. PPP projects deliver significantly improved public services in terms of both the quality and the quantum of investment, release the full potential of public sector assets to provide value-for-money for the taxpayer and wider benefits for the economy (Balfour Beatty, 2004).

Concession Contracts

In concession contracts, a contractor effectively becomes the promoter and finances the project, operates and maintains it over an agreed period of time to generate a commercial return. At the expiration of the concession period, all assets revert back to the original owners.

Variants of Concession Contracts

Pricewaterhouse Coopers (2004) developed a framework for the implementation of concession projects in Ghana. Some other variants in concession contracts identified in Pricewaterhouse Coopers (2004) include: Finance Build Own Operate Transfer (FBOOT), Build Own Operate (BOO), Build Own Lease (BOL), Design Build Operate Maintain (DBOM), Design Build Operate Transfer (DBOT), Build Operate Deliver (BOD), Build Own Operate Subsidise (BOOST), Build Transfer Operate (BTO), Maintain Operate and Transfer (MOT), Reconstruct Operate and Transfer (ROT) and Build Operate Transfer (BOT).

Private Finance Initiative (PFI)

PFI is the system of procurement, which involves the use of private sector finance and management in the provision of public services in which the public sector or the government makes a commitment at the contract stage to acquire the services to be provided by the private sector (Merna and Smith, 1999). In its simplest form, PFI incorporates a guarantee by the government to procure the services to be provided by the management organisation or a guarantee by the government that the services will be procured by the public (Merna and Smith, 1994).

Using PFI in Infrastructure Provision

Why PFI?

The PFI system of procurement enables the provision of world-class infrastructure and public services (HM Treasury, 2003) and the modernisation of infrastructure even in times of public-sector spending controls where strict limits are placed on public sector borrowing (Grout 1997). This according to Grout (1997) removes the need for the "upfront funding" as in the case of traditional funding of projects. Where debt financing is used to finance infrastructural development and public services provision, these costs and associated interests are kept off government books.

Types of PFI Projects

There are three (3) main forms of PFI namely: joint ventures, financially independent projects and services-sold projects. Financially independent projects involve the identification of a business opportunity in public service delivery by a private sector operator which seeks approval from the state and sets out to design and finance the project. The private entity after completion charges the consumer for use of the facility. Joint-ventures involve an agreement by the public and private sectors to share equity of a facility to be operated by the private sector with the aim of making profit whilst the private sector retains control. The public sector's interest stems from the fact that the project will deliver a public service or help solve a public problem (Owen & Merna, 1997). In the services sold system, the public entity has specifications for a public service to be provided for a concession by a private partner selected competitively and is required to provide a service for a concession period of usually 25-30 years. During this period the state will make payments for the availability of the service till the end of the concession period. After this period, the public sector takes over the ownership and operation of the facility (Owen & Merna, 1997).

PFI versus Privatisation

PFI differs from privatisation because in PFI schemes unlike privatisation, the public sector retains a substantial role, either as the main purchaser of the services provided, or as an enabler of the project and guardian of the users' interests (Merna and Smith, 1999). In the case of Ghana's urban water sector, the state could assume the role of an enabler responsible for protecting user interests.

Financing PFI Projects

Project Financing

In Project Financing, the future cash flow provides the basis for raising resources for investing in the project. Merna and Smith (1999) explain that the entire financing of the project is dependent on an assured income stream from the project since the lenders and investors would have recourse to any funds other than the income streams generated by the project when complete. The project sponsor would therefore need to demonstrate evidence of future income for the proposed project.

Equity Finance

Equity represents the portion of the finance required that the project sponsor is willing and able to mobilise for the project. The sponsors provide the seed equity to the project company to start operating. According to Merna and Smith (1999), the project company can raise additional equity funds from the general public to part-finance the construction and early operation phase. H-M Treasury (2003) guidelines acknowledge a debt-equity ratio of 90:10 as being an acceptable ratio. However this needs not be always the case as shown by Tiong (1995). Tiong (1995) cites several examples of different projects around the world with equity ranging from 0 to 59% (Tiong, 1995)

Term Loans

These are for large infrastructure projects where the funds required to be raised are very high. A group of banks and financial institutions pool their resources together to provide the loans to the project. In the case of the Channel Tunnel project in the UK, the original financing structure for this project involved 210 organisations. More than half the capital raised was underwritten by a UK government guarantee, which substantially reduced the cost of borrowing (Source: ctrl.co.uk, accessed 19th October, 2004). Despite problems with financing and scheduling problems with the Channel Tunnel project, the project presents a financing model which if managed well can provide a useful alternative to the use of public funds for infrastructure projects.

Using Bonds in PFI

Part of the funding for the landmark Channel Tunnel Project was raised through bonds issued in two tranches comprising of fixed-rate tranche with a weighted average life of 20 years and index-linked tranche with a weighted average life of 40 years. The bonds involved in the securitisation paid interest to investors at a relatively small margin above the yield payable on gilts, reflecting the favourable credit status granted by the government obligations, and also the unusually long maturity of the bonds, for which there was significant investor appetite (CTRL, 2004).

Low Equity Finance

Tiong (1995) describes instances when the revenues, which are projected to be generated from PFI projects are reliable and predictable in which case little or in extreme cases no equity finance may be used as in three BOT projects in the UK – Dartford Bridge, Second Severn Bridge and the Skye Bridge in Scotland. This was possible because being estuarial crossings, they were monopolistic in nature, which made their revenues both predictable and reliable (Tiong 1995)

Use of Special Taxes / Levies

In Greece, a new airport was constructed using a special tax on all airline tickets to raise money. The funds yielded were used as a second source of equity to bridge the gap between the level required by the lenders and the equity raised by the promoter (Merna and Smith, 1999).

Critical Success Factors for PFI Projects

Zhang (2005) identifies Critical Success Factors for PFIs largely responsible for the modest successes achieved on the PFI projects front in the UK as follows:

1. Favourable Investment Climate.

2. Economic viability

3. Reliable concessionaire consortium with strong technical support.

4. Sound financial package.

5. Appropriate risk allocation through reliable contractual arrangement.

PFI in Other Countries

In nations like China, Uganda and Malaysia, forms of private involvement have been used with varied degrees of success. Other countries are beginning to consider various forms of private-public participation to deliver badly needed water supply infrastructure. The case of Guinea gives an example of the operational efficiency of the private sector in the late 1980s when the

Government of Guinea together with two French companies formed a consortium for the management of the water sector (Baumert & Bloodgood, 2004).

Monopolies in the Water Sector

Firms in the water sector usually operate as monopolies due to the nature of the industry which leads to concerns over the private control of a monopoly which provides public service. Such concerns may be addressed by the use of competitive selection methods (Edwards & Shaoul, 2003) which help to regulate pricing. This ensures that fees paid by end-users are modest (Baumert & Bloodgood, 2004). In the UK for example, there are around 24 water companies most of which consistently exceed 99% of targets set by the Office of the Water Regulator, OFWAT. Increasing the number of participants in the water sector has generated competition and innovation as different providers strive to outperform the other and deliver more value to both customers and shareholders (water-guide.org.uk).

Protecting the Interests of the Poor

According to PURC(2005), the majority of those without direct access to water supply are poor and are mostly supplied water by private operators who charge substantially higher rates compared to the public supplier. In some cases, private suppliers may sell to the poor at rates which may be as high as 20 times the GWCL rates (Water Aid, 2008). In the traditional PFI project, the government or public sector retains some control over the project during the concession term (Merna and Smith, 1999). This control may be in a regulatory capacity or to ensure quality and affordability for the end users. In the UK example, the water supply companies make proposals for new prices every five years. The proposals are subject to review by the regulator, OFWAT which approves new prices (water-guide.org.uk).

Discussion

Despite progressive intervention programmes by previous governments and development partners, the current situation of water supply in Ghana is poor with less than half the population of Ghana having access to safe drinking water from the public water supply company. The quantity and quality of water produced are still poor. After five years of private sector management, the management of the Ghana’s water production and delivery has reverted to public control. The government of Ghana retains sole responsibility for the funding and management of water supply. However given the scarcity of resources and the number of competing demands, investment in the water sector has been and continues to be insufficient. The resultant effect of this and other problems facing the water sector such as political interference and poor management is that Ghana’s urban water infrastructure is poor and in need of urgent updating.

Whilst the idea of private sector management which saw the involvement of AVRL was a positive move, the fact that AVRL brought no new funding to the operations made this a poor choice for the water sector. What the sector needs is an urgent injection of much needed finances to repair and maintain old parts of the network and to develop capacity to meet the standards of 21st century water supply services for a rapidly growing population. Whilst the government is still able, to a limited extent, to source for loans and grants to develop the network, it is our opinion that the risks and responsibilities for sourcing finance could be better borne by the private sector. The private sector is also better motivated to handle some of the problems which the sector faces such as leakages and unaccounted for water and non-revenue water in the system. It is in this vein that we propose the PFI system of financing infrastructure as the best way forward for Ghana's water sector.

Different options of PFI approaches such as joint ventures and financially independent project may be adopted for Ghana's water sector. Each of these options provides public infrastructure which is critical to efficient public services and utilities such as water without the need for direct investment by the state. This offers benefits for government accounting as PFI investments are kept off the government's balance sheet.

Amongst the risks associated with PFI schemes is the lack of political will based on a fear of public opposition to so-called "privatisation of essential public services". However the PFI scheme is clearly distinct from privatisation because in PFI schemes, the public sector maintains an on-going involvement in the scheme which safeguards the interests of consumers. The state's involvement in PFIs as a PPP type project also addresses the concerns over the operation of monopolistic utilities by private companies. The issue of monopolistic operation of utilities such as water can be addressed through the break-up of these single water supply companies into smaller leaner operations to promote efficiency. This can be seen in the UK example where water companies serve different areas thus promoting efficiency. In the UK example, most of the water companies are public listed companies thus diversifying their fund raising capacities. The proposed smaller companies may be privately owned or state owned though the general trend suggests private sector management is more effective than state run enterprises. PFI presents several innovative options for raising finance including project financing, equity financing, the use of term loans and bonds or special taxes/levies. Where debt financing is used, the expected cash inflows can be used for re-payment. In developing a PFI approach for Ghana's water sector, Government Guarantees may be used as part of the public's contribution. Guarantees may be given in the form of guaranteed revenue for private operators, by varying the concession periods, through exchange rate guarantees, debt guarantees, equity guarantees or as compensation for changes. Whilst PFI has been mainly applied in the UK health, defence and road sectors, the model can be easily adapted to Ghana's urban water sector.

Most of the critical success factors for PFIs such as a favourable investment climate can be met easily in Ghana. Further innovation will need to be introduced to enhance the economic viability of PFIs in the Ghanaian water sector. For example given the low levels of tariffs collected in Ghana as compared to many developed countries, it may be helpful to increase the concession period for PFIs from the usual avearge of between 25 and 30 to a new avaerage of 40 to 50 years to enable investors to obtain reasonable return on their investment in PFI projects.

