

The State of a 'Choked' Lagoon: A Two-decade Overview of the Fosu Lagoon in Cape Coast, Ghana

Baffour-Awuah, E.
Mechanical Engineering Department, Cape Coast Polytechnic, P. O. Box AD 50, Cape Coast, Ghana.
Email: emmanuelbaffourawuah37@yahoo.com

Abstract
Environmental researchers all over the world are concerned with the rate at which lagoons are being negatively modified beyond critical threshold capacities to the detriment of future generations. The Fosu lagoon located in the Cape Coast Metropolis in the Central Region of Ghana is no exception. The lagoon was identified as polluted by the close of 1993. Various strategies to prevent, if not curtail, pollution and its effects on the lagoon, since then, have been suggested. Though the privatization of waste collection management in the metropolis was introduced during the 2000's, this has not been enough to save the lagoon from the effects of pollution. Using content analysis as research technique the study looked at various works of researchers in relation to the lagoon from 1993 to 2013. Secondary data was basically employed using texts, essays, book chapters, journal and non-journal articles, historical documents, theses and dissertations. Informed interviews and observations were also employed. The paper contends that various stakeholders have failed to heed to suggestions made by researchers. It attributes the inadequacy of efforts to save the lagoon to myopic leadership, bribery and corruption, lack of shared visionary leadership among political parties and traditional councils, discontinuity of local government leadership and general institutional failure. The study sought to provide recommendations to stake-holders ways by which the lagoon could be salvaged from complete demise. It identified the central government, lands commission, metropolitan assembly, traditional council, town and country planning, the Environmental Protection Agency and educational institutions as the major stake holders in this regard.
Keywords: aquatic; landfills; food chain; nitrates; solid waste.

1. Introduction

Stress on coastal lagoons is increasing day by day as a result of both natural and anthropogenic manipulations and activities (Mahapato, Panigrahy & Panda, 2013). A coastal lagoon is a water body that is generally parallel to the coast line and close but usually demarcated from the ocean by offshore bars or islands of marine origin (Emery & Stephenson, 1957). In terms of the most noticeable and important features, a coastal lagoon may be described as a partially surrounded water body with open connection to the ocean making it possible for mixing of saline water from the sea and fresh water from drainage systems from inland; the mixing taking place in the lagoon enclosure (Pritchard, 1967). Though this definition includes estuaries, it does not take care of both closed and semi-closed lagoons.

A more general definition describes a coastal lagoon as a shallow inland marine water body whose position is parallel in relation to the coastal surroundings and detached from the ocean by one or more restricted inlets (Phelger, 1969). Lankford (1978) also gave the definition of coastal lagoons as 'coastal zone depressions below mean high water, having permanent or ephemeral communication with the ocean, but protected from the sea by some type of barrier'. This definition appears to distinguish closed coastal lagoons that are permanently isolated from the ocean by having depressions above mean high water tidal levels. According to Day (1980) the definition of Pritchard seemed to be more appropriate. Thus a coastal lagoon may be defined as a coastal water body that is partially enclosed with either a periodic or permanent opening into the ocean within which there is a mixture of both fresh water from inland drainage systems and saline water from the ocean. This definition equally excludes water bodies that are close and parallel to the ocean but are, somehow, permanently isolated from the sea. However it includes estuaries, small inlets of the seas, partially closed lagoons, coastal saline lakes and etc. But a more recent definition of coastal lagoons describes it as a shallow stretch of saline water that communicates with the ocean and may be partially separated from it by a low, narrow and/or elongated piece of land. This piece of land may be a barrier reef, a barrier island, a sand bar or split (Bates & Jackson, 1987).

In spite of this more generalized definition Kjerfve (1994) gave the most up-to-date definition. He defines a coastal lagoon as a 'shallow coastal water body separated from the ocean by a barrier connected, at least intermittently to the ocean, by one or more restricted inlets' (Mahapato et al, 2013; Gonenc & Wolfin, 2004; Hill, 2001)). This definition appears to be the most widespread and most accepted by policy makers, limnologists, ecologist, and scientists (Mahapato et al, 2013) though it distinguishes itself from the fact that coastal lagoons are usually and generally parallel in orientation to the coastline close to it.

