Alternative drinking water supply in low-income urban settlements using tankers

A quality assessment in Cape Coast, Ghana

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Abstract

Purpose – The purpose of this paper is to verify claims that water supplied by operators of tanker trucks in Cape Coast does not meet quality standards recommended for human consumption, and to investigate the sources of any contamination.

Design/methodology/approach – Samples were collected from a water hydrant from which tanker operators draw water from the Ghana Water Company Limited distribution system in Cape Coast and a number of tankers sampled at random. Additional samples were taken from the premises of a patron of the tanker service and a regular customer of the Ghana Water Company Limited. All samples were subjected to physico-chemical and bacteriological analyses and the results compared with the World Health Organization's guidelines for drinking water.

Findings – It was found out that water supplied by the tanker operators indeed failed to meet the World Health Organization's guidelines for some quality parameters as alleged by patrons of the service. The tanker-supplied water was found to contain high levels of *Escherichia coli*, colour, turbidity and total iron. This was found to arise from the management of the water hydrant and the tankers by the Ghana Water Company Limited and the tanker operators respectively.

Originality/value – The study provides a basis for the set of actions that must be taken to safeguard public health and consumer confidence in drinking water supply using tankers as an emerging alternative to conventional water supply in urban centres of the developing world.

Keywords Water supply, Quality, Ghana

Paper type Research paper

1. Introduction

1.1 Background to the study

Access to quality drinking water is a subject of immense interest in the developing world where 2006 figures indicate that only 58 per cent of the population have access to potable water as compared to an aggregate global coverage of 89 per cent (OneWorld-UK, 2008). The concern commonly expressed about the disparity in good drinking water between the developed and developing world is founded on the obvious connection between good drinking water, on the one hand, and good health and

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improved livelihoods on the other. The United Nations (UN) World Report 2 notes that poor water quality is a major cause of poor livelihood and health and estimates that the provision of access to safe drinking water, sanitation and hygiene could save about 1.6 million lives annually (UNESCO, 2006). Moreover, the WHO notes that "management of small community drinking water supplies has been universally identified as a critical issue for sustainable development and health, and an issue that requires significant attention to protect community health and to ensure the water-related Millennium Development Goals (MDGs) can be met" (WHO, 2006, p. 5). On livelihoods, Butterworth (2006) reveals that access to potable water eventually translates into poverty alleviation and improved livelihood.

Conventionally, the supply of potable drinking water involves the construction of treatment plants to remove contaminants from naturally occurring water, extracted either from a surface water body or an aquifer, using various processes such as aeration, sedimentation and flocculation, filtration, and disinfection. The treated water is then distributed to the final consumer through a piped network. Pipe-borne treated water thus represents the commonest source of drinking water in the developed world.

Governments in the developing world are, however, faced with a daunting task providing all communities with conventional water supply systems. In Ghana, for example, by the year 2007, the only urban water supply utility – the Ghana Water Company Limited (GWCL) – operated 82 urban water systems with an average output of 572,012m^3 per day. This was against a daily demand of 1,049,306m^3 per day required by the then 8.3 million urban residents (MWRWH, 2007). The low coverage (54.5 per cent) is certainly the outcome of the high costs of investment and system maintenance coupled with constraints on the national budget – but not a scarcity of water resources. The high cost of investment and operation and maintenance weigh down the provision of adequate infrastructure to impound the abundant surface water resources of the nation for treatment and supply through piped systems to meet the demand. Interestingly, the consumptive water demand for the country by the year 2020 is estimated to be 5 billion m^3, which is equivalent to only some 12 per cent of the total surface water resources of the nation (MWRWH, 2007).

Consequently, various alternative water supply options are resorted to by the population that are not served, usually comprising rural communities, and new settlements at the periphery of urban centres. In the case of Ghana, the Community Water and Sanitation Agency (CWSA), supported by donor agencies, supplies potable water to rural communities through the provision of communal boreholes with or without some form of treatment, depending on the natural water quality. Small towns (with population between 2,000 and 5,000) are also supported under the CWSA-donor arrangement to construct what has become known as "small-town water supply systems", which involve the pumping of groundwater to overhead tanks for storage and distribution under gravity through a small-scale piped network. For rural communities of the developing world, in reality, these can hardly be referred to as alternative drinking water supply systems since they – but not conventional systems as described previously – are usually the officially recognised primary option. For a fact, they represent Ghana's National Water Policy objective for such communities (MWRWH, 2007).

