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The Korle Lagoon in Distress: The Stress of Urban Solid Waste on Water Bodies in Accra, Ghana

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ABSTRACT: Human activities on the Korle lagoon have had considerable effects on the water quality and the aquatic life therein. The rapid population growth and its attendant high waste generation, cost of disposal, depletion of landfill space and the difficulty of obtaining new disposal sites have been the major constrains thwarting the effective management of waste in Ghana. This paper examines the water quality of the Korle lagoon through a full physico-chemical analysis and buttressed with secondary data and field observations. The results show variously, the different levels of contamination of certain pollutants such as heavy metals and eutrophic elements. The high dominance of chloride over other elements indicates high domestic activity influences. PO_4, NH_3 and Na levels also exceeded their acceptable levels. However, levels of other metal investigated (Cu, Zn, Fe and Cd) were all below the maximum levels of the Environmental Protection Agency of Ghana and the World Health Organization guidelines. For the sustainable management of the lagoon, the Accra Metropolitan Assembly in conjunction with the Environmental Protection Agency should evolve sanitation programmes particularly on proper waste management mechanisms as well as propagate these measures through environmental education and stringent regulatory measures.

KEYWORDS: Korle Lagoon, sanitation, environmental stress, bioaccumulaion, solid waste.

1 INTRODUCTION

Water resources come in different forms and have multiple uses ranging from aquatic biome to livelihood activities for humans. Despite this fact, the management of our water resources leave much to be desired. The Korle Lagoon, in Accra-Ghana, is losing its aquatic value due to persistent pollution by its neighbouring communities who have turned it into a natural depression that serves as a cesspool for most of the city's industrial and human waste [1]. Owing to the high pollution level, it has lost almost all its aquatic organism and subsequently its economic and aesthetic value.

It is however important to understand what constitutes high quality, clean water. In nature, pure water does not actually exist, hence it is not possible to find water that has absolutely nothing in it. Water is always found in combination with minerals and chemicals. The types of minerals and chemicals found in water will depend on a number of factors such as human activities, precipitation and runoff from adjacent land, surrounding vegetation and wildlife or soil, geologic formations and terrain in the catchment area. If water quality is degraded its adverse effect on the ecosystem is very sombre. Similarly, when ecosystems become degraded, this has a negative impact on the water.

Water resources are important to the viability of the ecosystem on which our livelihoods depend. Despite this fact many of our water resources have been poorly managed. While the growth of towns and cities have resulted in increased population coupled with increased socio-economic activities, there has not been a commensurate increase in essential

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logistics for effective and efficient waste management services delivery. Our water resources have therefore had to suffer the consequences of the increasing accumulation of wastes.

The Korle lagoon which is one of the major receptacles of run-off water in Accra has been turned to a point source of pollution into the Gulf of Guinea. It is a natural depression that serves as a cesspool for most of the city's industrial and human waste and referred to by [1] as an "environmental nightmare". About 60 percent of the Metropolis of Accra lives in the catchment of the Odaw river and the Korle lagoon and contribute to the environmental problems which results in flood situations [2]. Owing to this pollution level, no organism has been able to survive in the lagoon for years. Its stench wafts back to envelop the adjoining shantytown that is home to hundreds of families who have turned the shores of the lagoon into a giant latrine because they have no access to sanitation facilities [3].

2 THE MENACE OF SOLID WASTE

Solid waste management is one of the most thought-provoking and naysaying issues in the capital city of Ghana, Accra. In quite current citywide survey conducted by the World Bank and the Accra Metropolitan Assembly (AMA), solid waste management was viewed by residents as the third-most important urban service lagging behind sanitation and drainage [4].

Whilst urbanization is not a new phenomenon in Accra, the current rate of slum encroachment and uncontrolled urbanization in the city have resulted in the large volume of liquid and solid wastes generation. These wastes have long outstripped the capacity of city authorities to collect and properly dispose-off safely [5], [6], [7]. This rapid urbanization and by the same logic, rapid accumulation of waste is what [8] have likened to "a monster that has aborted most efforts made by city authorities, urban planners, states and federal governments" to manage or at least contain it hence, posing a major social quandary.

According to the Environmental Protection Agency (EPA) of Ghana's 2003 draft report on the environment, municipal solid waste is the "waste discarded by households, hotels/motels, commercial, institutional and industrial sources. Municipal solid waste consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint and batteries and does not include waste water" [9]. Solid waste hence comprises all solid material generated by households, institution, and commercial establishment and discharged from their premises for collection [10]. The Environmental Sanitation Policy (2001) of Ghana also generalizes solid waste as any unwanted solid material that is discharged from their premises for collection. By our operational definition, solid waste is any persistent manufactured or processed solid material which is discarded, disposed-off, or abandoned in the environment, also called marine debris, if dumped or generated in the marine environment. Solid waste entering the marine and coastal environment has multiple sources which include poorly managed or illegal waste dumps adjacent to rivers and coastal areas, windblown litter from coastal communities, and waste that is channelled to the marine and coastal environment through municipal storm water systems and rivers [11]. Solid waste is therefore any useless, unwanted or discarded material that is not liquid or gas.

According to [12], nine out of every ten African cities are facing serious waste disposal problems. Consequently, most African countries generally lack adequate waste collection, treatment and disposal facilities. It is estimated that throughout Ghana only about 10% of solid wastes generated are properly disposed-off [13]. It is against this background that the United Nations Millennium Development Goal number seven aims at halving the people without access to sanitation services in the world by the year 2015. This goal however seems to lag behind and will be taken up by the Sustainable Development Goals and the Post 2015 development agenda. Despite efforts made in recycling there will always be some of the solid wastes that will elude the recycler hence will need to be properly disposed-off [14].