Lessons

This paper establishes that the PFI system of finance has been used successfully to develop infrastructure projects including water sector infrastructure in some developing countries. The system allows the development of public infrastructure without the upfront commitment of government funds. Loans used to finance infrastructure projects are thus kept off government books. It is argued that the private sector is better incentivised to manage public services to ensure a good return on the investment in such projects. The paper asserts that PFI differs from privatisation in that the interests of the consumer are protected through the active involvement and regulatory function of the public sector. This ensures services provided are of an appreciable standard and that charges are affordable. Different approaches to PFI implementation and potential funding strategies which can be adapted to implement the PFI system in Ghana's urban water sector are identified.

Recommendations

It is recommended that the PFI system of financing projects be adopted for the development of infrastructure for Ghana's urban water sector. This will transfer project risks including both financial and construction to the private sector which is better equipped to manage these. In this vein, it is proposed that government borrowing to develop urban water infrastructure be discontinued and instead, the government should create an enabling environment which supports private sector fund raising efforts.

It is also proposed that instead of the commonly used 25-30 year concession period used for most PFI projects, a 40 to 50 year concession period may be considered for the Ghanaian urban water sector. This will provide ample time for investors to obtain a reasonable return on investments.

This paper proposes that the Ghana Water Company Limited be broken up into smaller companies which will manage specific areas and regions. In this case, the Kpong, Owabi, Barekese, Weija Water Works etc. would be managed as concessions by independent private or public listed companies able to independently mobilise private sector finance or enter into joint ventures for the purposes of raising finance to develop and maintain their infrastructure.

It is further recommended that bidding for the respective concessions be open to international competition in the hope that international contractors with sufficient financial resources and proven track record in world-class water provision are selected to run Ghana's water production and distribution facilities as concessions.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Towards a Sustainable Allocation of Potable Water in Ghana: Evidence from Kumasi

J. D. Quartey

Abstract

The provision of potable water for human sustenance both now and in the future is one of the most critical issues in the world today. This paper sought to assess the sustainability of potable water distribution in Ghana through the Contingent Valuation Method in Kumasi, Ghana's second largest urban centre. Willingness-to-pay values were elicited by means of a bidding game technique through administered questionnaire to communities in Kumasi, where potable water supply was either non-existent or very irregular. The analysis shows that Ghana Water Company Limited (GWCL) can increase current tariffs by about 300% without hurting consumers, since, that would rather increase welfare considerably. A sizeable consumers' surplus exists, which is an indication of households being susceptible to extortion by water vendors. This requires urgent government intervention to save some residents of Kumasi from undue exploitation as well as the return to the consumption of unwholesome water that would increase pressure on medical and Health Insurance resources.

Introduction

Efficient and equitable distribution of potable water is a key requirement for urbanization to lead to improved welfare. Increasing urbanization as well as the growth in human populations has resulted in an increasing need for a sustainable allocation of potable water in Ghana. This requires efficient water distribution to people wherever they live, no matter the cost involved. Where this is not done, long hours and much energy are spent to search for water; which turns out to be labour-intensive, excessively time-consuming and counter-productive. Reasonable access[12] to potable water for a community would mean the saving of time and energy due to reduced walking distance to the source of water or waiting to be served from a distant source. This releases labour which may be used for productive purposes leading to economic benefits. Even if the economic value of the saved labour is zero, there would be a social benefit from the time saved and drudgery eliminated because more time can be spent with one's family or on domestic activities and leisure.

In Ghana, increasing amounts of water is being used to meet the needs of a rapidly growing population. This has resulted in the reduction of the per capita annual availability of water. According to the Ghana Water Company Limited, in 1960, when the population of Ghana was 6.77million, the annual surface water available to each Ghanaian was 4950 cubic metres. By the year 2025, when the population of Ghana is projected to be 35.44 million, the annual surface water

[12] Reasonable access to potable water means "a disproportionate part of the day is not spent in water fetching

that will be available to each Ghanaian would be 950 cubic metres. Ghana would then have reached a theoretical limit for 'water stress' - below the 1000 cubic metres per capita annual water availability threshold (Ghana Water Company Limited, 1995). This insight about Ghana's water resources calls for a sustainable allocation of water resources to delay or even avoid 'water stresses' for present and future generations.

The provision of potable water being largely a responsibility of government in Ghana or even in collaboration with donor agencies is not sustainable, considering the huge capital investments involved, coupled with high population growth rate. It was estimated by the Ghana Water Company Limited (GWCL) that an amount of about $2billion was needed to extend the water sector in Ghana from 1998 to the year 2020.

It is however interesting to know that since the early 1980s, World Bank (IDA) total support to Ghana in credit and grants has been only a little above $5 billion (World Bank, 2007). It can be asserted that the slow pace at which potable water has been made available to communities in Ghana stems from the fact that the sector does not get meaningful returns from the investments made to sustain the sector (considering the fact that the Ghana Water Company Limited until June, 1999, supplied water at a loss). This is further worsened by the waste and inefficiencies associated with the handling of public property, partly responsible for the 50% unaccounted-for-water rate.

Kumasi, the second largest city in Ghana with a population of about 1.2 million has suffered and continues to suffer from water shortages. This situation has given water vendors the opportunity to sell water to residents of various suburbs at exorbitant prices. The pertinent question here is whether the residents would shift from the consumption of potable water to other water sources which might negatively affect their health and well-being. This study examined how the distribution of potable water could be done on an equitable and efficient basis to enhance human welfare, as a means of attaining sustainable allocation of water resources. This is against the background where about 97% of the budget of the Ministry of Water Resources Works and Housing in Ghana is donor funded (Ministry of Water Resources Works and Housing, 2011).

Conceptual Framework

The current structure of the distribution of potable water in Ghana is skewed in favor of people who are capable of paying for water. Effective demand encompasses the ability and willingness to pay for an economic good. Since potable water is a merit good,[13] the effective demand need not necessarily include an ability to pay. In such a situation the willingness to pay (WTP) is sufficient to warrant government provision. However, this notion of potable water being a merit good does not contradict the 1992 Dublin statement from the United Nations Conference on Environment and Development, calling for the recognition of water as an economic good. There have been several debates on the theoretical and operational implications as well as the economic impact of this call on the poor. The main objective therefore of this study is to use the Contingent Valuation Method (CVM) to assess the welfare implications of potable water pricing and provision, to appropriately inform policy, towards a sustainable distribution.

[13] A merit good is one considered by government as so important for health and well being that more of it should be provided than what the market mechanism alone will allow.

A change in the provision of a good gives rise to a 'full price effect' in the ordinary demand curve where real increases of consumers are allowed to vary. The Hicksian approach however yields a theoretically more accurate measure of welfare change since it holds real income constant (Varian, 2006; Katz and Rosen, 1998). With the change in the provision of potable water, the consumer's utility can be maximized subject to his budget. The assumption here is that the consumer has an exogenous budget Y which is to be spent on some or all of n commodities which can be bought in non-negative quantities at given fixed, strictly positive prices.

A change in the provision (distribution) of potable water produces a change in utility whose maximization will bring optimum satisfaction leading to welfare maximization (Johansson, 1987).

Environmental Economic methodology describes six phases in the practical application of the CVM. These are the market description, elicitation, calculation, estimation, aggregation and validation phases.

Methodology

A hypothetical market was set up for the provision of a 24-hour supply of easily and quickly accessible potable water to communities in the suburbs of Kumasi that had no access to potable water in the description phase of this research.

The hypothetical market explained the services that could be made available and at what price. The payment mechanism, modalities of delivering the service, its quality and reliability were also discussed to make the market scenario complete.

These are presented in the elicitation scenario as discussed below. The survey used questionnaires that started by describing the problem and the change envisioned - the provision of a 24-hour supply of potable water just around consumers' homes through public taps by private operators. Payment for the commodity would be made through on the spot pay-as-you-fetch principle or arrangement.

The questionnaires included questions on the socio-economic and demographic background of the respondents and their families. This was mainly for purposes of cross-checking WTP responses. In each case the respondent was a household head, representing his or her household.

The iterative bidding game method was used to elicit responses from respondents. The question asked for the iterative bidding game is, "suppose you are supplied with a 24-hour daily service of potable water just outside your home, how much would you be willing to pay for each bucket[14] of potable water you fetch?" If the respondent's answer is yes to the bid of (say) 7 pesewas (7p) per bucket, then the question is repeated with a higher bid of 8p, if the answer is no, the question is repeated with a lower bid of 6p. This continues until the respondent's maximum WTP is reached. This same method was repeated for 24-hour in-house taps as an alternative commodity. The bidding game approach produces a continuous bid variable which can be analyzed using the Ordinary Least Squares (OLS) method.

[14] A bucket here refers to an 18 liter volume. The use of bucket emanated from ascertaining which measure was more familiar to households in Kumasi for water. Even though the 'Kufuor galon' is used, households were more familiar and accustomed to the bucket as a measure. This is confirmed by Whittington et al (1992) and Owusu (2009)

In all, 23 suburbs of Kumasi were identified as areas not receiving regular supplies of potable water. Through random sampling from the list 5 suburbs were selected, namely Buokrom Estates, Sepe Buokrom, Asuoyeboa (SSNIT flats area), Kokode (Agric college) and Edwinase. 70 households were interviewed from the randomly selected suburbs.

The starting point bid of 5p per bucket was to give respondents enough room to be realistic since the current 5p per bucket charged by vendors was for water with uncertain purity and wholesomeness. This amount was also considered high enough to satisfy potential investors.

The Variables

For all households information was collected on socio-economic characteristics including measures of monthly income, education level, household size, total expenditure on other commodities, proximity of current water source and characteristics of the current water source.

The dependent variable for the study is maximum Willingness-To-Pay for potable water (WTP) in each of the two market scenarios depicted, which was regressed on the quantity of potable water demanded to obtain the demand functions. For a quantity dependent variable, quantity of water consumed per day in buckets of water (Q) was regressed on Households' monthly Incomes in cedis (Y), Educational levels in codes of years (E), Ages in years (A), proximity of current source of water (Pc), Expenditure on other commodities(x) and maximum Willingness-To-Pay for potable water (WTP). This therefore gave a functional relationship between maximum Willingness-To-Pay and the remaining variables, stated as

$$WTP = f(Y,E,A,Pc,Q, X).$$

Similar functional relationships have been used by Briscoe et al (1990), Hanley and Spash (1993) and Carruthers and Browne (1977).

Based on the theoretical framework, respondents' WTP were modeled on a continuous utility framework in which each household head's response represents the indirect utility that the household receives from consuming a bucket of potable water. Such WTP is based on the characteristics of the commodity.

