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Assessing The Potential of A Natural Wetland in Grey Water Treatment (A Case Study in Cape Coast - Central Region of Ghana)

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Abstract

Grey water has been discharged onto this wetland for more than thirty years without any measurement of the quality of the influent and effluent. The effluent eventually joins a stream (Kakum River) which is a source of water for recreation, farming, drinking and fishing. The quality of the effluent which enters the receiving water as well as the potential of the wetland in the treatment process has not been determined. The purpose of this research is to assess the potential of the wetland in grey water treatment.

Three communities in Cape Coast, the formal capital of Ghana were selected for this work. The wetland under study has an area of about 17,928m^2 and hydraulic loading rate of 0.0164m/d. Field studies were conducted to demarcate the borders as well as to confirm the communities which discharges into the wetland.

The results indicate that the wetland has very high potential in treating grey water, with suspended solids showing high removal efficiency. It was also inferred from the results that the wetland's treatment is influenced by the precipitation pattern of the area and this is clearly shown in the removal efficiency of manganese.

The findings will help decision makers to make proper laws concerning wetland use in Ghana. It will inform decision makers to officially consider wetlands as alternatives for grey water treatment.

This paper assesses the potential of natural a wetland and makes recommendations on its proper use as well as its limitations.

Keywords: Dry weather, Grey water, Limitations Natural Wetland, Potential, Treatment, Wet weather.

Introduction

Grey water is part of the household wastewater without black water (water containing faecal matter). It is the drain from bath tubs and shower trays, washing basin, sand washing machines and may also contain high-strength kitchen wastewater. Grey water from washing dishes, showers, sinks and laundry comprise the largest part of residential wastewater.

It is estimated that about 80% of the water used domestically end up as waste water. Grey water as part of domestic waste water contains pathogens, micro organisms, suspended solids and biodegradable organic matter, nutrients, heavy metals and other toxic pollutants [1].

The problem of water pollution has increased due to the increase in industries, development of land area, and rapid population growth. The watercourses have now become receivers of wastewater along with contaminants. Pollution of surface water supplies became more critical because wastewater of upstream community became part of the water supply of the downstream community. When the concentration of added substances became dangerous to humans or so degraded the water that it was unfit for further use, water pollution control began.

Modern public health protection is provided by highly refined and well controlled plants both for the purification of the community water supply and treatment of the wastewater. Any natural watercourse contains dissolved gases normally found in air in equilibrium with the atmosphere. In this way fishes and other aquatic life obtain oxygen for their respiration. The amount of oxygen which the water holds at saturation depends on temperature and follows the law of decreased solubility of gases as temperature increases.

Degradable or oxidizable substances in wastewaters deplete oxygen through the action of bacteria and related organism which feed on organic waste material, using available dissolved oxygen for their respiration. If this activity proceeds at a rate fast enough to depress seriously the oxygen level , the natural fauna of a stream is affected ; if the oxygen is entirely used up, a condition of oxygen exhaustion occurs which suffocates aerobic organisms in the stream. Under such conditions the stream is said to be septic and is likely to become offensive to the sight and smell. It could also reduce the use of the receiving water body (eg. as a source of water supply, recreation, irrigation etc). It may also increase the incidence of water borne diseases.

Due to the negative impacts which associate with water pollution many technologies both natural and manmade were researched into. One discovery made during these studies is the use of wetlands in wastewater treatment.

Though the value of wetland for fish and wildlife protection has been known for several decades, in more recent biological and human time periods, wetlands have been valuable as resources, sinks, and transformers of multitude of chemicals, as well as biological and genetic materials. They (Wetlands) are sometimes described as “the kidneys of the landscape ‘because they function as the downstream receivers of water and waste from both natural and human sources. The tendency for wetland to serve as sinks for chemicals of all kinds encouraged researchers in the United States in the

1970s to investigate the role of natural wetland, particularly in areas where they are found to be in abundance to treat wastewater and thus recycle clean water back to groundwater and surface water [2].

Although wetland use in wastewater treatment is very well known in particularly United States and Europe the situation is different in Africa and Ghana. The recent research work on wetlands in Ghana can only be traced to [3] and [4], who worked on both natural and artificial systems in the Ashanti region of Ghana.

The natural wetland under study has been in existence before the university was started and has been receiving grey water from some communities around the university. However some people living along the river, fish in it whilst children swim in the river downstream. Also some inhabitants use the stream for domestic purposes while some farmers use it to irrigate their crops. The study seeks to find out whether the grey water which enters the wetland is treated to the acceptable level as far as the Ghana EPA standards are concerned and to make recommendations on how the wetland could be used effectively and efficiently.