Statistics provided by the EPA shows that at present, the Accra Metropolitan Assembly which is in charge of waste disposal in Accra is only able to collect about 55 percent of solid waste generated within the city [9]. In 1998, solid waste generated in Accra was estimated at 765,000m^3 and that of liquid waste 75,000m^3 [9]. According to [15] the total quantity of solid waste collected in the same year in Accra was 669,000m^3, implying that about 96,000m^3 of the waste was unaccounted for proving that the menace of waste has hunted the city for quite a while. Dating back, most people dump their garbage in community collection points. Most of these containers have no covers, and always very full and overflowing (fig. 8) which adversely affects the aesthetic value of the environment. Due to Accra's limited sanitation infrastructure, the Korle lagoon receives huge amounts of solid wastes as well as wastewater through the Odaw river. The lagoon has become heavily silted, the outlet is often blocked, and the water fails to flow into the sea fast enough to avoid becoming stagnant with its attendant environmental stress [16].

The catchment of the Korle lagoon has been associated with intensive land use. Numerous abandoned vehicles, old machinery, small garages and workshops are located within the catchment of the lagoon. The location of a yam market on

the bank of the lagoon adds to its pollution load. Treatment plant for septic tank effluent is sited about 200m west of the mouth of the lagoon and adjacent to the mouth of the lagoon, on the east side, is located a sewage outfall. Although no figures are available, a good percentage of the people have no access to toilet facilities, and as such, resorts to open defecation and wastes disposal along the banks of the lagoon and along the beach [3].

The shallowness and grossly polluted state of the lagoon renders it unsuitable for navigation, recreation or even fishing. The combined effects of the above have adversely affected the lagoon, which according to historical evidence, supported commercial fisheries and other socio-economic activities for the communities living around it up to the 1960's [2], [17]. Subsequently, the floodwater carrying capacity of the lagoon and its Odaw river have been reduced significantly, flooding is therefore widespread during the rainy season and often results in loss of lives and properties [17], [18]. With the ambition of making Accra a millennium city, what is the way forward in terms of sanitation and the preservation of our surface water resources? Will Accra without filth be a reality or a mirage and will the Korle lagoon be an attraction site or a repulsion site?

When human cities began to be more concentrated, solid waste management however, became a serious issue. Houses that did not have room to bury their garbage would throw it into the streets making a stroll to the corner store an unpleasant prospect. In response, many cities started to set up municipal garbage collection, in the form of rag and bone men who would buy useful garbage from people and recycle it or waste collection teams which would dispose-off unusable garbage [19]. The management of solid wastes tries to reduce the harmful environmental impacts through different methods. Waste management practices differ for developed and developing nations, for urban and rural areas and for residential and industrial producers.

The disposal of solid waste has always been an intractable problem throughout the country. Landfills, the widely used disposal method in Ghana are primarily open dumps without leachate or gas recovery systems. Several are located in ecological or hydrological sensitive areas and are generally sited based on considerations of access to collection vehicles rather than hydrological or public health considerations [15]. They are generally operated below the standards of sanitary practices. Municipal budgetary allocations for operation and maintenance are always inadequate. The recent proliferation of plastic bags for packaging has seriously aggravated the negative impact of uncontrolled dumping creating very unsightly conditions. The result is substandard and unsafe facilities which pose public health risks and aesthetic burdens to the citizens they are meant to serve. There is however, a real need for improvement in the current levels of operations and in the design and siting of new facilities to ameliorate current levels of environmental degradation.

Whilst better stories could be told in terms of solid waste collection in rich neighbourhoods, the same cannot be told of the poor areas such as along the lagoon. This means that there is a need for different approaches to handling solid waste, which will accommodate both the rich and the poor areas [2]. However, it is not supposed to be different solutions but one that is all embracing and takes into account contextual factors operating in rich and poor areas alike.

3 PROFILE OF THE STUDY AREA

The Korle lagoon is located to the south-west of the central business district of Accra within longitude 05°35'N and latitude 00°06'W and it is estimated to drain a total catchment area of 400 km^2 . The lagoon covers a total surface area of about 0.6 km^2. From its opening in the south, the lagoon stretches northwards inland for about 2.8 km with varying widths between 179m at the narrowest cross-section and 349m at the widest cross-section. The entire settlements around the lagoon are peripheral with a population density of 250 persons per hectare. It is characterised by a mixture of different land uses with a large concentration of industries including Ghana Breweries Limited, several textile factories and vehicle repair workshops.

Fig. 1 shows the catchment of the Korle lagoon. Its major hydrological input includes the Odaw river; two huge drains that border the lagoon on its eastern and western sections and drains Dome, Legon, Achimota, Ring Road Industrial Area and the high density low income areas of Nima, Maamobi and Accra Newtown, all suburbs of the city. It is the major basin into which the greater proportion of the floodwaters of metropolitan Accra flows before entering the sea.