Analysis of Results

Plotting midpoint values for willingness- to- pay (in Ghana Pesewas) against quantity of potable water demanded, which here is pegged at two buckets per household member, gives us the Hicksian demand function for potable water supplied through community taps near households.

The assumption of two buckets per household member (meaning the demand per household is equal to twice the number of people in the household) is consistent with the findings of Nyarko et al. (2006); Feachem (1973); and White et al, (1972) that city dwellers without taps consume on the average about 30 litres (2 buckets) of potable water per person daily. This then means that for each WTP value, the cumulative percentage number of households represent the quantity (number of buckets) demanded.

For community taps near consumers' homes the demand function was

$$WTP_1 = 756.626 - 6.629Q_d \qquad (1)$$

(13.289) (-9.254) t- values

$R^2 = 0.966$, R^2 Adjusted = 0.955, F-statistic = 85.629

While for in-house taps, the demand function was

$$WTP_2 = 639.024 - 4.297Q_d \quad \text{----------------------------------} \quad (2)$$

(8.643) (-4.105) t- values

$R^2 = 0.849$, R^2 Adjusted = 0.799, F-statistic = 16.853

The two demand functions are consistent with the tenets of economic theory.

Total Willingness-to-Pay Aggregation

To aggregate for Kumasi as a whole we convert the mean WTP bids to a population total figure. Here, it is possible to capture all those whose utility would be significantly affected by the change in provision of potable water in Kumasi.

Tables 1 and 2 below show the computations to obtain the mean total willingness to pay for potable water and the expected total revenue for Kumasi.

Table 1: Total Willingness to Pay for potable water in Kumasi for one day

WTP (Midpoints) (a)	Percentage of Households (b)	Number of Households (c)	Cumulative No of Households (d)	% Cumulative Frequency (e)	TWTP (in GH□) f=(a)×(c)×2
0	0.1	300	300,000	100	0
0.5p	1.4	4,200	299,700	99.9	42.00
1p	1.4	4,200	295,500	98.5	84.00
5p	47.8	143,400	291,300	97.1	14,340.00
8p	46.4	139,200	147,900	49.3	22,272.00
10p	2.9	8,700	8,700	2.9	1,740.00
Total	**100**	**300,000**			**38,478.00**

Source: Author's fieldwork

From Table 1, with the mean household size in Kumasi of 4 (GSS, 2008), if each household member consumes two buckets in a day, then for one day the TWTP would be GH¢ (4 x 38,478.00) = GH¢153,912.00 for the 300,000 households. The Freshwater Country Profile of Ghana of the United Nations Organization has indicated that it costs Ghana US$0.80 per cubic meter to produce, transport and distribute potable water. This cost could be as a result of the serious efficiency challenges the water sector faces. For instance, in 2006 approximately 60 employees were responsible for 1,000 connections, a figure extremely higher than the international good practice level of less than 4 employees per 1000 connections (Kauffman and Pérard, 2007). This implies 15 times less efficient cost for Ghana.

Given efficient equipment and systems, the cost could be about US$0.05/m^3. If the average population of Kumasi of 1.2 million is considered, then the production cost with efficient production, transportation and distribution would be about US$60,000 which is GH¢96,000.00.

Apart from the fact that consuming 2 buckets a day is limited to those without reasonable access and therefore a minimum (since those with house taps consume about twice this amount), the TWTP of GH¢153,912.00 far exceeds the efficient cost of supply of GH¢96,000.00. The difference, GH¢57,912.00 constitutes the minimum daily net gain that could accrue to any private investor that would efficiently manage Kumasi's water supply system.

Expected Revenue

Calculations from Table 2 below indicate that the tariff that would provide the highest revenue is 5p per bucket. The tariff of 8p, the second highest source of revenue would attract a patronage of just 49.3% of consumers, and would therefore not be socially efficient. The modal tariff of 5p provides the highest revenue to investors- this is so close to the current vendor–tariff. This tariff would provide about 97.1% patronage .This might even still not be socially acceptable since denying access to about 2.9% of the populace could have far reaching social consequences. However, this is the fairest deal for both investors and consumers (this position is explained in the next section).

Table 2: Expected Revenue for potable water per day in Kumasi

% Frequency Distribution (a)	% Cumulative Frequency (b)	Cumulative No of Households (c)	WTP Midpoints (d)	Expected Revenue e = c x d×8
0.1	100.0%	300,000	0	0
1.4	99.9	299,700	0.5p	11,988.00
1.4	98.5	295,500	1p	23,640.00
47.8	97.1	291,800	5p	116,720
46.4	49.3	147,900	8p	94,656
2.9	2.9	8700	10p	6,960

Source: Author's fieldwork

Consumers' Surplus

Consumers' surplus (CS) computations are carried out for current and sustainable provision of potable water by the Ghana Water Company Limited (GWCL) in Figure 1 below. Currently the GWCL charges a minimum of 80p per cubic metre of potable water. This comes to 1.44p for a bucket (i.e. 18 litres).

Figure 1: Consumers' Surplus and Revenue for potable water in Kumasi

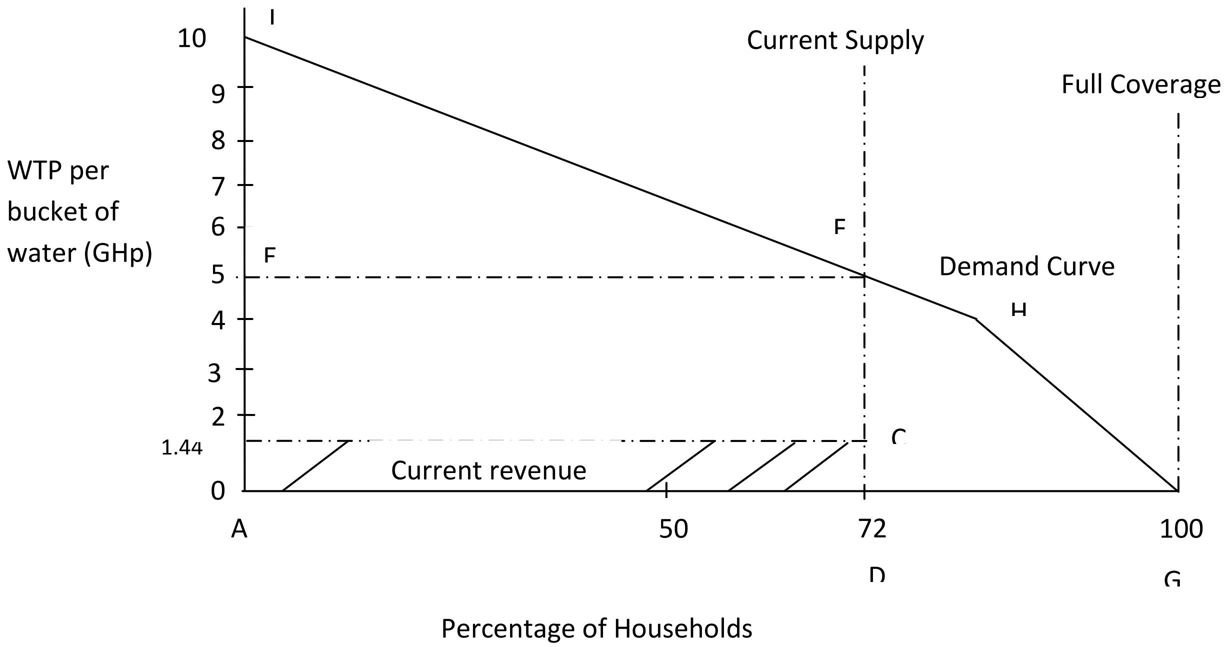

Figure 1 above indicates that the current about 72% coverage for Kumasi (Ministry of Water Resources Works and Housing, 2011) produces ABCD revenue with technically no consumers' surplus at 1.44p per bucket as far as the demand curve GHFJ is concerned. With a price of 5p per bucket which attracts 97.1% WTP, the new revenue would be about four times the current revenue. The resulting substantial consumers' surplus which exceeds the current revenue is evidence of better welfare at this new price. This implies more revenue for GWCL as well as better welfare for residents of Kumasi due to improved access to potable water. This is so because the 2.9% who will not have access would take up only about 8% of the CS to be realized, which means the net gain to society will be 92% of the CS. Hence a tariff of 5GHp will more than compensate the losers to bring welfare improvement for all residents of Kumasi. Clearly, everybody stands to gain eventually if tariffs are increased by at least 300%!

Private sector exploitation can easily exist since over 49% of residents are willing to pay 8p per bucket which is more than 5 times the current tariff. This therefore, means that, urban households in Kumasi are willing to pay higher potable water tariffs.

Conclusion and Recommendations

In Kumasi, as has been discussed earlier, public water systems provide a low level of communal service with few private connections compared with the current population. The service is heavily subsidized and the monthly tariff of 80p per cubic meter from household connections is too low. Little revenue therefore is generated by the service and the GWCL cannot afford to maintain the system above a low level of service. Therefore, consumers are forced to supplement their potable water with water from traditional, often low quality sources such as shallow wells and vendors. Thus, the water supply is in a "low-level equilibrium trap" – poor service generates little revenue thereby ensuring continuing poor service. The way out is through water tariff increase if the current level of efficiency is maintained.

It is recommended that Government should allow the GWCL to increase tariffs at least by 300%. This would be the most equitable for society's welfare in general if the efficiency status quo is maintained. An alternative approach however would be to improve upon the efficiency of production, transportation and distribution systems.

Private participation in the water sector must be regulated in terms of tariffs; otherwise the high consumers' surplus can be exploited to the detriment of residents of Kumasi. There is a small percentage (about 2.9% for Kumasi) of urban dwellers that would still have to have free access to potable water, subsidized through the revenue from the increased tariff.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Impacts of Energy Price Changes on the Financial Sustainability of Water Facilities: Case from Ghana

S. J. Tenkorang, S. N. Odai, F. O. Annor & K. A. Adjei

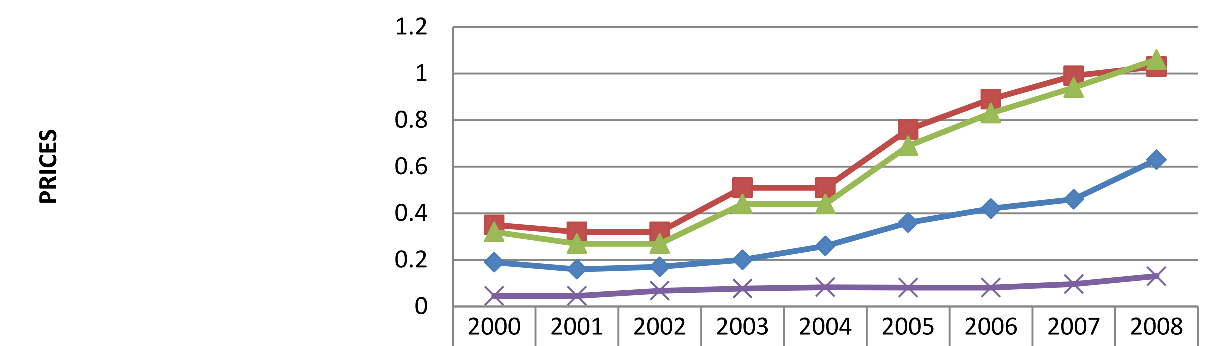
Abstract

Water is conveyed to consumers through systems that rely greatly on energy, which has become a challenge after frequent variation in global oil prices. This paper focuses on the impacts of energy price changes on the financial sustainability of water facilities in Ghana. It further investigates the proportion of energy to the total costs of water supply and the effect of energy price changes on the management of water facilities. The study is based on a field survey that targeted 5 small town water systems. The results show that Energy (diesel and electricity) expenditure forms substantial component of water production costs. The total operational cost and proportion of energy to total costs for water supply for small towns are 1.19 US$/$m^3$ and 31% respectively. The energy costs per water supply using small town water systems is 0.40 US$/$m^3$. Results further shows that diesel-driven water systems are more sensitive to energy price changes than that of electricity-driven systems; therefore making financial profits from diesel - driven systems highly elastic to diesel price changes. This paper recommends that outcomes and methodologies be adopted and utilised during reforms of water pricing policies and subsidies to the energy sector.