According to Kjerfve (1986) coastal lagoons are classified as leaky, restricted or choked. Leaky lagoons are characterized as having wide tidal channels, fast currents with normally undisturbed water exchange with the ocean. Restricted coastal lagoons have well defined water exchange system with the ocean, multiple channels and tend to show a net transport of water to the ocean. Choked lagoons occur along high energy coastlines and have one or more long narrow channels which restrict exchange of water with the ocean and separated from it by a bar of mixed sand and gravel. Wind patterns normally control and regulate water circulation in such lagoons (Kjerfve, 1994; Smith, 1990; 1987). The Fosu lagoon may be classified under this category.

Coastal lagoons stretch from temperate zones to the tropics (Nichols & Boon, 1994). They cover about 13% of global coastal lands, ranging from 0.01 square kilometers to 10,000 square kilometers of landmass (Bird, 1994; Kjerfve, 1994). In spite of their richness in biodiversity, importance to research, fisheries and agriculture, sports and recreation, tourism, economic and religions activities, these natural ecological systems continue to be negatively affected by human activities as a result of man's quest for development and higher standard of living.

Mahapatro et al (2013) are of the view that population increase has also affected the way in which man has negatively affected these ecosystems. Population increase, development and the desire for higher standard of living brings pollution. Many coastal lagoons have therefore been polluted to the extent that their value and importance have continued to dwindle. Examples of such lagoons include the Indian river lagoons in Florida (the Liberty Caucus, 2014); Marapendi lagoon near the 2016 Olympic village in Brazil (Asiaone sports, 2012); Chilaka lake, which is the largest coastal lagoon in Asia (Nayak, Nahak, Samantrari & Sahu, 2010); Tam Giang lagoon in Central Vietnam (Ngu, 2010); Korle lagoon in Accra, Ghana (Boadi & Kuitunen, 2002) and the Fosu lagoon in Cape Coast (Mohammed, 1993), also in Ghana. For choked lagoons the impact of pollution could be enormous, actually 'choking' them to total demise, since exchange of water is severely hampered between the ocean and the lagoon while drainage of fresh water into the lagoon is usually diminished with urbanization and human development.

The Fosu lagoon is located in the Cape Coast metropolis in the Central Region of Ghana. It is currently virtually surrounded by institutions, domestic, commercial and industrial settlements. Notable among are the Siwdo automobile workshops and garages, the Metromass Transport Terminal and workshop (formerly Omnibus Services Authority workshop) the Metropolitan hospital at Ola, St. Augustine's College and the Adisadel estates. Others are Bakaano Suburb and the Robert Mensah Sports Stadium. Wastes from these sites directly find their way into the lagoon, contributing to pollution of the lagoon (Mohammed 1993). Currently various kinds of new structures are being constructed within the sphere of influence of the lagoon, including the some of the lagoon wetland areas. Residential, industrial and commercial structures are still being developed close to the lagoon (refer figure 1).

Figure1: Map of Cape Coast showing Fosu Lagoon

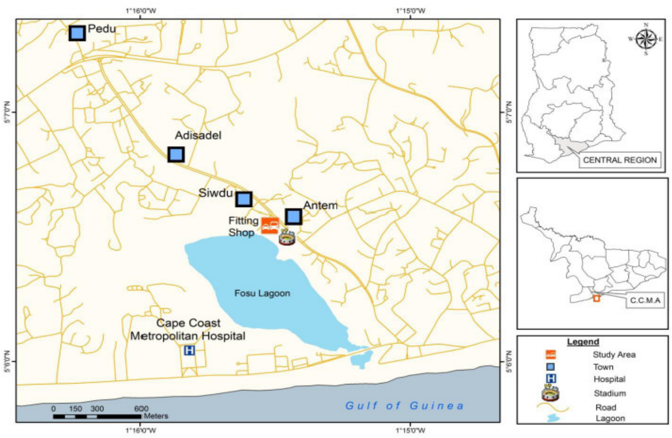

Figure 1: Map of Cape Coast showing the Fosu Lagoon and some settlements (Source: Arthur & Eshun, 2012)