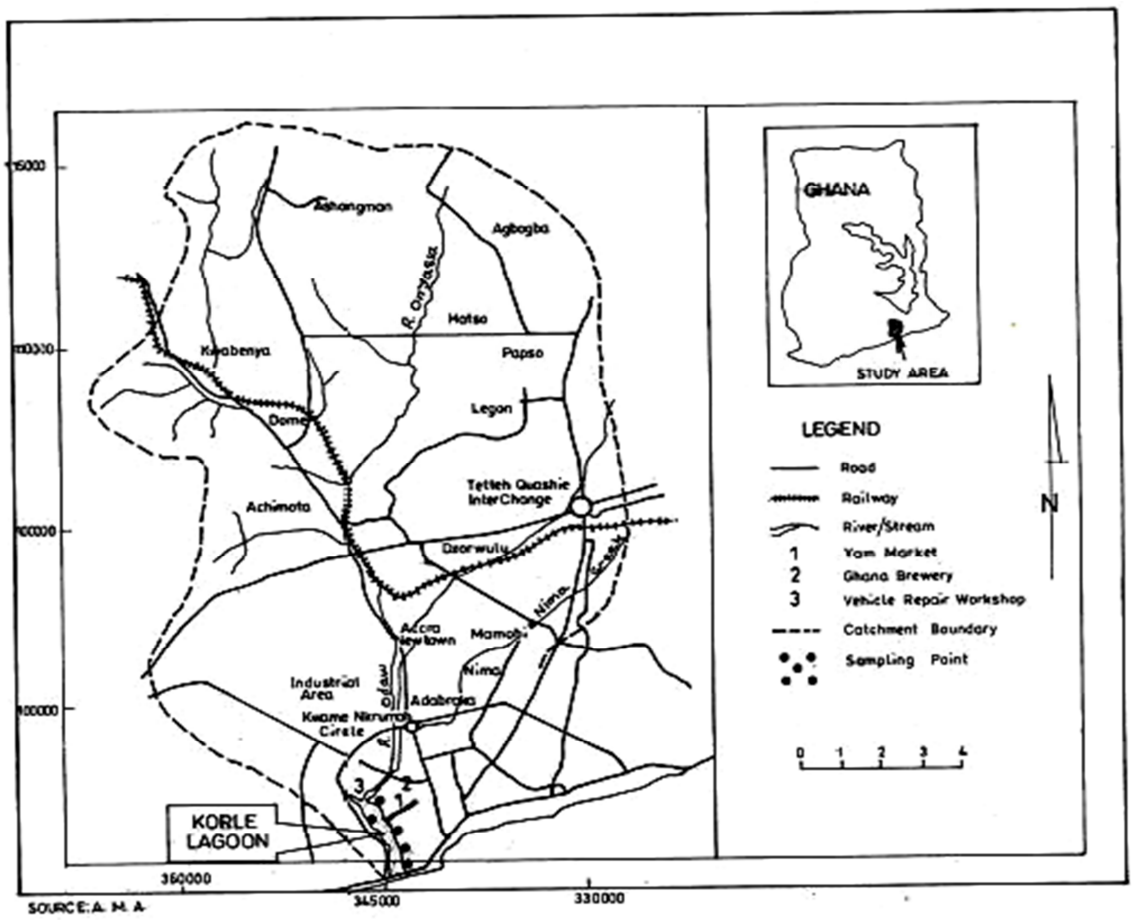

Fig.1. Map of the Study Area

The catchment of the Korle lagoon has been associated with intensive land use with the siting of many industries, markets, mechanic shops and more significantly, the development of uncontrolled and unplanned urbanization with many slums and squatters erupting on its fringes. These settlements are usually devoid of sanitary facilities hence result to the use of the lagoon as a giant latrine and/or dumps site. Largely, solid waste are gotten rid of by disposition at uncontrolled and poorly managed dump sites which are found in unsuitable locations with no specific form of engineering.

4 RESEARCH MATERIALS AND METHOD

This paper evaluates both quantitative and qualitative data comprising primary sources obtained from the field survey and buttressed with secondary materials on solid waste management in Ghana and the impact of human activities on the Korle Lagoon. Content analysis of the nexus between consumption, solid waste generation, water resource management and human appropriations has been done. Based on relevant literature, analysis and discussions have clearly provided the contextual justification on the impact of waste and human exploitation on the lagoon.

In testing the water quality the following specific parameters were considered: pH, Dissolved Oxygen (DO), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Heavy metals, the Nutrient/Eutrophication level and the Ion Concentration. On the assumption of a uniform contamination of the lagoon, due to its small size, the samples were collected into a clean 1.5 litre plastic bottle, stored in a dark condition and transported to the Water Research Institute (WRI) laboratory for analysis.

5 RESULTS AND DISCUSSION

5.1 SOLID WASTE GENERATION

Globalization, notwithstanding its positive impacts, has been recognised as playing a negative role in solid waste management. This is mainly due to the transfer of international waste management methods and ideologies together with an increased volume and variety of waste, resulting from increased flows of goods and services, changing lifestyles and consumption patterns [20], [21], [22].

With a population of approximately 25 million, Ghana generates about 4.5 million metric tons of solid waste annually. Refuse generation in Accra alone is estimated to have increased three-fold over the last two decades, due to factors including population growth, increased urbanization, and lifestyle changes [23]. Currently, Accra is estimated to generate approximately 2,000 metric tonnes of waste daily, however only 1,200-1,300 tonnes are properly collected disposed-off [24]. This certifies [6], [7] opinions that the current rate of uncontrolled and unplanned urbanization in the city, evidenced in the rapid rate of slum encroachment on the lagoon fringes as depicted in fig. 2, has given rise to a huge amount of liquid and solid wastes being produced so much so that these wastes have long outstripped the capacity of city authorities to collect and dispose-off them safely and efficiently. In view of the fact that about 60 percent of the Metropolis of Accra live in the catchment of the Odaw river and the Korle Lagoon [2], a higher proportion of the waste generated is found here. As indicated by [25] it has been observed that while the solid waste generation keeps increasing, the amount being collected remained almost the same.

Fig. 2. Slum Encroachment on the Lagoon Fringes

Upon interrogation with residents in the catchment area coupled with field observation, it was detected that sachets and polythens are the largest constituents of all the solid waste generated. This is because these materials are always used to wrap and transport almost everything hence their frequent generation. This was justified by the Waste Management Department that the main constituents of solid waste generated in descending order of volume are: sachets and polythene, organic waste, plastics, paper, wood and metals as well as glass and inert textiles. Unfortunately a very small proportion of these waste are collected and recycled even though it could be an input for many industries further creating employment and generating revenue.