Introduction

Sustainable access to safe water is essential for human health and survival, and important for economic growth (SIWI, 2005). Raw water abstracted from water bodies usually undergoes some form of treatment before delivery to homes, institutions, industries, etc. The water systems which perform the treatment processes and conveyance run on energy (diesel or electricity). In Ghana, the energy dependent water systems can be categorised broadly into the Urban water systems and Rural water systems.

Frequent variation in global oil prices coupled with exchange rate depreciation have impacted on the domestic energy prices (Figure 1). Increments in domestic oil prices tend to affect the management of the water systems whose operations depend on energy.



	2000	2001	2002	2003	2004	2005	2006	2007	2008
GLOBAL OIL PRICE (US$/Lt)	0.19	0.16	0.17	0.2	0.26	0.36	0.42	0.46	0.63
PETROL PRICE - GHANA (US$/Lt)	0.35	0.32	0.32	0.51	0.51	0.76	0.89	0.99	1.03
DIESEL PRICE - GHANA (US$/Lt)	0.32	0.27	0.27	0.44	0.44	0.69	0.83	0.94	1.06
ELECTRICITY TARIFF - GHANA (US$/kWh)	0.046	0.046	0.068	0.077	0.083	0.081	0.081	0.096	0.13

Figure 1: Ghanaian energy prices against global crude oil prices.
(Source: Based on raw data on Global Oil Prices of US EIA, 2009 and Ghanaian Energy Prices.)

Water tariff serves as basis for revenues for the water service providers. Figure 2 reveals that as global oil price increases, the water tariff also increases. For sustainability of the water systems, the increments in the water tariff must commensurate with that of the global oil prices else there will be a break in the sustainability cycle of the water facilities.

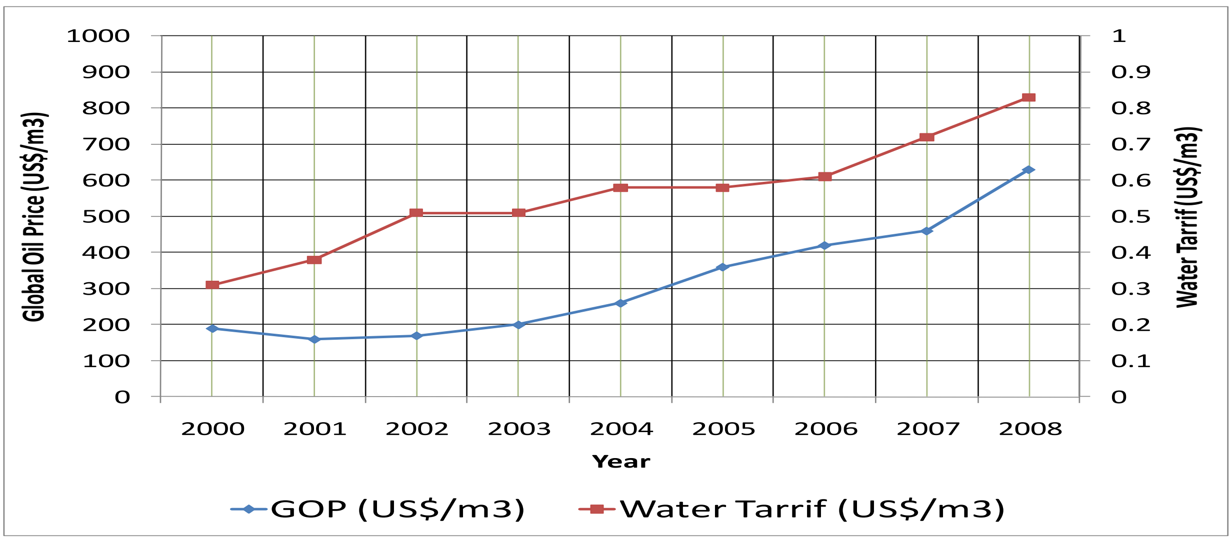


Figure 2: Domestic Water Tariff against Global Oil Price Changes
(Source: Based on raw data on Global Oil Prices of US EIA, 2009 and Effective Small Town Water Prices.)

This research seeks to assess the impacts of energy price changes on the financial sustainability of water facilities and specifically to identify the types of energy dependent water systems, to investigate the proportion of energy to the total costs of water production and also to assess the impacts of energy price variations on the sustainability of the water systems.

Water service provision is seen to be sustainable if water is delivered at the same rate and quality all the time as designed and constructed. According to the Operation and Maintenance (O & M) guidelines for Small Towns Water Systems in Ghana (CWSA, 2004), a water system is said to be delivering water in a sustainable manner if:

1. The design quantity of water is produced over the design life of the system.
2. Water produced meets Ghana Standards Board Water Quality Standards.
3. Water is delivered in a cost effective manner.
4. Water is delivered in an uninterrupted manner (at least 95% of the time)
5. Planned routine and periodic maintenance are carried out for all electro mechanical equipment and civil works.

Sustainability can only be guaranteed where sufficient money (or financing) is available to offset necessary expenditure (Carter et al., 1999). Tariffs serve as means of recovering moneys expended on the water systems in providing water to ensure long term sustainability (Nyarko *et al.*, 2007).

Study Area

Ghana can boast of two water sectors; Urban water sector under the mandate of Ghana Water Company LTD (GWCL) and Rural Water Sector whose operations are facilitated by Community Water and Sanitation Agency (CWSA) and operated by District Assemblies (DAs). A small town is defined in the CWSA Act as “a community that is not rural but is a small urban community that has decided to manage its own water and sanitation systems”. A further working definition used by CWSA is “a community of between 2,000 and 50,000 inhabitants, who are prepared to manage their water supply system”, even though the Small Towns Act goes on to define rural community to be those with a population of less than 5000.

The main water supply technologies adopted for small towns’ water service delivery in Ghana includes (CWSA, 2003):

- Surface water piped system
- Groundwater piped system
- Rain water harvesting.

It is worth noting that, all the systems mentioned above directly or indirectly use energy as an input in both abstraction, treatment and distribution purposes. Generally, energy sources for both the small town and urban water systems include:

- Grid electricity
- Solar energy
- Diesel generator

Five small town water systems were considered for this research; Wenchi, Bekwai, Kuntunase, Atebubu and Aburi small town water systems. Wenchi, Bekwai and Kuntunase water systems are powered by electricity whiles Atebubu and Aburi water systems driven by diesel motors.

Research Methodology

The data collection procedures comprised of field visits and surveys including interviews with technical operators of the systems, field investigation and review of annual, quarter and monitoring reports. The analytical period of the small town water systems is five years (2003 – 2007). For the purpose of effective comparison, all the income and expenditure components were adjusted to a 2009 base year with the aid of inflation values according to the Ghana Statistical Services (GSS, 2008).

Direct operational costs (OPEX) are the sum of diesel and electricity expenses (E), personnel cost (L), and other operation costs (O). Calculation of revenues was based on the water/wastewater tariffs (T), and water quantities supplied (Q) (Abu-Madi, 2009).

Our intention is to highlight the profitability implications of changes in diesel and electricity (the energy elasticity of profit), thus, profits from the small town water systems were forecasted in response to diesel and electricity price changes.

The financial viability of the operations of water facilities is represented in terms of profit change ratio (ΔP) as represented in equation (1), which is the percentage of change in financial profit ($Pt - Po$) with respect to current profit (Po); this is in response to a set of incremental increases and decreases (αE) to the diesel and electricity expenditures. The degree to which a change in energy price will cause a change in profit is called energy elasticity of profit (ε), as represented in equation (2); if ε is greater than 1, profit is considered to have high energy elasticity, and if ε is less than 1, profit is considered to be energy inelastic.

$$\Delta P = (Pt - Po)/Po \quad (1)$$

$$\varepsilon = \Delta P / \alpha E = \frac{[(Pt - Po)/(Po)]}{[(Et - Eo)/(Eo)]} \quad (2)$$

Results and Discussions

Proportions of OPEX

The results show that energy costs represent 31%, 26%, 26%, 34% and 39% of the total Operational costs for Wenchi, Kuntunanse, Bekwai, Atebubu and Aburi water systems respectively (Table 1). The diesel-driven water systems recorded higher proportion of energy values and this can be attributed to the diesel motors which incur higher costs than electricity-driven systems. The proportions of personnel and O&M to total Operational costs for small town water systems range between 27% and 42% and 29% and 47% (Table 1).

Table 1: Proportions of OPEX from Small Town Water Systems

Income and OPEX (US$/Yr)					
	Electricity - Driven			**Diesel - Driven**	
	Wenchi	**Kuntunase**	**Bekwai**	**Atebubu**	**Aburi**
Proportions of OPEX (%)					
Energy Cost	31	26	26	34	39
Personnel Cost	36	42	27	37	32
Other O & M Cost	33	32	47	29	29

Operational Costs Ratios

Wenchi, Kuntunase, Bekwai, Atebubu and Aburi small town water systems recorded energy cost per m^3 of 0.21 US$/m³, 0.16 US$/m³, 0.18 US$/m³, 0.56 US$/m³ and 0.90 US$/m³ respectively (Table 3). It can be seen from Table 2 that, total cost per cubic meter of water supply are relatively higher for diesel-driven systems than for electricity-driven ones. It is therefore evident that diesel driven systems incur higher unit production cost than electricity driven systems (Table 2).