Experimental

Within a period of seven weeks, different samples of grey water, soils and plants; were taken and analyzed. In other to use composite samples of the grey water, three samples were collected within a period of two hours (6am – 8am). Collection of samples was twice a week, but the first week was sampled only once.

Parameters analyzed included BOD, COD, pH, nitrates and nitrites, total phosphorus, Total coliforms, suspended solids, turbidity, and heavy metals. Soils samples as well as predominant plant species in the natural wetland under study were collected for classification and identification.

The Biochemical Oxygen Demand (BOD) test is used to measure waste loads to treatment plants, determine plant efficiency (in terms of BOD removal), and control plant processes. It is also used to determine the effects of discharges on receiving waters. A major disadvantage of the BOD test is the amount of time (5 days) required to obtain the results.

Two BOD bottles were completely fill with dilution water. Additional BOD bottles were partially filled with dilution water, and a measured volume of samples was then added to the partially filled bottles. Dilution water was added until the bottles were completely filled. Because the meter method was used for Demand Oxygen (DO) measurements, the initial and final DO determinations were performed on the same bottle unlike the modified Winkler procedure where two different bottles would have been required for the same analysis.

Principle of Chemical Oxygen Demand (COD) Using Open Reflux Method: Most types of organic matter are oxidized by a boiling mixture of chromic and sulfuric acids. A sample is refluxed in strongly acid solution with a known excess of potassium dichromate ($K_2Cr_2O_7$). After digestion, the remaining unreduced $K_2Cr_2O_7$ is titrated with ferrous ammonium sulfate to determine the amount of $K_2Cr_2O_7$ consumed and the oxidizable matter is calculated in terms of oxygen equivalent.

Results and Discussions

Table 1: Grey Water Characteristics for Dry and Wet Weather Period.

Dry Weather Period				Wet Weather Period			
Parameter	Influent	Effluent	Removal%	Influent	Effluent	Removal%	EPA(GHA)
TSS(mg/l)	281	2.8	99	66.6	4.09	93	50
TURD(NTU)	209.6	11.2	94.6	41.4	6.5	84.2	75
COND(uS/cm)	184	186.5	-0.81	740.3	597	19.3	1500
BOD(mg/l)	302	28	90.7	74.4	36.7	50.6	50
COD(mg/l)	364.6	44	87.9	137	62	54.7	250
PO_4(mg/l)	31.21	6.78	78.2	36.9	9.6	73.9	2
NO_3(mg/l)	15.36	0.37	97.5	4.5	1.6	64.4	75
T-COLI(	2.91E+05	8.20E+04	71.8	5.66E+05	8.20E+04	8.30E+01	4.00E+02
Pb(mg/l)	0.012	8.00E-03	61.9	0.01	0.004	60	0.1
Cd(mg/g)	0.001	0	100	0	0	100	<0.1
Fe(mg/l)	7.197	3.035	57.8	5.795	3.105	46.4	
Cr(mg/l)	0.012	0	100	0.002	0.001	50	0.5
Mn(mg/l)	0.15	0.239	-59	0.205	0.16	21.9	2.5
Zn(mg/l)	0.207	0	100	0.04	0.003	92	5

All the parameters in the table except conductivity have their influent concentration above the EPA Ghana permissible limits. Even though the phosphate and total coliforms effluents during the dry and wet period were above the EPA Ghana guidelines, all the other parameters showed high level of treatment which meets the guidelines already stated .

Total suspended solid (TSS) show very high removal efficiency in both dry and wet weather period. The high removal efficiency observed in the dry weather may be due to low velocity which makes sedimentation easier [5]. It could also be due to wetland cover vegetation binding sediments to reduce erosion, by trapping sediments, interrupting water flows and building peat [2]. The picture below shows the southern part of the wetland under study.

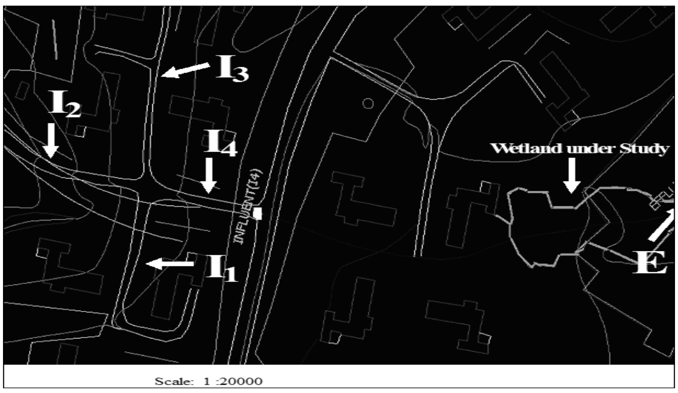

Figure 1: A map of the study Area: Source.