5.2 THE PHYSICO-CHEMICAL ANALYSIS OF THE LAGOON

The physico-chemical analysis of the water was aimed at scrutinizing the level to which the Korle lagoon has been polluted; assuming a uniform pollution level for the entire lagoon due to its small size and confinement. Table 1 summarises the results of the full physic-chemical analysis of the Korle lagoon. It was observed from the results that the pH level is within

the guideline value of the EPA as it recorded 7.14, an almost neutral state indicating that it could support organic life however should be noted that pH is not the only factor determining a serene environment for aquatic life nonetheless extreme values on either end of the scale can be lethal to most organisms [26]. It should therefore be complemented with other indicators such as eutrophication level, dissolved oxygen, total dissolved and total suspended solids among others.

Dissolved oxygen is one of the best indicators of the health of a water ecosystem. Dissolved oxygen can range from 0-18 parts per million (ppm), but most natural water systems require 5-6 parts per million to support a diverse population [27]. In the Korle lagoon there have been an overload of organic waste causing algae growth increase and exhausting dissolved oxygen level as the plant material dies off and is decomposed through the action of the aerobic bacteria. As [27] points out, a decrease in the dissolved oxygen levels is usually an indication of an influx of some type of organic pollutant. This low level of dissolved oxygen, usually called *hypoxic* levels indicates a high level of pollution or some type of human-caused change to the lagoon.

The term "total solids" refers to matter suspended or dissolved in water or wastewater, and is related to both specific conductance and turbidity. Total solids (also referred to as total residue) are the term used for material left in a container after evaporation and drying of a water sample. Total Solids includes both total suspended solids, the portion of total solids retained by a filter and total dissolved solids, the portion that passes through a filter [28].

Table 1. Results for the Full Physico-Chemical Analysis of the Korle Lagoon

PARAMETER	CONCENTRATION	EPA/WHO GUIDELINE
Conductivity	47040 µS/cm	1500µS/cm
pH	7.14 pH	6-9 pH Units pH
Potassium	16.4 mg/l K	-
Dissolved Oxygen	0.00 mg/l DO	5.0–7.0mg/l, WHO
Total Suspended Solids	24.0 mg/l TSS	50 mg/l TSS
Total Dissolved Solids	2210 mg/l TDS	1000 mg/l TDS
Sulphate	121 mg/l SO_4	250 mg/l SO_4
Nitrate	0.223 mg/l NO_3	50 mg/l NO_3
Phosphate	4.51 mg/l PO_4	2 mg/l PO_4
Ammonia	4.17 mg/l NH_3	1 mg/l NH_3
Calcium	96.2 mg/l Ca^{2+}	700mg Minimum daily intake, WHO
Iron	2.18 mg/l Fe	10 mg/l Fe
Copper	0.049 mg/l Cu	5 mg/l Cu
Zinc	0.136 mg/l Zn	5 mg/l Zn
Lead	0.134 mg/l Pb	0.1 mg/l Pb
Cadmium	<0.002 mg/l Cd	0.003 mg/l , WHO
Chlorine	937 mg/l Cl^-	150 mg/l Cl^-
Sodium	482 mg/l Na	200 mg/l, WHO

Total suspended solids (TSS) fell almost halfway below the standard value of the EPA. Much of the solids have settled at the bottom and have eventually blanketed the lagoon's bed destroying its ability to serve as a habitat for fish as well as making the lagoon experience uneasy flow and discharge with its associated flooding problems. However, if the levels of TSS increase, the lagoon will continue to lose its ability to support a diversity of aquatic life [29]. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen [30]. Photosynthesis will hence also decrease, since less light will be able to penetrate the water. As less oxygen is produced by

plants and algae, there is a further drop in dissolved oxygen levels. It can further smother the eggs of fish and aquatic insects, and can suffocate newly-hatched insect larvae. Suspended solids can also harm fish directly by clogging gills, reducing growth rates, and lowering resistance to disease. It is therefore important to control the level of TSS in the lagoon within the guideline since inorganic suspended solids attenuate light, primarily through the process of scattering.

Total Dissolved Solids (TDS) are materials dissolved in water that can pass through a filter (usually with a pore size of 0.45 micrometres) [28]. These materials can include carbonate, bicarbonate, chloride, sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. A certain level of these ions in water is necessary for aquatic life. Changes in TDS concentration can pose a threat to aquatic organisms since the density of the water determines the flow of water into and out of an organism's cells.

The lagoon recorded 2210 mg/l of TDS which is more than twice the standard value of the EPA indicating a high concentration of ions in the water. This implies that the growth of many aquatic lives has been utterly limited. Corrosion or encrustation of metallic surfaces by waters high in dissolved solids causes problems with industrial equipment and boilers as well as domestic plumbing, hot water heaters, toilet flushing mechanisms, faucets, and washing machines and dishwashers [31]. This implies with that the current level of TDS, the water cannot be used for many industrial nor domestic activities because of its high corrosion or encrustation property.

The indirect effects of these excess dissolved solids are primarily the elimination of desirable food plants and habitat-forming plant species. Agricultural uses of the water for livestock watering as well as for irrigation have also been limited [31]. These effects directly relate to how impure the water is hence affecting everything that consumes, lives in or uses the water for any purpose. The high concentrations of TDS has also reduced the lagoon's clarity, contributing to a decrease in photosynthesis and combine with toxic compounds and heavy metals stimulates an increase in the water's temperature. This high level of TDS concentration in the lagoon has rendered it unsuitable for many domestic and industrial applications.