Table 2: O and M Cost for Small Town Water Systems

	Electricity-Driven System			**Diesel - Driven System**	
	Wenchi	**Kuntunase**	**Bekwai**	**Atebubu**	**Aburi**
Operational Ratios (US$/m³)					
Total Cost per m³ of Water Supplied	0.67	0.61	0.69	1.66	2.30
Energy cost per m³ of Water Supplied	0.21	0.16	0.18	0.56	0.90

Sustainability of Water Facilities

Sustainability can only be guaranteed if operational cost (OPEX) and CapEx (depreciation) cost are fully recovered. This study focused only on the OPEX and did not consider the CapEx. For water systems to be sustained, operational income must be adequate enough to defray OPEX, and the surplus is the profit (Pt) before depreciation and tax. The study sought to find out to what extent energy increases would make the system unsustainable or breakeven (where revenue equals Opex) The point one (1) on the horizontal axis is the current coefficient of energy ($\alpha E = 1$) and it serves as the reference point (base year) on all the figures below.

The results as depicted from the figure shows that currently, the small town water systems powered by electricity motors are sustainable and can withstand up to 145% increments in the current electricity prices when all other OPEX components are held constant (Figure 3). Any further increment beyond the 145% mark will render the system unsustainable.

The results as depicted from the Figure 3 show that small town water systems powered by diesel motors cannot withstand the current energy prices (Figure 4). For diesel-driven systems to recover just their OPEX, there has to be a reduction of 25% in the current diesel prices. Reduction in domestic energy prices is dependent on the variation of global oil prices, as such water tariff may be reviewed and other challenges like high UFW tackled to save the burgeoning crisis associated with the systems.

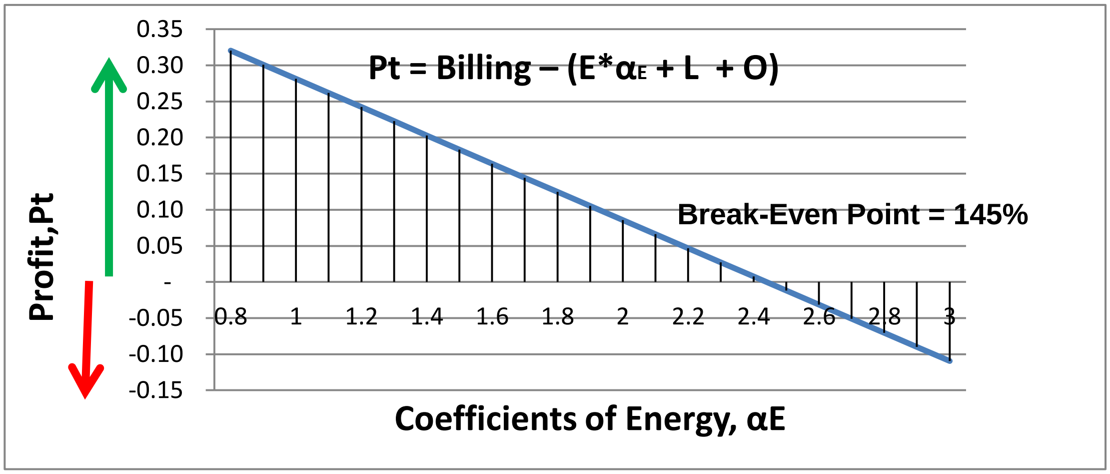


Figure 3: Sustainability of Small Town Water Systems (Electricity-Driven)

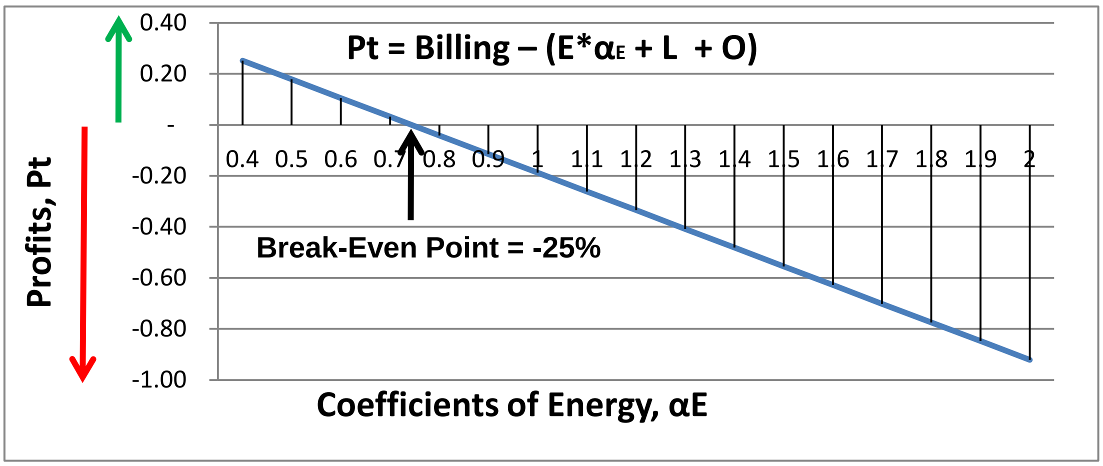


Figure 4: Sustainability of Small Town Water Systems (Diesel-Driven)

Energy Elasticity of Profit

The effect of energy price changes (αE) on profit is expressed in terms of energy elasticity of profit (ε) for each water system (Equation 2). The energy elasticity of profit values recorded by the systesms show that Wenchi, Atebubu and Aburi small town water systems are sensitive to energy price changes, therefore an elastic relationship exist between profit and energy price changes.

Again, the study reveals that profits from Kuntanse and Bekwai small town water systems are inelastic to electricity price changes because they recorded absolute value of the energy elasticity of profit is less than one (1).

Table 3: Energy Elasticity of Profit from Small Town Water Systems

	Electricity – Driven			**Diesel – Driven**	
	Wenchi	**Kuntanase**	**Bekwai**	**Atebubu**	**Aburi**
Energy Elasticity of Profit, ε	-1.37	-0.19	-0.63	-1.64	2.54

Conclusions and Recommendations

Energy expenses have susbstantial impact on the financial profit from the water systems and form a substantial component of the total money expended in providing water to consumers. Increased energy prices reduce profits from the water systems and threaten their sustainabilities. Additionally, electricity driven systems are more sustaianble to run than diesel driven systems beacuse diesel driven systems are more susceptible to global oil price changes. This suggests improvement of electricity infrastructure in areas of water systems and creating awareness on the enormous payback of converting the diesel driven systems into electricity driven ones. Policy makers may adopt the outcomes and methodologies of this study and utilise them during reform of water pricing policies and subsidies to the energy sector. Continuity of this research in assessing the impacts of the other variables (labour cost and O&M cost) on the sustainabilty of water facilities may enhance the opeartions and efficiency of the water sector.

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First of all, I owe this great gratitude to the Almighty God for guiding and directing me throughout the entire duration of this study. My heartfelt gratitude is highly expressed to Professor S. N. Odai, Mr. K. A. Adjei and Mr. F. O. Annor for their continuous guidance. My sincere thanks also go to my twin brother, Tenkorang Somuah Senior and to my friends; Stephen Owusu Adjei and Jacinta Carroll Osei Adutwumwaa. I appreciate in profoundness the support of my dad, Mr. Maxwell Rex Tenkorang and my dear mum, Mercy Obeng for their encouragement for me to continuously disseminate the output of this research.

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The Urban Pro-Poor Water Services Delivery – The Access Dimension: The Case of AVRL Tanker Service Supply

Benedict Tuffuor, Eugene Larbi & Anne Barendregt

Abstract

In Ghana, JMP estimates that in 2008 only 30 percent of the urban population was served by piped water into a dwelling, plot or yard and 60 percent by other improved sources. This is as a result of historically low investment in new infrastructure, weak maintenance of existing facilities, and poor management of water services. The present level of unaccounted for water in Ghana's cities hovers around 50%. The urban poor are the worst affected by the current situation which contributes significantly to their economic and social hardship. Unfortunately, efforts by governments over the years have not improved significantly the plight of the poor who are mostly the un-served/under-served. The paper looks at a Tanker Services Project implemented by the Aqua Vitens Rand Limited[15] (AVRL) in 2008/09 and makes case for the need to prioritise improvements in water supply and management to the poor as a first important step in addressing the problems the poor face with access to potable water.

Introduction

Access to water through direct connection into a dwelling, plot or yard is generally considered to be the highest level of service. Globally, there have been significant increases in percentage of people with direct household connection to tap water in the period 1990-2006, but the situation has been different in Sub-Sahara Africa, where access to water through household connection and yard taps has remained stagnant (UNICEF/WHO, 2010). Figures released for 2008 by the JMP showed that, in Ghana, only 30 percent of the urban population was served by piped water into a dwelling, plot or yard and 60 percent by other improved sources (public standpipe, borehole, etc.).

The general regularity and reliability of water supply by the GWCL in Accra is not assured (SWITCH/RCN Ghana, 2011). This has resulted in some kind of rationing over the years. Water service delivery to the poor (un-served and under-served) faces a lot of challenges - a situation which is worsened by the notion at the level of GWCL that it is not profitable to serve such population, but it is also related to GWCL's ability to provide these services. The utility is technically challenged in providing service to the densely populated, unplanned areas, where many of the urban poor reside. These areas, often located at some distance from the network, are the most difficult areas to connect given that utilities normally face financial and human resource gap and the incentive to address the needs of these areas. Additionally, the urban water delivery system does not deliver adequate water due to reliance on ageing systems. These difficulties have

[15] The national utility, Ghana Water Company Limited (GWCL), on behalf of the Government of Ghana entered into a 5-year management contract (2006-2011) with AVRL. AVRL was in-charge of production, distribution and tariff collection. The contract ended in June 2011 without renewal.

contributed to poor and unsatisfactory water supply services in most urban areas in Ghana, especially Accra and Tema. In 2009, AVRL estimated it distributed about 372,000m^3 of water a day to the Accra-Tema Metropolitan Area (AVRL, 2009). This level of production was inadequate given the demand level which was over 50% more than the production level.

In Accra and other urban areas in Ghana, available water is rationed to ensure equitable distribution. The inhabitants of Accra do not receive water every day of the week. The rationing is in some cases not predictable. Notwithstanding the efforts of GWCL/AVRL to manage the water supply through rationing in such a way that people receive a fair amount of water on designated days, some locations in Accra and its peri-urban areas still do not receive water at all. This problem becomes more pronounced annually during the dry spell between January and March, when there is no rain water to complement the piped water source. Due to the irregularity and unreliability, households have resorted to storing water for later use. The situation has also led to a thriving business of water vending in the under-served and un-served areas through tanker service. Whilst the water vending has been under the circumstances of immense support to households without connections, it has also contributed to exploitation of the poor. These vendors mostly 'source' their water from the urban pipe-borne network. There are essentially 2 types: large scale enterprises requiring a capital outlay for purchase of tankers that supply water in large volumes to richer households situated in water scarce neighbourhoods, and small scale vendors who buy water from tankers and sell in smaller volumes to individual households at the community level.