For urban centres such as the Cape Coast Metropolitan Area (CCMA), where the GWCL is unable to serve most residents with pipe-borne treated water as expected, various alternatives have evolved. Some residents depend all entirely on boreholes drilled privately while the more affluent reserve borehole water for washing and other household chores except drinking. They resort to bottled or "sacheted" water, christened "pure water", for drinking. Some urban residents also depend on private water vendors, from who they buy either in buckets or order in large quantities delivered by tankers. The National Water Policy quotes the Ghana Living Standards Survey, Round 4 (GLSS4) as reporting that approximately 40 per cent of urban families were depending on neighbours and vendors for their water supply. The Policy notes that "with rapid expansion of new housing developments, often ahead of utility services, more and more urban residents will depend on vendors and tanker services, at costs far in excess of utility rates" (MWRWH, 2007, p. 29).

For the affluent, water supply by tankers is a reasonable compromise between quality and cost. Household boreholes offer, perhaps, the cheapest alternative to conventional water supply but its high salinity, especially in coastal areas like Cape Coast, limits its patronage. On the other hand, commercially bottled water, regarded as the safest and most reliable (FEMA, 2004), is economically prohibitive to supply for bathing and other household chores. Tanker service is therefore emerging in low-income urban settlements as a preferred alternative to conventional water supply, usually patronised by sections of the middle-to-high class residents who are not covered by conventional systems. Nevertheless, in developed economies where pipe-borne water supply is readily available, water supply by tankers is largely regarded as an emergency option (WHO, 2005). Wars, natural disasters, accidents and breakdown of conventional water supply systems are among the several emergency conditions, which necessitate water supply by tankers in the developed world.

Owing to the inescapable link between the quality of drinking water and health, the major concern expressed about any alternative or emergency water supply scheme is the quality of water delivered to the final consumer. This engenders efforts by state institutions to regulate or monitor such schemes to safeguard the safety of the section of the populace who are not served under more secure systems. In New Zealand, for example, the Drinking-water Standards for New Zealand, 2005 (revised 2008) (MoH, 2008), dedicates a section to Tankered-drinking Water Compliance Criteria, which provides a regulatory framework for the delivery of safe water by tankers. It is required that every operator of vehicles used to transport water ensures, among other things, that the tanks and other systems used for loading and unloading water:

- have not been used previously for transporting any noxious, toxic or hazardous matter, non-food liquids or human or animal wastes;
- are protected from contamination during loading, transportation and delivery; and
- are kept clean and clear of any possible contaminants before sourcing the water to be delivered, with all openings and connections sealed to protect them from possible contamination (ibid, p. 114).

As part of New Zealand's monitoring procedures, samples from the delivery tank must be regularly collected for E-coli testing at a recognised laboratory.

To safeguard the integrity of vended water supplies, in general, the WHO's Guidelines for Drinking-water Quality (WHO, 2008) recommends that system risk assessment should include issues such as:

- the nature and quality of source water;
- control measures, including protection of source waters and treatment;
- mechanisms for abstraction and storage, including hoses, hydrants and pipe work; and
- design and characteristics of containers used to transport and deliver water (ibid, p. 120d).

1.2 The problem

Cape Coast, the capital of the Central Region of Ghana lies in the southern part of the country, along the coast of the Gulf of Guinea, with a population of 82,291 (2000 census). The main source of water supply is the Brimsu Headworks of the Ghana Water Company Limited (GWCL). The headworks is an impoundment of surface water (the Kakum River) with a 4 million gallon (18,000m^3) per day capacity treatment plant, which also serves other towns in the Region. According to the GWCL, the share of the Cape Coast Metropolitan Area (CCMA) in the daily water supply from the Headworks covers only 60 per cent of the residents of the Metropolis, a little higher than the national average of 54.5 per cent for urban communities. The remaining 40 per cent, mostly in new housing developments where pipelines have not been laid, have to resort to alternative sources of water supply. Groundwater, which is readily available by virtue of the shallow water table, tends to be salty due to the proximity of the Metropolis to the sea.

An emerging option for domestic water supply is bulk delivery of treated water from the Brimsu Headworks by tankers trucks operated by private individuals under the supervision of the GWCL. The GWCL provides the tanker truck operators access to its distribution system via a hydrant located at Pedu, a community situated along the Cape Coast-Takoradi highway. The tankers, with capacities ranging between 2,500 gallons (11.25m^3) and 3,500 gallons (15.75m^3) are connected to the hydrant via a hose attached to the hydrant and filled under the pressure within the distribution system. At the delivery point, the tankers discharge the water through their own hose to the vessels of the receiving customer.