The specific conductance test measures the ability of water to pass an electrical current. The conductivity of the water in the lagoon is affected by the presence of inorganic dissolved solids [26], [32] such as chloride, sulphate, sodium and calcium. The high conductance reading was mainly influenced by industrial pollution and urban runoff; water running off of streets buildings, parking lots and the backwash of the Gulf of Guinea. Extended dry periods and low flow conditions also contributed to the higher specific conductance readings [26]. A level of 4740 µS/cm as recorded for the water in the lagoon is far above the standard level of 1500µS/cm, this level makes the water unsuitable to support aquatic life and for human consumption. It also reflects the high level of TDS recorded as well as the high level of ion concentration in the lagoon, certifying the fact that the more Sodium (Na^+) and Chlorine (Cl^-) are found in the water and the more these elements are contained in water the higher the conductivity. Fig. 3, however shows a linear pattern of six ions among which it is observed that Potassium, Sulphate, Calcium and Iron have recorded low levels. Nevertheless it is noted that Iron, Sodium and Chlorine concentration is excessively high and above the standard levels contributing to the increase in the conductivity as well as influencing the other parameters.

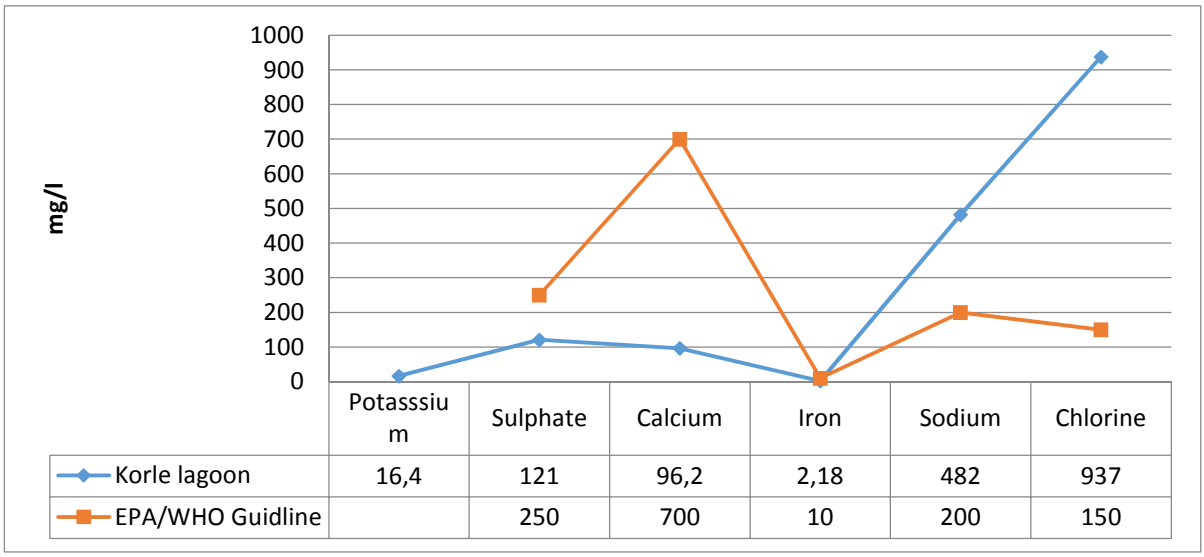

Fig. 3. Ion Concentration

It is also clear that the very high amount of total dissolved solid which is 2210 mg/l, conductivity of 47040 µS/cm and the lack of dissolved oxygen attest that the lagoon is highly polluted with solid waste particularly organic matter as well as faecal matter.

The lagoon as already indicated is choked with Sediments which comprise of particles derived from rocks, biological materials or chemical precipitates and can include pavement dust and particles, atmospheric dust, natural soils, traction sand and cinders, vehicle rust particles, brake pad and tire dust and particles, trash and plant material. Many heavy metals and other trace elements are associated with these sediments [30]. Of all the heavy metals tested for, only lead was about 0.034 mg/l above the standard level whereas Cadmium was just 0.001mg/l below the maximum level as depicted in fig. 4. This indicates that the lagoon cannot be considered polluted with dissolved heavy metals suggesting that heavy metal form a minute proportion of all solid waste generated hence having little effects on the ecosystem in the larger context. Nevertheless a continuous use of the water can have adverse effect on the skin and other organs through bioaccumulation.

Though trace amounts of metals are common in water, these are normally not harmful to our health. In fact, some metals are essential to sustain life. However it is important to pay attention to heavy metals poisoning because of its environmental and health threats since it tends to bioaccumulate; that is, an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. These heavy metals accumulate in living things any time they are ingested and stored faster than they are broken down (metabolized) or excreted [33]. One of the major symptoms of chemical toxicity is the breakdown of the immune system, which opens the gateway for all kinds of diseases in the body. Also, another major symptom seems to be damage to the nervous system and increased nervousness [34]. The main sources of entry of heavy metals into the lagoon is by industrial and consumer waste particularly the scrub dealers at Agbogbloshie and from acidic rain which breaks down soils and release the heavy metals.