Brief History of Tankers Services in Ghana

Water Tanker services in Ghana has its history from the 1980s when it started as a way to meet the ever increasing demand for water in the growing construction sector during that period, especially in Accra. The continuous decline in the regularity and reliability of water supplied by the GWCL gave impetus for some domestic consumers to develop business out of the situation. These were mostly entrepreneurs with the interest who could afford to install tanks to store water for resale to those who were not connected. The phenomenon developed to a stage where even those without connections installed tanks and relied on tanker supplies for water to resell. The activities of water tanker operators continued to grow over the years to the point that the GWCL had to give the operators of tanker services recognition to curtail the tendencies where some operators were drawing water illegally from the utility's fire hydrants and unsafe sources. The tanker operators were therefore given designated tanker service points where they could go and draw water legally to sell.

The process developed and led to the initial establishment of a Tanker Operators' Association to serve as the mouth piece of the operators and protect members' interest (Kariuki and Acolor 2000). Since then, tanker services in the water sector have picked up and according to Sarpong and Abrampah (2006: p.47), the number of tanker service associations has been increasing. An Accra Mail report (27 March, 2008) on the launch of the Guideline for Tanker Operators by the Public Utility Regulatory Commission, estimated the number of water tankers in the Accra and Tema Metropolitan areas at 1000. The activities of these tanker operators are very prominent in the Accra and Tema Metropolitan areas and constitute a key component of the water delivery system, especially in areas of low pressure and un-served areas.

The Case of AVRL Tanker Services Intervention

The AVRL, in collaboration with the GWCL and the Ministry of Water Resources Works and Housing (MWRWH) adopted the Tanker Services as an interim measure to deal with acute water shortages in various parts of Accra during the first half of the year 2008. The most affected segment of the population was the poor. In response to the problem, the AVRL, in April 2008, initiated a Tanker Services Project where 2 private tankers were resourced and commissioned to supply water as an interim and auxiliary measure to selected water-poor areas in the Accra East Region[16] including parts of Osu, La, Teshie-Zongo, Adenta-Ashalley Botwe, Dome-Taifa and Kwabenya and Dodowa, (Daily Graphic, 2008 and The Ghanaian Times, 2008). In these areas, 20 vantage points (selling points) were selected and AVRL installed storage tanks (averagely 2 per site) where tankers supplied water for sale by an appointed vendor to consumers at a fixed rate (GHp5/20litres). The intention was to run the service for about 6 month by which time the drought would have ended and supply situation would have improved. However, the scheme was found to be still in high demand by the affected communities even after one year of its operation. This was because the supply situation had not improved much and for some of the areas supply through the water mains was virtually non-existent. This paper focuses on the implementation of the project in parts of Osu, La, Taifa, Dome and Kwabenya and relies a lot on information gathered from a project evaluation conducted on the scheme by the AVRL in 2009.

Partners and Their Roles and Responsibilities

A summary of roles and responsibilities of partners in the implementation of the project according to AVRL (2009) is presented below:

- AVRL Head Office was to be in charge of the organisation and financing of the project.
- AVRL Regional Office, Accra East was to be in charge of the supervision at the various locations and the construction of the selling points together with the various District Offices of AVRL.
- The selection of the community was done by GWCL, MWRWH, AVRL Head Office and Accra East Regional Office based on demands from communities and assemblymen.
- In the concerned areas, the communities and assemblymen were involved in the selection of the locations for the selling points, the construction of the platforms and the selection of the vendors.
- During the whole process a consultant from a local NGO was contracted to be responsible for facilitating community involvement and education.

Operational and Management Arrangements

The AVRL through a consultant facilitated a community involvement process which led to the selection of community representatives (referred to as **Coordinators**) to man the selling points in their respective communities or areas. The Coordinators recruited and supervised vendors, and also had the responsibility of financial management, and arranging for supply of the water. The

[16] Accra East is one of the 12 Operational Regions in which AVRL operates. Each Region is divided into Operational Districts.

coordinators played the oversight role over selling points. The proceeds from the operation went to the coordinators and they were responsible for paying the vendors their commission and ordering and paying for tanker supplies. It was arranged that the coordinators paid for the number of trips being ordered directly at the AVRL Accra East District Office and were issued with waybills. The coordinator would then, with the copy of the waybill, make requests for water supply from the tanker operator/driver. The tanker driver would present a copy of the waybills before he would be served at the filling point. The above notwithstanding, there were slight variations in the management at different locations including:

- Where an Assembly Member is the coordinator. He exercised oversight responsibility over the running of the selling points including recruitment and supervision of the vendors. For example, all selling points at La and two at Osu areas were under the respective assembly members.

- Where an opinion leader who showed commitment to the project is given a coordinator's role with the same oversight role as above. This arrangement was identified at three selling points in Dome.

- The third option is a situation where the coordinators were themselves the vendors and this was found at Taifa (three selling points) and two at Osu.

- The fourth option identified was where an identifiable local group or body is given the responsibility of coordinating. In this case the Kwabenya Residents Association spearheaded the project for the affected areas of the community and exercised the oversight responsibility.

The **vendors** were basically, in charge of selling the water and cleaning the site. There were very few instances where the vendors happened to be the co-ordinators themselves as mentioned above. Payment arrangements for vendors varied in two ways: commission (average of GHC4) on each consignment of $15.75m^3$ or monthly fixed payments (average of GHC60). Customer-Vendor relationship was found to be cordial. Operation periods (hours) of vendors varied slightly among selling points and they were generally suitable for consumers. This was because vendors had over the period scheduled their operational hours according to the demand trends in their areas.

Water was supplied by 2 private **tankers**, each with a capacity of 3500 gallons ($15.75m^3$), hired by AVRL. Whenever there was pressure, AVRL supported the supply with its own KIA truck fitted with 2 storage tanks of $9m^3$ each. The tanker drivers were made to pack at the AVRL premises when they were not in use to check abuse and also ensure that they were readily available whenever needed. The tankers filled all locations depending on the request of the coordinators of the selling points, which was found to be mostly daily or every other day. The mandate of the tankers was to fill only the project selling points. Under the agreement with AVRL, the tanker operators received an average of 180 litres of fuel per truck for every week. In addition, they were paid GHC250 a day per tanker for their services.

AVRL funded the provision of the storage tanks and the raising of the platforms with communities providing labour at the various selling points. Even though the facilities are solely managed by people at the community level, the ownership of the storage tanks remained with AVRL and the tanks were labelled as such. AVRL funded all the other costs (tankers service charges, fuel for tankers, fees for software consultants). The project did not intend to recover the cost of establishing the selling points.

The arrangement for **selling points (20) management** varied from one area to the other, and generally differed from typical community managed schemes in small towns water supply. These management arrangements, as described above, centred on local champions of the implementation process in the different communities.

The Successes of the Intervention

- ***Modest improvements in water supply:*** The project supplied, on average, 128.8m^3 of water to all the 20 selling points per day. The quantity to each area however, varied according to the level of demand. For instance, the demand from La selling points was more than twice that from selling points in Taifa. Notwithstanding the community variations, the intervention met a felt need of the beneficiaries.

- ***Cost saving for the household:*** The project supplied quality water (based on account of AVRL) to the beneficiaries at a lower cost than water supplied by private tanker operators within the communities (most of whom existed before the AVRL interventions started). 20 litres of water was sold at GHp5, compared to local private vendors who sold the commodity at between GHp10 to GHp20. This means that the same amount of money that was used to buy a certain quantity of water could now buy 2 to 4 times of the same quantity.

- ***Time savings***: The beneficiaries recounted that the turnaround time which used to be a minimum of 30 minutes (even more in the dry season), drastically reduced to an average of 15 minutes. Queues were experienced only in the peak hours between 6am and 7.30am, and also between 5pm and 6pm. "The perennial problem of carrying containers about in search of water has stopped" said one respondent.

- ***Perceived Water Quality***: There was widespread consumer perception that the water from the AVRL selling point was of good quality and would contribute to improved health. Therefore, consumers who could not get enough for entire household needs would get enough quantity for drinking from the AVRL selling points.

The Challenges of the Intervention

- ***Bringing down the cost of water:*** One key objective, aside improving water supply to the affected areas, was to bring down the prevailing prices of water in the communities which ranged from 200% to 400% of the AVRL price of GHp5. However, this was not possible because: the quantity of water supplied to the communities was far below their demand, locations of the selling points were not convenient to all consumers due to distance, and also the private vendors bought water at higher price than AVRL sold to the selling points. Consumers preferred the arrangement where they could walk almost any time to buy from the private vendor because they operate in the vicinity of their home.

- ***The project had to run on huge subsidy which is not sustainable***: In order to ensure that consumers buy water at the rate of GHp5/20litres and also allow some margins for the coordinators, AVRL sold water to the selling points at GHc18.00 per 15.75m^3 of water by absorbing the cost of engaging the water tanker which was estimated at GHc14,000.00 per month. The same quantity was sold to the private vendors by private tanker operators at GHc32.00. It worth noting that, the 20 litres of water would have cost GHp1.3 if consumers were supplied through direct connection, based on the life-line tariff.

- ***The tanker service was subsidy depended***: The AVRL had to highly support the operations to be able to purge the consumer buying price at official standpipe rate. Tanker service therefore, is not a feasible option for delivering water at official rate to the urban poor without huge subsidy support on sustainable basis. A comparative cost analysis of tanker supply and direct piped supply showed clearly that generally, water tanker services are considerably more expensive than piped systems.

- ***The scheme is not attractive for private sector investment***: Profitability analysis of operations, under the subsidy and fixed selling price of GHp5, showed low level of profitability. Coordinators could make a profit of GHc100.00 per month only if they were able to sell 25 trips of supply. With exception of selling points in La, most selling points sold about just 15 trips of supply.

Conclusion: The Case of Access (Supply)

Generally, the intervention succeeded in making some improvements in the acute water shortage situation in the affected communities to calm down the agitations. It met the needs of a section of the population that led to the continuous demand for the service. It is however obvious that the project could not make wide spread impact on prices of water in the affected communities. Again, the low pricing did not change the patronage pattern in favour of the selling points against the private vendors. There was no evidence of prices of water sold by private vendors being reduced because of the introduction of the project. The demand for services of the private vendors was still substantial. This was because consumers generally prioritised access/regularity, reliability and convenience over the price of the service. In planning for a pro-poor intervention these expectations should be adequately catered for. This paper does not write off the potentials of other pro-poor mechanisms if they are well targeted, but emphasises the point that to achieve significant impacts of pro-poor delivery interventions, water supply to the un-served and under-served areas should increase significantly through the mains. The sustainability of the supply will require other well targeted pro-poor mechanisms to ensure that poor actually benefit from the services.