Some patrons of the tanker service have raised doubts about the quality of water delivered by the tankers. Though their claims are based on mere physical observations without any scientific analysis the WHO (2008) admits that, consumers' attitude towards their drinking-water supply and suppliers is considerably affected by aspects of water quality that they are able to perceive with their own senses. The WHO, therefore, emphasises that "the appearance, taste and odour of drinking-water should be acceptable to the consumer" (WHO, 2008, p. 210). The question is: does the water, supplied by the tanker operators meet the minimum requirements of safety and acceptability as recommended by the WHO guidelines?

Besides, the presence of any contaminants cannot be unconditionally attributed to the use of the tankers since it is possible that the supposedly treated water fails to meet acceptable standards. It is also possible that the quality deteriorates in the distribution network, between the Headworks, and the hydrant, before it is fetched, by the tankers.

The quality status of the tanker-supplied water needs to be determined scientifically and the source of contamination, if any, established for the necessary actions to be taken to protect public health and boost consumer confidence.

1.3 Purpose of the study

The main purpose of the study is to ascertain the claims by some consumers that water supplied by tanker operators is of a poorer quality, and to investigate the source of any possible contamination: whether the GWCL's treatment and distribution system or the use of the tankers.

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

- to conduct quality analysis on treated water sampled from the hydrant, tankers, a tanker service customer and a GWCL customer;
- to compare the results with the World Health Organisation (Who) guidelines (2008); and
- to investigate the source of any contamination.

2. Methodology

2.1 Sampling

2.1.1 Sampling points. Samples for analysis were taken from the following points:

- *Pedu water hydrant*: This is the point from where the GWCL serves the tanker operators. Samples were taken from this point to investigate the quality of the water as the tankers receive it. The samples were taken directly from the hydrant without the hose. The hydrant is managed by the GWCL so any quality deterioration in water taken from the hydrant could be attributed to the company.
- *Tankers*: Samples were taken from the tankers to investigate any change in quality, which could be attributed to pollution sources in the tankers.
- *Tanker service customer*: Samples were taken from this point to verify the quality of water supplied to customers as a result of, which the complaints arise.
- *GWCL customer (Cape Coast Hotel)*: The hotel is an independent customer of the GWCL. Samples were taken from the premises of the hotel to compare with the quality of water taken from the hydrant. This was done to investigate whether any deterioration in water at the hydrant results from the management of the hydrant in particular or the entire GWCL treatment and or distribution system in general.

2.1.2 Sampling procedure. Samples were taken in January and March. It is during this period that water is scarce in the Cape Coast municipality and as a result, tanker services are heavily patronised. In all, 14 samples were taken. Two samples each were taken from the hydrant, the tanker service customer and the GWCL customer, one each in January and March. Out of a total of 16 tankers registered by the GWCL, four were sampled randomly in January and another four in March. Only one of the tankers were found to have been repeated in both months. Thus, seven different tankers out of the 16 were captured in the study.

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 taken were stored at 4°C for further analysis in the laboratory. Analyses were performed within 24 hours.

2.2 Analyses of samples

2.2.1 Selection of parameters. Analyses were performed to verify the bacteriological safety and physical acceptability of water sampled from the various points of interest. For each parameter, three analyses were performed and the average taken. For bacteriological safety, the test for *Escherichia coli* (e-coli) is commonly used as in MoH (2008) and was adopted. For physical acceptability, parameters used were selected from those identified by WHO (2008) as relating or contributing to colour, odour and taste, which are the common causes of consumer complaints. Those analysed include colour, turbidity, aluminium, iron, copper, sulphate, chloride, and hardness. The pH was also measured as an important operational water quality parameter (ibid).

2.2.2 Bacteriology. E-coli was measured with the traditional Multiple Tube Fermentation method proposed in Standard Methods (APHA, 1998). All equipment used were first pre-sterilised using an autoclave and 95 per cent ethanol.

2.2.3 Physico-chemistry. pH was measured with the Horiba Compact B-122 and Inolab 7300 Conductivity/TDS portable meters. Colour, turbidity, aluminium, copper, sulphate and total iron were also analysed by spectrophotometry using Hach DR/2500 following Standard Methods (APHA, 1998). Hardness and chloride analyses, were performed by acid, EDTA and Argentometric Titration Methods (APHA, 1998).