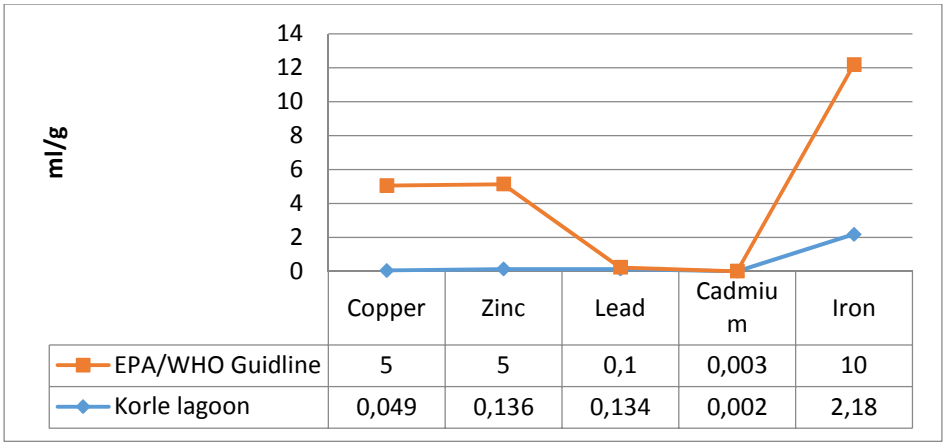

Fig. 4. Heavy Metals

In the case of the Eutrophication level, ammonia being a source of nitrogen is also a nutrient for algae and other forms of plant life and thus contributes to overloading of natural systems. In the Korle lagoon ammonia was recorded to be 4.17 mg/l which is far above the standard level of 1 mg/l and being toxic to fish has resulted in their death. Although not particularly toxic to fish, excess nitrate-nitrogen in the water is often used as an indicator of poor water quality. In the lagoon however, the level of nitrate which is 0.223 mg/l is far below the maximum standard level of 50 mg/l. This has negatively affected the growth of plankton and water weeds that provide food for fish. With the high level of phosphate present in the lagoon, algae and some water weeds have grown wildly and bloomed, choke the waterway and used up all the oxygen dissolved in the water [28]. Many fish and aquatic organisms have died with the high level of 4.51 mg/l of phosphate recorded as against the acceptable level of 2 mg/l. This has also affected the recreational value of the lagoon as well as its discharge and flow.

These sequences have characterized the changes in the water quality of the Korle lagoon such that with the increasing nutrient concentration of ammonia and phosphate there is a corresponding increase in algae growth, reduced water clarity, water treatment problems such as; odour and bad taste, increased filtration costs and disinfectant by-products, reduced oxygen in the water and toxins from cyanobacteria (blue-green algae) affecting aquatic, human and animal health. With this degree of eutrophication especially that of phosphorous, severe environmental effects have developed such as an increased phytoplankton biomass in the lagoon which has also decreased its clarity, reduced the levels of light and decreased the level of oxygen. All of which ultimately have had negative consequences for organisms that live in it [35].

It is subsequently clear that the high concentration of total dissolved solids which is 2210mg/l, conductivity of 47040µS/cm and the lack of dissolved oxygen attest that the lagoon is heavily polluted with solid waste particularly organic and faecal matter. As [36], [37] puts it; dumping of solid and liquid domestic waste into rivers and streams in Ghana has been a major problem with the waste finally ending up in our water bodies in this case, the Korle lagoon. Supporting the physio-chemical analysis are figures 5 and 6 below depicting the solid waste accumulation layers at the banks of the lagoon.

Fig. 5. Waste Accumulation in the Korle Lagoon

This further explains and confirms why the Korle lagoon has received great attention worldwide as an environmental nightmare although it is considered as part of the Ramsar conservation sites of wetlands. During the field survey contact was made with situations of waste accumulation that is difficult to imagine without seeing it. The Korle lagoon's hydrographical basin overlaps with a large extension of Accra, bringing most of the city's waste into the lagoon. This process becomes more evident with the intense surface runoffs during rainy seasons. Inhabitants residing immediate around the Korle lagoon such as Old Fadama and Abgogbloshie do not have enough waste collection bins hence have resulted to dumping their waste directly into the lagoon. Adding to that, e-waste is being dumped on the surroundings of the Lagoon, where scrap dealers try to extract, recycle and sell part of its components mainly through unhygienic and uncontrolled combustion.

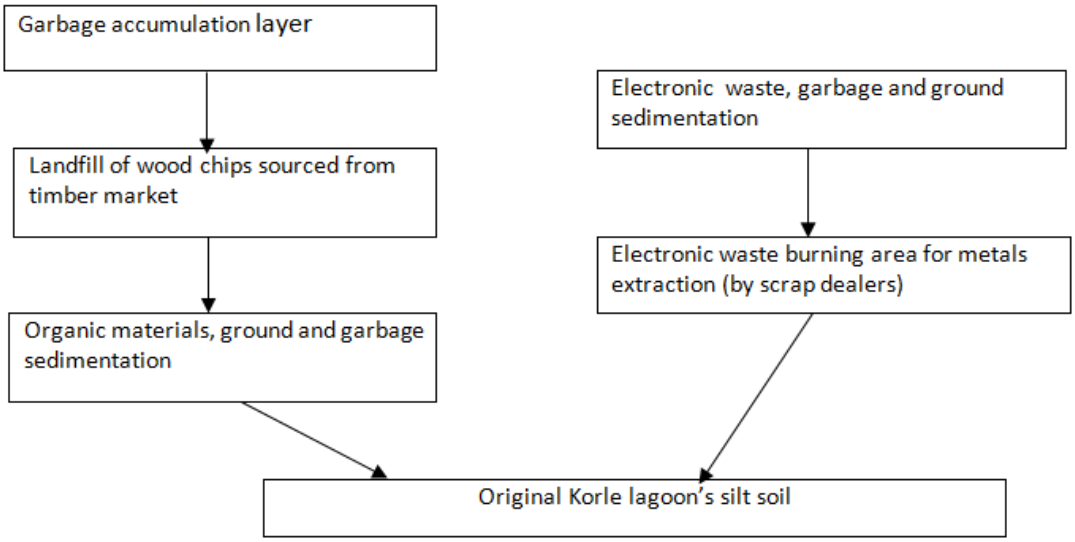

Fig. 6. Solid Waste Accumulation Layers [38]

5.3 ENSURING ENVIRONMENTAL SANITY

In 1992, the Waste Management Department (WMD) of the Accra Metropolitan Authority (AMA) was decentralized by creating a system whereby the other six-metropolitan assemblies popularly referred to as "sub-metros" were given the day-to-day activities of collection, transportation and disposal of waste within their locality. Whilst this was created to offload some of the problems and work of the WMD, it actually made a bad situation worse. As [39] remarked, the limited logistics available to the sub-metros made servicing extremely sensitive to vehicle breakdown as each area used its equipment solely for work within its own jurisdiction, whereas previously the WMD had used its fleet of vehicles and equipment as a pool which could be dispatched to the area's most in need according to their discretion.