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Economic Efficiency of Water Storage Options: An Application of the Approach to Ghana

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Abstract

Water storage is widely promoted as an effective method for mitigating some of the adverse impacts of climate change. Cost benefit analysis is one approach to evaluate which is the most appropriate water storage type under any specific biophysical and socio-economic conditions. However, this often results in loss of significant information for those characteristics which cannot be easily assessed using monetary values. Against this background, the study reported in this paper developed an outranking-based methodology, designed with threshold systems and weighting values, in order to overcome some of the constraints of traditional cost-benefit analysis. The method has been applied in three representative catchments in central and northern Ghana. The results present a preponderance of upstream areas linked with small reservoirs because of the considerably high income, the sufficient water supply, the low costs given for water related illnesses and the low costs for domestic water use.

Introduction

Procedures for water storage selection often resort to a form of cost-benefit analysis (CBA) to identify the most appropriate option. However, in cases where imperfect market conditions exist and non-market goods and services occur, CBA may lead to non-optimal results.

The first weakness of CBA arises from the strong comparability principle, which stems from the monetization of heterogeneous goods and services (Hanley and Spash, 1998). The monetization of all elements inevitably leads to reductionism and loss of information about the nature of each factor (Munda, 1996). Second, the assumption of the absolute substitutability among goods and services also causes errors, since in reality this is not always the case (Munda, 1996). For instance, the revenues derived from the electricity sold by a hydro-electricity plant will often outweigh the financial costs arising from the displacement of communities and the flooding of ancient forests. Consequently, the option identified through CBA as the best option, should not necessarily go ahead.

Another major constraint arises from the potential irreversibility of conditions associated with the development of water storage. For example, the construction of a hydropower dam often results in soil erosion due to deforestation, siltation of downstream areas and loss of wildlife (Mishan, 1981). The issue of ecosystem complexity is another major issue that is poorly handled by the CBA method. For example, the climate change projections for Sub-Saharan countries indicate the likelihood of increased rainfall variability in many places (IPCC, 2007). If these climate change scenarios occur it may drastically affect the costs and benefits over the lifetime of a planned water storage project.

Institutional capture is another major impediment to CBA, mainly represented by inter-generational inequities. The notion of a discount rate is often used to address trade-offs between generations. In many instances, this is a highly arbitrary process associated with the identification of a discount rate which is used to assign values to environmental goods and services that will be inherited by future generations (Söderbaum, 2005). In relation to distributional aspects and intra-generational issues, this is often a highly contested approach which is aligned with the core concept of economic theory. The principles of economic theory are based on the identification of the most efficient utility level on an individual basis without considering the distributional and equity aspects of the efficiency (Munda, 1996).

To overcome the aforementioned constraints, we propose a method that is based on a multi-criteria outranking approach (Roy, 1996). The suggested method assesses diverse indicators related to both economic performance and environmental impacts of water storage schemes. The approach also attempts to enumerate the gains and losses between different users. The suggested approach has been tested by evaluating the performance of different small reservoirs and the effects to upstream and downstream users in three catchments in central and northern Ghana.

The Outranking Based Approach

Our concept is based on the principles of decision aiding approaches. These can be divided into two types, "descriptive" and "constructive" (Vincke 1994). A descriptive approach focuses on the identification of pre-existent preferences. This assumes that for whoever's preference is sought, they are predefined and pre-exist in a stable state. The descriptive approach forms the basis of the development of a simple and comparable System of Preference Relations (SPR), which is based on the strict preference and indifference conditions (Roy, 1996). In the descriptive approach, the most efficient solution should be identified using trade-off processes between different criteria. The descriptive approach delineates the concept of optimization usually through a single criterion. The CBA method is a representative descriptive approach where the monetization of all results should identify the best solution.

However, over the last two decades, the difficulty of adequately comparing and quantifying heterogeneous criteria, such as the environmental and economic ones in water resource projects, has steadily increased (Munda et al, 1994). As a result, the "constructive" approach has been developed. In this approach, apart from the "strict preference" and "indifference" conditions, the "weak preference" condition is introduced. In the "weak preference" situation, two possibilities could prevail in which one criterion is weakly preferred to another or vice versa. Table 1 below summarises each of the three preference conditions.

Table 1: Preference conditions through a constructive approach (Vincke 1994, adjusted by authors)

Conditions	Definition
Strict Preference	Corresponds to the existence of clear and positive reasons that justify significant preference in favour of one (identified of the two actions).
Weak preference	Corresponds to the existence of clear and positive reasons that invalidate strict preference in favour of one (identified) of the two actions. The reasons are insufficient to deduce either strict preference in favour of the other action or indifference between the two actions, thereby not allowing either of the two preceding situations to be distinguished as appropriate.
Indifference	Corresponds to the existence of clear and positive reasons that justify equivalence between any two actions.

By adopting the above set of conditions, the proposed methodology attempts to establish an outranking based approach that avoids the inherent constraints of traditional CBA. The operationalisation of an outranking-based approach based on the constructive concept demands the introduction of specific relations and values. To help clarify the basic concepts, the essential components of the outranking approach are given below:

a, b = Alternatives of a proposed project (e.g. a= big reservoir, b= small reservoir)

j = A number of j criteria proposed for the ranking of the examined alternatives

p = strong preference threshold, q= indifference threshold

Initiating from the "strict preference" condition, a threshold value (p) establishes that a strict preference occurs only when the difference between the examined alternatives is beyond the defined value. In mathematical form, and assuming a maximization criterion without loss of generality, this condition is expressed as below:

a**P**b (a is strongly preferred to b) $\Leftrightarrow$, $g(a)-g(b) > p$ (1)

Next, the "weak preference" condition is represented by the introduction of another threshold value (q) which is added to the strict preference above. The condition is then presented through a double threshold model, where a binary relation measures weak preference as below:

a**Q**b (a is weakly preferred to b) $\Leftrightarrow$ $q < g(a)- g(b) < p$ (2)

In effect, the thresholds q and p comprise the lowest and highest values that could ever occur between the two alternatives. The weak preference should be determined within the range of these two values. Finally, there is also the indifference condition where the preference of one alternative (a) over another (b) is lower than the weak preference threshold and hence is considered as nominal. The model of this condition is expressed as:

a**I**b (a is indifferent to b; and b to a) ⇔ g(a) - g(b) < q (3)

The relations of strict, weak preference and indifference situations are operationalized as follows:

$$c_j(a,b) = \begin{cases} 1 & g_j(a) + q_j \geq g_j(b) \\ 0 & g_j(a) + p_j \leq g_j(b) \\ \theta & q_j \leq g_j(b) - g_j(a) \leq p_j \qquad \theta = \dfrac{p_j + g_j(a) - g_j(b)}{p_j - q_j} \end{cases} \tag{4}$$

Where $g_j(a)$, $g_j(b)$ = the performances of alternative scenarios *a* and *b* respectively for each criterion *j* , p_j, q_j = the preference and indifference thresholds respectively.

The values of 0, 1 and θ presented in equation (4), decipher the following messages:

a) 1 = when the difference between the two alternatives *a* and *b* for jth criterion is smaller than the indifference threshold; b) 0 = when the difference between the two alternatives *a* and *b* for jth criterion exceed the preference threshold; c) θ= when the difference between the two alternatives *a* and *b* for jth criterion is between the indifference and preference thresholds

Through the operationalisation of the preference conditions, an outranking relationship (S) between any two alternatives a and b can be constructed. The outranking relation can be interpreted as ''a is at least as good as b (aSb)'' or "a is not worse than b". It should be mentioned that these relationships are applied to each of the j criteria; that is, a**S**jb means that "a is at least as good as b with respect to the jth criterion" (Fülöp, 2008).

Many of the outranking-based approaches handle the distributional and significance related concerns by introducing multipliers, commonly known as weighting factors (DTLR, 2002). To this end, we introduced higher co-efficient to those criteria which better reflect the linkage of water storage with livelihood status. The weighting assumptions are necessarily subjective and require that the analysts should wisely judge the significance of the criteria in order to avoid bias in the assessment process. However, weight factors are currently the most widely applied approach for the consideration of distributional aspects (Seager, 2004).

We then calculate the findings of the outranking approach. Customarily, in most of the outranking based approaches (Roy, 1991), a formula composed by the weighting factors is applied. Usually a fraction is designed with nominator as the multiplication of weights and outranking results, and with the denominator representing the sum of the weights:

$$C(a,b) = \frac{1}{w}\sum_{j=1}^{n} w_j C_j(a,b) \qquad (5)$$

Where a, b = water storage options, w = weigthing factor, C_j = the outranking processes among the options and the criteria

Application of the Approach to Ghana

The economic performance of water storage in Ghana is defined by a set of diversified indicators divided into two different groups. These indicators are effectively input criteria in the outranking approach presented above. In the first group, the criteria are related to the direct and indirect economic effects of water storage to agricultural (cultivation and livestock) and domestic water use. The second group relates to the level of satisfaction of farmers about water use in agriculture and domestic sectors (Table 2).

Table 2: Criteria of economic performance for water

Group 1: Direct and Indirect economic effects	
Net revenues from agricultural produce	Ratio of net revenues from agricultural produce and water charges
Impact of Water Use on Health	Water for Domestic Use
Ratio of net revenues from agricultural produce and water consumption	
Group 2: Farmers' preferences in water use	
Level of satisfaction from water volume	Applied in Crops, Livestock and Domestic Sectors separately for each sector
Level of satisfaction from water quality	
Level of satisfaction from water abstraction methods	

The two groups of criteria are combined in order to determine the most effective economic performance of a water storage scheme.

The testing of the methodology was conducted in 3 small reservoirs in the Volta Basin of Ghana, namely; Sata in Ashanti Region, Vea in Upper East Region and Golinga in Northern Region (Figure 1). The objective of the analysis was to assess the economic performance of water storage types in downstream and upstream users through the aforementioned criteria. For the Sata case there was no "downstream" so only households in the upstream were interviewed. In the cases of Vea and Gollinga, the users of existing small reservoirs were surveyed. In total, five options; 3 upstream (Gollinga, Vea and Sata) and 2 downstream (Gollinga and Vea) were examined. For each site, 200 households were interviewed; 100 from households living upstream and another 100 living downstream. In all, 500 households were surveyed.