3. Results and discussion

3.1 Results

Table I presents the results of the study showing the WHO (2008) guideline value for each parameter and the value recorded in January and March at the various sampling points, namely the hydrant from which the GWCL serves the tanker operators, the Cape Coast Hotel, which is served directly by the GWCL, a tanker service customer and the four tankers sampled randomly in each month. For the tankers, the results show the averages and standard errors computed for each parameter from the set of four samples taken in each month.

Parameters, which exceeded WHO guideline values, have been identified with a grey background.

3.2 Discussion

3.2.1 Water quality at the hydrant. The results obtained from the analysis show that, samples taken from the hydrant failed in the test for e-coli in both January and March and colour in March. While the WHO guideline, requires that drinking water contains no e-coli, the samples taken in both months exceeded the maximum detectable limit of 23. This implies, water served to the tanker operators by the GWCL is contaminated with faecal matter. Though bacteriological contamination cannot be easily detected by the physical senses of consumers, the high colour, as recorded in March, could be a potential cause of the complaints of customers since coloured water can be easily recognised by sight and thus create consumer insecurity.

In view of the fact that the hydrant is under the direct management of the GWCL, the company assumes responsibility for the contamination at this point. Although only

Table I.
Summary of results

Parameter	Unit	WHO Guideline	Pedu water hydrant		Cape Coast Hotel		Tanker service customer		Tankers	
			January	March	January	March	January	March	January	March
pH	–	6.5-8	6.70	6.72	6.51	6.55	6.69	6.71	6.58 ± 0.03	6.81 ± 0.06
Colour	mg/l Pt-Co	15	12	16	4	4	17	19	18.75 ± 4.35	20.20 ± 4.60
Turbidity	NTU	5	4.31	4.33	2.51	2.53	7.26	7.28	8.23 ± 5.29	6.54 ± 2.41
Total hardness	mg/l $CaCO_3$	500	58	60.0	55	57	73	75	77.50 ± 3.0	56.80 ± 4.60
Total iron	mg/l	0.3	0.29	0.25	0.20	0.22	0.30	0.50	0.49 ± 0.3	0.43 ± 0.27
Sulphate	mg/l	250	25	25	20	24	28	28	28.50 ± 0.58	25.00 ± 2.74
Chloride	mg/l	250	31	33	32	32	33	35	36.50 ± 3.11	34.20 ± 0.84
Aluminium	mg/l	0.2	0.03	0.05	0.01	0.01	0.06	0.06	0.08 ± 0.01	0.05 ± 0.01
Copper	mg/l	1.0	0.03	0.03	0.02	0.02	0.07	0.09	0.23 ± 0.35	0.17 ± 0.31
E-coli	MPN/100 ml	< 1.1	> 23	> 23	< 1.1	< 1.1	> 23	> 23	> 23	> 23

two samples taken from the hydrant in January and March are inadequate for an authoritative conclusion on the water quality at that point, the repetition of bacteriological contamination, in particular, gives a cause for concern and calls for some corrective actions by the GWCL. This is due to the important connection between the bacteriological safety of water supplies and public health. It was observed that, the immediate environment of the hydrant was neither paved nor fenced. The presence of dirt and leakages could be the main cause of contamination at the hydrant (WHO, 2008). However, the unsupervised handling of water hoses, which lie on the bare, unpaved ground create obvious conditions for further contamination in the tanks

If the environment is kept clean, probably paved, it would help address the situation. Also, routine checks and repairs of cracks and leaks would prevent any bacterial entry into the water to contaminate it (WHO, 2008). Another corrective measure is the installation of structures to hang the water hoses on, instead of leaving them on the bare ground when they are not in use.

3.2.2 Water quality in the tankers. As can be expected, the samples taken from the tankers in January and March, on the average, failed in those parameters in which the samples from the hydrant failed: colour and e-coli. In addition, the tankers failed in turbidity and total iron in both sampling months.

Certainly, faecal pollution must have been transferred from the hydrant to the tankers. It is, however, not possible to tell whether there was any further faecal pollution sources in the tankers. Faecal pollution in the tankers could result from use of the tankers for carrying polluted water, which is a common malpractice by tanker operators.

Similarly, high colour might have been transferred from the hydrant but the high averages recorded by the tankers in both January (18.75 ± 4.35) and March (20.20 ± 4.60) as compared to those recorded at the hydrant for the same sampling dates (12 and 16 respectively) suggest further colour impartation in the tankers. Colour impartation in the tankers could result from accumulation of dirt in the tanks due to irregular cleaning. This is supported by the fact that, though the hydrant passed in turbidity in both January and March, the tankers sampled in both months failed in that parameter which could also be linked to accumulation of dirt.