Currently, the most common system of waste collection is the central container collection system (Fig. 7), whereby households are responsible for transporting their waste to refuse containers located within the communities, managed by private waste collection companies. Both middle and low-income areas are serviced in this way, representing approximately 80 percent of the total collection system in Accra. Although the central containers are to be sited at a maximum of 150 meters from residences [24], it was observed that these containers are usually located further way from residents, up to about 500 meters in some neighbourhoods. This has mad the populace lose confidence in the public sector giving rise to an increasing proliferation of private waste contractors popularly called "*Borla men*" who provide residents with an assumed efficiency and frequency of service however, with very poor final disposal methods most of which are open dump sites which eventually find their way back into the city through runoffs, wind and other mechanisms.

Fig. 7. Community Waste Collection Point

The rapid growing waste generation rates, high cost of disposal, depletion of landfill space and the difficulty of obtaining new disposal sites have been the major constrains thwarting the effective management of waste thereby resulting in open dumping with its accompanying problems [40]. The lack of and/or inadequate financial and technical resources of city authorities to keep pace with the challenges associated with huge amounts of solid waste [41] is also another force to reckon with. This makes it difficult for waste management authorities to identify and create solutions [42]. Consequently, heaps of solid waste are not uncommon sights in these areas.

6 CONCLUSION

The rapid increase of our population and its concomitant increase in consumption have greater implications for the Accra Metropolitan Authority. Accra, the capital city of Ghana, has experienced the greatest share of solid waste management problem due to multiplicity of factors ranging from sorting, collection, transportation, disposal and evaluation of impact on the environment and public health. These threats are exacerbated by the lack of awareness regarding the environmental impact of solid waste and the deficiency of systems for proper waste management and disposal. Generally existing public facilities including sanitary facilities are inadequate to serve the user population.

It was observed from the study that the waste management companies have mainly been engaged in collection and semi-controlled dumping thus, the dump sites are not technically engineered to meet the standard of sanitary landfill sites. Other disposal methods such as composting, incineration and recycling are still dreams yet to be realised. The main problem clued-up from the semi-controlled dumping currently practiced is the difficulty in acquiring land for disposal and the ability to compact the waste at the dump sites.

From the above results and analysis the contention of the lagoon being an "environmental nightmare" cannot over emphasised. Owing to the high level of pollution no living thing, animal or plant, has been able to grow or survive in it for years resulting from the lack of dissolved oxygen and over concentration of dissolved solids as well as the presence of other toxic substances. Based on this pragmatic studies, this paper argues that the major step towards safeguarding our water resources and promoting environmental sustainability is to tackle solid waste with much prudence.

REFERENCES

[1] Bourgoing, R. *Ghana: the nightmare lagoons*, IDRC, Ottawa, Canada, 1996

[2] Abraham, E. M., Drechsel, P. and Cofie, O. *The Challenge of Urban Flood Control: The Case of Accra's Korle Lagoon*. Paper presented at the 5th Worldwide Workshop for Young Environmental Scientist in France, 8th-14th May 2006. 8p

[3] Karikari, A. Y., Asante K. A. and Biney C. A., "Water Quality Characteristics at the Estuary of Korle Lagoon in Ghana", *West African Journal of Applied Ecology*, Vol. 10, 2006.

[4] World Bank. City of Accra, Ghana, Consultative citizens' report card. World Bank: Washington, D.C., 2010.

[5] Porter, R. and Boakye-Yiadom Jr. *The economics of Water and Waste in Three African Capitals*. Ashgate Publishing Limited, England, 1997.

[6] Chazan, D. *A World drowning in litter*, 2002, BBC
[Online]. Available: http://news.bbc.co.uk/2/hi/Europe/1849302. (December 28, 2013).

[7] Wetherall, I., *Zimbabwe: Editor's Memo - Rubbish Piling Up*, 2003, [Online]. Available: http://allafrica.com/stories/200303280395.html (December 28, 2013)

[8] Onibokun, A. and Kumuyi, J*. Governance and waste management in Africa*. In, Adepoju G. Onibokun (ed) "Managing the monster": Urban waste management and governance in Africa. International Development Research Centre, Canada, 1999.

[9] Environmental Protection Agency (Ghana); for Ministry of Works and Housing. *Korle Lagoon Ecological Restoration, Environment and Social Impact Statement*. Final Report. Accra, Ghana, 2001.

[10] Ministry of Local Government and Rural Development (MLGRD). *Environmental Sanitation Policy*, May 1999 Re-printed in November, 2001

[11] United Nations Environmental Programme (UNEP). Recommendations for decision making on municipal waste: practical policy guidance for implementing the global programme of action for the protection of the marine environment from land based activities on sewage. UNEP Working Document, Version 10, 2000.

[12] Lyse, O., Zambia: *Waste Disposal Haunts Cities* [Online]. Available: http://allafrica.com/stories/200303050103.html (January 26, 2014).

[13] Mensah, A., and Larbi, E. *Solid Waste Disposal in Ghana*. Water and Environmental Health at London and Loughborough (WELL), Loughborough, UK, 2005.

[14] Fei-Baffoe, B. *Double Stage Dry-Wet Fermentation of Unsorted Municipal Solid Waste*. Brandenburg University of Technology Cottbus, Faculty of Environmental Sciences and Process Engineering. International Course of Study: Environmental and Resource Management (PhD Dissertation), 2006.

[15] Tsiboe, A. I. and Marbell, E. *A Look at Urban Waste Disposal Problems in Accra, Ghana*, Roskilde University, 2004

[16] Boadi, K.O., Kuitunen, M. "Urban waste pollution in the Korle Lagoon, Accra, Ghana", *The Environmentalist,* Vol. 22, pp. 301–309, 2002.

[17] Biney, C. A. and Amuzu A. T. *Review of Korle Lagoon Studies*. *Accra, Ghana*: Institute of Aquatic Biology, 1995.