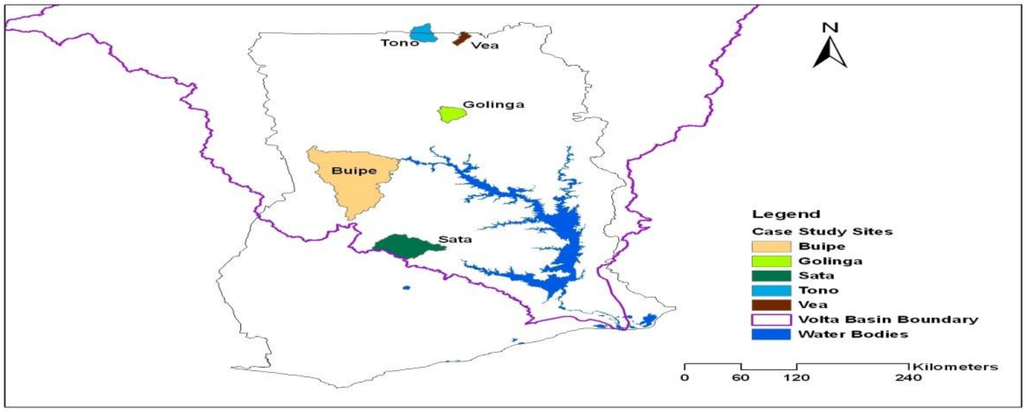

Figure 1: Case studies from Middle and Northern Ghana

For the application of the outranking approach, a set of preference and indifference thresholds were introduced while the weighting factors were also inserted. The calculation of the thresholds and weights was conducted according to the relevant guidelines suggesting the relation between the thresholds and co-efficient (Vincke, 1994).

Table 3: Thresholds and values

Criteria	Net Rev.	Rat. Net Rev./Wtr	Imp. Wtr Hlth	Wat.Dom.	Rat. Net Rev./Con.	Pref. Cr.
Indif. Thrs	100	100	30	5	6	1
Pref. Thrs	150	150	60	10	12	2
Wgt.	1.2	1.3	1.1	1	1	1

Note: Net Rev. = Net revenues from agricultural produce, Rat. Net Rev./Wtr=Ratio of net revenues from agricultural produce and water charges, Imp. Wtr Hlth. = Impact of Water Use on Health , Wat. Dom.= Water for Domestic Use, Rat. Net Rev./Con=Ratio of net revenues from agricultural produce and water consumption, Pref. Cr. =Preference related criteria, Indif. Thrs.= Indifference thresholds(q), ,Pref. Thrs.= Preference threshold (p), Wgt= Weights

The performances of the five alternative options in Vea, Gollinga and Sata were ranked for each criterion in a pair-wise manner through equation (4) (e.g Vea Upstream Vs. Gollinga downstream, for the criterion “Impact of Water Use on Health”). The aggregated performance of all criteria for each pair-wise outranking was then assessed through equation (5). Finally, all the performances of the pair-wise outranking combinations among the options produced a final scoring index as below (Table 4):

Table 4: Outranking assessment

Options	**Vea Upstream**	**Vea-downstream**	**Gollinga-upstream**	**Gollinga-downstream**	**Sata-upstream**
Vea- Upstream	-	1.00	1.00	0.82	0.82
Vea-downstream	0.00	-	0.82	0.64	0.82
Gollinga-upsteam	0.00	0.36	-	0.13	0.39
Gollinga-downstream	0.18	0.57	1.00	-	0.82
Sata- upstream	0.18	0.18	0.61	0.41	-
Total	0.36	2.11	3.43	2.01	2.86

As displayed in table 4, the upstream area of Gollinga together with upstream of Sata present a better performance among the other water storage options. Moderately behind stands the downstream area of Vea and the downstream of Gollinga whereas the upstream of Vea performs significantly worse than the other options.

It should be mentioned here that the research has not proceeded to a parallel CBA application for a comparative analysis of the results due to time and budgetary constraints. However, it has been proven that the inclusion of heterogeneous quantitative and qualitative criteria can be conducted for the economic assessment of water storage options without the threatening of reductionism and information loss as occurs in CBA process.

Conclusions

This study attempted to provide a methodology for the identification of efficient water storage options in regard to climate change effects by also capturing the trade-offs between upstream and downstream farmers. The application has overcome the simplifications occurring through the application of a cost-benefit analysis by aligning with the economic theory through the adoption of mainstream economic criteria. The additional introduction of environmental and technical related criteria attempted to capture the information related with water storage options. These diversified set of criteria was assessed though a systems of thresholds and weighting factors for the avoidance of complete trade-off assumptions which entails in knowledge reductionism and high uncertainty in the final outcome. It is considered that the suggested approach should be better applied through the introduction of more diversified criteria and also more heterogeneous storage options. However, the current results could offer an insight on the performance and effects of different water storage options through a solid and transparent approach.

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Poster Presentation Abstracts

The Effects of Climate Change – The Anthropogenic Factor on Vea Reservoir

Etornyo Agbeko & Barnabas Amisigo

Climate Change has been a global environmental challenge. Vea reservoir as a water storage system is vulnerable to the impacts of climate change in the rapidly changing rural to peri-urban environment of the Bongo District, Upper East Region. This poster briefly identifies anthropogenic activities on the littoral zones that could contribute to the exacerbation of climate change impacts on safe water delivery. Anthropogenic activities including bad farming practices, illegal logging of trees, over-grazing, sand-winning for block moulding and poor water culture that affected water quality were the main human factors that were identified. These activities in the near future (probably by 2020) could trigger eutrophication in the Vea Reservoir as a result of nutrient loading with the propensity to cause algal bloom. Higher rate of evaporation from the reservoir could be imminent in view of climate change in the distant future. If these activities go unchecked, the availability and cost of treatment for municipal and industrial water supply for the Bongo District and environs would become higher as in the case of the Weija reservoir serving the Accra metropolis. Integrated Water Resources Management (IWRM) strategies must be implemented as a matter of urgency. Creation of buffer zone with indigenous tree species and regular water quality monitoring system should be enforced. Riparian communities needs psyche-up for behavioural change towards safe and sustainable water delivery.

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

Enhancing Sustainability of Water and Sanitation Facilities Through Mobile Phone Technology

Patrick Apoya & Aelaf Dafla

This poster shows a mobile phone based system developed to record the operational status of community water and sanitation facilities and order spare parts when repair is needed. The system is designed to improve monitoring of facilities by enabling community members to SMS the operational status of the facilities. The system also allows spare parts to be ordered and be paid for by community using SMS and mobile money provided by mobile network providers. One of the Millennium Development Goals (MDGs) is to reduce the population without portable water and sanitation by half. Many countries including Ghana are following Community Ownership and Management (COM) approach as one of the strategies to achieve this goal. In this strategy community members are given responsibility to operate, manage and maintain water and sanitation facilities located in their locality. Studies have identified this method as a successful approach, at the same time some problems in monitoring and evaluation have been identified. The proposed system in this paper aims at addressing the challenge of monitoring facilities.

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Construction of Ferrocement Rain-Harvesting Tanks

L. Danso-Amoako & Herbert Attefuah

Ferrocement tanks are used for storing water for domestic, industrial and agricultural purposes in many parts of the world. The construction of the tanks was introduced into the country by ***UNICEF.***

Ferrocement tanks are built by hand trowelling a cement-rich mortar onto straight fencing wire (mostly BRC mesh) with woven mesh (mostly chicken wire) wrapped around them. The thickness of the tank wall varies from 3 to 10cm depending on its capacity.

Ferrocement tanks are preferred to concrete tanks for these reasons:

The ***Public Works Department*** *of the* ***Ministry of Water Resources, Works and Housing*** *has constructed over 50 Ferrocement tanks, listed below. Majority of the tanks are over 20 years, but they are all functioning normally without any defects. The tanks are constructed by formidable mobile gangs, some with over 24 years experience in tanks construction (Concrete and Ferrocement Tanks).*

Ferrocement Tank vs Other Tanks

Item	Ferrocement Tank Capacity) : 20,000 litres (Approx 5,000 gal	Concrete Tank Capacity: 20,000 litres (Approx 5000 gal)	Polymer Tanks Capacity: 20,000 litres (Approx 5000 gal)
Cost	GH¢45,000 to GH¢50,000 Depending on location	GH¢120,000 to GH¢150,000 Depending on Configuration, wall thickness and location	GH¢45,000 to GH¢50,000 Depending on brand
Construction Period	Can be constructed and ready for use within a maximum of 15 days.	Can be constructed and ready for use within a maximum of 28 days.	
Wall thickness	Average 5cm (2 inches)	Minimum 15cm (6 inches)	
Basic Materials	Cement Sand Mesh	Cement Sand Stones Steel Rods	Product of Polymerization
Artisans	Masons, Labourers	Masons, Carpenters Steel benders, Labourers	
Transportability	Can be transported	Cannot be transported	Can be transported
Others	Attractive, easy to repair, difficult to construct during raining seasons. Mortar on sugar sack can wash away.	Not Attractive, difficult to repair.	Cracks easily by sun rays when empty.

Tanks Constructed By Public Works Department

Institution/Organization	Quantity
Amedzikope Junior Secondary Schools (JSS).	2
Accra, West Africa Examination Council.	1
Aburi, Aburi Girls Secondary School.	2
Koforidua, Public Works Dept.	1
Koforidua, Ghana Telecom.	1
Koforidua, Koforidua Secondary Tech. School.	3
Koforidua, SDA Training College.	1
Koforidua, Electricity Company of Ghana.	1
Somanya, Somanya Secondary School.	2
Benkum, Benkum Secondary School.	4
Akosombo, Ghana Telecom.	2
Akim-Tafo, Ghana Telecom.	1
Akim-Oda, Ghana Telecom.	1
Nkawkaw, Ghana Telecom.	1
Koforidua. New Juaben Municipal Assembly.	1
Donkorkrom, Former Donkorkrom Dist. Assembly.	3
New Abirem Dist. Assembly	4
Abetifi, Abetifi Secondary School.	2
Nsawam, Ghana Telecom	1
Bunso, Bunso Rest. House	1
Ejura, Ghana Highways compound.	1
Larteh, Larteh Presby. Junior Secondary Schools	2
Wenchi, Ghana Telecom	1

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Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment

No Toilet at Home: Sanitation Strategies for Urban Dwellers

Adrien Mazeau

In the context of a rapidly changing urban environment, provision of infrastructure and basic services such as sanitation has to overcome a range of technological, institutional and social challenges. Land tenure, space to build and low household income (or poverty) are often recognized as barriers to the provision of private toilets. To overcome some of these barriers, public and private providers have built blocks or individual toilets to serve more multiple families. These shared facilities can be of many types but in the context of low-income and high density areas, they remain one of the most used solutions for access to sanitation. Shared sanitation facilities serve more than 50 % of the urban population of Ghana.

The poster presents pictures and initial results from an on-going study regarding the options available to urban dwellers when selecting a sanitation facility. In Ashaiman, dwellers may have access to public toilets managed by the municipal assembly, toilet blocks run by private entities, single toilets belonging to neighbours or toilets managed by landlords. Facing this range of facilities, residents of Ashaiman make a choice of which facility to use based on their perceptions and past experiences and a set of parameters such as for instance proximity or price. The poster suggests that a better understanding of user perceptions will help stakeholders identify the circumstances under which different types of shared sanitation facilities would be acceptable for urban dwellers. Acceptability of a facility is one of the key aspects ensuring the future use of the facility.

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