The high level of total iron could result from corrosion in the tanks, as was observed on the external surfaces of some of the tankers. Corrosion and, hence, the introduction of iron in the tanks could also be responsible for the high colour and turbidity.

High colour, turbidity and total iron could be major contributors to any objectionable appearance of the water, which might have been the basis of customer complaints.

It is the duty of the GWCL, which incidentally happens to fail in its own role, to monitor and regulate the tanker operators in the management of the tanks to protect customer interests and public health.

Possible solutions to the prevention of contamination in the tanks include:

- regular washing of the tanks with a disinfectant, say monthly, followed by a compulsory test for e-coli at an officially designated laboratory (MoH, 2008);
- immediate washing and disinfection of the tank after being used to convey non-potable water (MoH, 2008); and
- ensuring that the hose used to fill the tank is well drained when not in use (WHO, 2008).

3.2.3 Quality of water served to the tanker service customer. Water served to the tanker service customer failed in the same parameters as that sampled from the tankers. It was found to contain e-coli, high colour, turbidity and total iron in levels comparable to those recorded in the tankers. Though colour, turbidity and iron may not have adverse effects on public health (WHO, 2008) other than consumer confidence, the presence of e-coli is rather serious and calls for prompt action to protect public health.

3.2.4 Quality of water served to the GWCL customer. Water sampled from the Cape Coast Hotel, which is served under the regular GWCL piped system, passed in all the parameters. There was no faecal contamination or high colour as recorded at the hydrant. This indicates that water supplied by the GWCL is of good quality and meets all required standards. This also affirms the fact that contamination at the hydrant originates from the poor management of the hydrant but not the entire GWCL treatment and distribution system.

It is observed that the results of other parameters other than colour and *e-coli* are quite similar in all the samples taken from the various sources. This is because all the samples are essentially from the GWCL distribution system and originally treated to the same quality. All things being equal, the quality of water sampled from the various sources is expected to be the same. In order words, if the tanker service is efficiently managed, the quality of water sampled from the hydrant, the tankers and the Hotel, which is served directly by the GWCL, should not show significant differences.

4. Conclusions and recommendations

4.1 Conclusions

From the results of the study, it can be concluded that water supplied by tankers in Cape Coast fails to meet the WHO guidelines for some quality parameters due to causes, which can be assigned to both the GWCL and the tanker operators. Specifically, it is concluded that:

- water supplied to tanker operators from the Pedu hydrant is contaminated with faecal matter and has a high colour level than the WHO guideline due to poor management of the hydrant by the GWCL;
- faecal contamination from the hydrant is transferred to the tankers and subsequently to patrons of tanker services though it cannot be said whether there is further faecal contamination beyond the hydrant;
- there is further colour impartation in the tankers and introduction of higher levels of turbidity and total iron than those recommended by the WHO, probably, due to poor management of the tanks by their operators;
- water delivered to the final consumer by tankers is contaminated with faecal matter and fails in physical parameters like colour and turbidity, which may be the cause of consumer complaints about the quality of the water; and
- piped water supplied directly by the GWCL to the Cape Coast Hotel satisfies the WHO guidelines for all parameters examined, which confirms that the poor quality of water supplied by the tankers does not arise from the GWCL treatment and distribution system, in general, but the poor management of the hydrant and the tankers.

4.2 Recommendations

Based on the conclusions of the study, it is recommended that:

(1) The GWCL, as a public utility which is unable to supply piped water to all sections of the populace, should place a high premium on the tanker services as an alternative to conventional water supply by:
   - taking steps to pave and tidy up the immediate surroundings of the hydrant to avoid stagnation of water around it and ensure its proper operation and maintenance;
   - providing structures for hanging of the hoses which are used by the tanker operators to draw water from the hydrant instead of leaving them on the bare ground; and
   - diligently carrying out its monitoring and regulatory role over the tanker operators to make sure they manage the tankers well by undertaking regular cleaning and disinfection to ensure consumer safety.

(2) Further research is conducted to enquire:
   - the effectiveness of existing institutional framework for the monitoring and regulation of the operation of tanker services due to its important role in meeting the water supply needs of sections of the populace who are not covered by the regular operation of the GWCL;
   - whether there is further faecal pollution sources in tanks or not; and
   - evidence of effects of consumption of faecal-contaminated water on the health of tanker service patrons.

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