The low removal efficiency observed in the wet weather may be due to high precipitation which occurred during the period of sampling resulting in surface runoff into the wetland and causing scoring of the binding sediments in the wetland and reducing the settling velocity of the suspended solids as compared to the traveling velocity (dragging force).Hence the particles remain in suspension and is eventually discharged as an effluent.

The difference observed in removal efficiencies during the dry and wet period for biochemical oxygen demand (BOD) and chemical oxygen demand (COD) may be attributed to hydrological changes in the wetland .The hydrology of a wetland has a significant effect on the nutrients that is fed into the wetland as well as the biological and chemical activities that takes place in the wetland [2].

In rainy season the weather is colder, metabolism and bio-activity of microbes are low; whereas, in the higher temperature, the biomasses and activities of microbes increase at high speed, which resulted in higher BOD_5 and COD removal [6].

Table 1 above shows that all the heavy metals analyzed in the study area during the dry and wet period have concentrations below the maximum permissible level for discharge into water bodies by Ghana EPA (Table 1). The level of manganese in the effluent during the dry weather period was higher than that of it influent; this may be due to the anaerobic conditions which occur in the wetland resulting in the decrease in the redox potential transforming manganese from manganic to manganous compounds at about 225mV [2]. Equation is shown below.

$$MnO_2 + 2e^- + 4H^+ \rightarrow Mn^{2+} + 2H_2O$$

The question now is what contributed to the exceptional observations made in the case of phosphate, conductivity and total coliforms removal.

Table 1 show clearly that the wetland could remove phosphate from the grey water but not as low as the permissible level. The removal is by sorption of phosphorus onto clay particles which is believed to be both the chemical bonding of the negatively charged phosphate to the positively charged edges of the clay and the substitution of phosphate for silicate in the clay matrix [2]. Most wetland macrophytes obtain their phosphorus from the soil; the sedimentation of phosphorus surged onto clay particles is an indirect way in which the phosphorus is made available to the biotic component of the wetland. The inability of the wetland to remove phosphorus to the acceptable level may be due to the load being higher than the environment could handle.

The observation made in conductivity may be due to high temperatures which catalyse chemical reactions during the dry period resulting in more ions being produced in the wetland. It must be noted that conductivity removal is mainly by attachment (chemical removal); plant uptake does not contribute much to anions and cations removal. The opposite occurs during the wet weather period where chemical activities are low with 19.8 %(estimated from table 1) removal efficiency.

Even though the removal of the total coliforms did not meet EPA Ghana guidelines, it can be inferred from table 1 above that there was a significant removal of 78.1 and 72 % during the wet and dry season. According to [7]; [8], removal efficiencies are high when inflow concentrations are high; removal efficiencies are nearly always greater than 90 percent for coliforms. This might have accounted for the high removal during the wet season. When inflow concentrations are less than background levels, removal efficiencies are low. Removal of indicator bacteria in wetlands may be correlated with solids removal and hydraulic residence times.

Conclusions and Recommendations

Conclusions drawn from the study are as follows:

The wetland even though showed 100% removal efficiency in cadmium , the removal of suspended solids (98.1%) was very encouraging as the removal in terms of mass is more significant in the later compared to the former.

The results indicate that the wetland has a high potential of removing pollutants from the incoming grey water. This the wetland achieves through the plant species which plays important role in the treatment processes as well as the soil type which spans from sandy loam and loamy sand.

From the discussions it is clear that the hydrology of the area have a great effluence on the performance of the wetland in terms of the treatment, for this reason the following recommendations have been made so that the wetland could work effectively and efficiently.

- Maximum permissible level of some parameters such as nitrite and iron which has not been done must be done.
- Periodic harvesting of plants must be carried out for wetlands of this type to ensure that the pollutant removed is not introduced back to the wetland when plants die and decompose.
- Though the study was conducted during the minor rainy season, the pollutant removal level is high and if primary treatment (sedimentation tank) is introduced the quality of the effluent will be improved.
- Properly channeled drain with equalizing pipes to ensure regularized and monitored flow onto the wetland will help keep the wetland from being over used and also perform effectively and efficiently.
- There should be public education on the economic as well as the environmental importance of wetlands.
- There should be laws that will prevent the abuse and misuse of wetlands.
- Further studies should be carried out to establish the quantity or level of precipitation which affects the treatment on the wetland.

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