[18] Tipple, G., Korboe, D., Garrod, G., and Willis, K. "Housing Supply in Ghana: A Study of Accra, Kumasi and Berekum". *Progress in Planning*, Vol. 51 (4), pp. 255-324, 1999.

[19] McMahon, M. *What is Solid Waste Management? wiseGEEK, Clear answers to common questions*. [Online] Available: http://www.wisegeek.com/what-is-solid-waste-management.htm. (May 29, 2014)

[20] Abd'razack, N.T.A., Ludin, A.N.M and Umaru, E.T. "Ecological Footprint, Lifestyle and Consumption Pattern in Nigeria". *American-Eurasian Journal of Agriculture and Environmental Science,* Vol. 13(4) pp. 425-432, 2013

[21] Eisenberg, R. and Schmidt. CRP 3840: Green Cities, Informal Sector Waste Management Practices in Developing Countries, 2009.

[22] Mukhtar, M. *The Economics of Waste Scavenging in Kano State*. Department of Economics. Bayero University Kano, 2011.
[23] WaterAid and European Union. Urban Sector Assessment Report. Accra, Ghana, 2008.
[24] Accra Metropolitan Assembly (AMA), *Integrated Solid Waste Management Strategy*. Hifab-SIPU-Colan Consultants. Urban Environmental Sanitation Project; Accra, Ghana, 2009a.
[25] Anomanyo, D. E. Integration of municipal solid waste management in Accra (Ghana): Bioreactor Treatment Technology as an integral part of the management process. Lund University, Sweden, 2004.
[26] Lower Colorado River Authority (LCRA), *Water quality indicators. Key measures provide a snapshot of conditions.* Lower Colorado River Authority. [Online]. Available: http://www.lcra.org/water/quality/colorado-river-watch-network/pages/water-quality-indicators.aspx (May 9, 2014)
[27] Cleveland A. J. *Water What-ifs, Water Quality and Dissolved Oxygen*, 1998. [Online]. Available: www.ncsu.edu/sciencejunction/depot/experiments/water/lessons/do/index.html. (March 12, 2014)
[28] Murphy, S. *General Information 0n Solid, City of Boulder/USGS Water Quality Monitoring* [Online] Last Page Update - Monday April 23, 2007. Available: http://bcn.boulder.co.us/basin/data/NEW/info/TSS.html (May 9, 2014)
[29] Carlson, G. *Total Suspended Solids from turbidity. Technical Support, In - Situ Inc*., 2005. [Online]. Available: http://www.deq.state.mi.us/documents/deq- swq- npdes-TotalSuspendedSolids.pdf. (December 23, 2013)
[30] Iqbali J., Mumtaz M. W., Mukhtar H., Iqbal T., Mahmood, S., and Razaq, A. "Particle Size Distribution Analysis and Physico- Chemical Characterization of Chenab River Water at Marala Headworks". *Water quality: Characteristics, modelling and modification* Pak. J. Bot., Vol. 42(2), pp. 1153- 1161, 2010.
[31] Oram B. *Drinking Water Testing and Conductivity of Water*. Professional Geologist (PG) Environmental Engineering and Earth Science Department Wilkes University. Water Research Centre. [Online]. Available: http://www.water-research.net/Watershed/conductivity.htm (March 18, 2014).
[32] United States Environmental Protection Agency (USEPA). *CADDIS Volume 2: Sources, Stressors & Responses* [Online]. Available: http://www.epa.gov/caddis/ssr_urb_wsq2.html. Last updated on 7/31/2012 (March 18, 2014).
[33] Kiliç E., *Heavy Metals Pollution in Water* –Chemical engineer (Hacettepe University) chemical division manager – Cag Kimya Turkey [Online] Available: http://www.tip2000.com/health/waterpollution.asp (May 9, 2014)
[34] Salem, H. M., Eweida, A., Eweida and Azza Farag A. *Heavy Metals In Drinking Water and their Environmental Impact on Human Health*, ICEHM 2000, Cairo University, Egypt, September, 2000, page 542- 556 [Onlin]. Available: http://goo.gl/BOQs36 (December 27, 2013).
[35] Mack, J. *Eutrophication, Lake Scientist* | Miami University [Online]. Available: http://www.lakescientist.com/learn-about-lakes/water-quality/eutrophication.html (May 9, 2014).
[36] Ansa-Asare, O. D. "Land-based sources of pollution and environmental quality of Weija Lake|*". Journal of the Ghana Science Association*: 2001 3(3) pp. 100-108, 2001.
[37] Abraham, E.M. Trip to Accra Sewage Treatment Plant and Chemu lagoon. Field report, 2001
[38] Supercity. *Waste accumulation layers of the Korle lagoon* [Online]. Available: http://craftcollectief.wordpress.com/2011/06/10/waste-accumulation-layers-at-the-korle-lagoon-2/ (December 20, 2013)
[39] Post, J. and Obirih-Opareh, N. "Partnerships and the public interest: Assessing the performance of public-private collaboration in solid waste collection in Accra". *Space and Policy*, Volume 7, No. 1, pp. 45-63, 2003.
[40] Monney I., Tiimub, M. B. and Bagah, C. H. "Characteristics and management of household solid waste in urban areas in Ghana: the case of WA". *Civil and Environmental Research* Vol.3, No.9, ISSN 2224-5790, 2013.
[41] Ogwueleka, T. C. "Municipal Solid Waste Characteristics and Management in Nigeria", *Iran. J. Environ. Health. Sci. Eng.* Vol. 6(3), pp.173-180, 2009.
[42] Gomez, G., Meneses, M., Ballinas, L. and Castells, F. "Seasonal Characterization of Municipal Solid Waste (MSW) in the City of Chihuahua, Mexico". *Waste Management*, Vol. 28, pp. 2018-2024, 2009.