The lagoon expanse is from the sea to the west to some parts of Adisadel. The commonest fish catch in the lagoon is the blackchin tilapia constituting about 90% of total fish catch in terms of weight (Baffour-Awuah, 2012). The lagoon serves as a religious, recreational and sporting importance to both residents and tourists who throng the metropolis on daily basis, and particularly during the annual *Fetu* Festival. In spite of these and other numerous benefits, the water, sediments and fish in the lagoon continue to be polluted (Arthur & Eshun, 2012; Eshun, 2011; Obodai et, al, 2011; Akwansah-Gilbert, 2007; Avi, 1998;)

By the close of 1992 the Fosu Lagoon was considered as one of the most polluted lagoons in Ghana (Mohammed, 1993). Water, sediments and tilapia in the lagoon were all considered polluted (Adjei, 1991; Tay1989; Hagan 1986). Organic and inorganic Leachates and run-off materials in the form of polycyclic aromatic hydro-carbons (PAH's) and heavy metals as well as euthrophication and mineralization of elements and compounds in the lagoon were some of the intermediate causes. The primary causes of lagoon pollution were poor sanitation conditions and poor waste management practices in the metropolis.

Between 1993 and 2013 various researchers have given suggestions meant to curtail pollution of the lagoon and to restore it. However it appears these recommendations have fallen on deaf ears. Though a few of these suggestions, such as the introduction of the polluter pay principle (PPP) policy at the domestic level has been introduced in the metropolis, pollution of the lagoon persist and therefore continue to be a bother to academicians, researchers, environmentalists and civil society. The questions that hence arise are:

1. Which bodies are responsible in dealing with waste management and sanitation in the Cape Coast metropolis?
2. What bodies are responsible for managing the Fosu lagoon?
3. Why have these bodies failed to deal with recommendations made by researchers over the years?

It is high time the causes of this adamancy are identified and dealt with in order to stop this pollution canker once and for all and pursue the restoration of the lagoon.

2. Literature review

This section dilates on literature about the subject. It emphasizes on sources, activities, processes, materials and substances that contribute to the pollution of the Fosu lagoon. It discusses issues concerning waste management, euthrophication, leachates, mineralization, polycyclic aromatic hydrocarbons (PAH's) and heavy metals.

2.1 The waste management problem

In the opinion of Brown (1980) the waste management problem has been of global issue in recent years. From advanced countries to the developing world the issue has become of concern. Enger & Smith (2000) and Cunningham & Cunningham (2000) wrote that material affluence results in volumes of garbage, junk, refuse and other types of solid waste through individual, agricultural and metal-mineral activities. They add that, for example, in 1960 municipalities in the United Sates were generating about 90 million metric tons of waste from institutional, commercial and residential sources. By the close of 1990, within a period of thirty years, the figure had more than doubled to about 196 million metric tons. By the end of 2000, the country's municipal solid waste had risen to 220 million metric tons in spite of various measures that had been put in place to check solid waste generation in the country. Over half the waste generated in the municipalities were of plastics, glass and paper origin. While about 36 percent of wastes were made up of cardboard, office papers and other related products, newsprints accounted for about 16 percent of solid waste in cities in the United States. In Snohomish County, United States, about 4540 tons of strict grit waste was estimated to have been generated in 1994. Street waste generation was estimated at between 12 and 75 pounds per resident (Alameda County, 1993).

Waste generation, disposal and its management can cause various negative effects on the ecology (Wilson, 1972). Air, soil and water could be polluted as a result of poor waste management. Pollution can cause various health problems. For example, gaseous emission from waste incineration such as sulfur oxides and nitrogen oxides can cause lung and respiratory non-communicable medical conditions. Leachates from land disposal sites could pollute both surface and ground water (US EPA 1977) which in turn could result in enteric diseases, tuberculosis, trachoma, murine, malaria, yellow fever, anthrax, yellow fever, trichinosis and encephalitis filariasis among others. Poor solid waste management can also result in cardiovascular diseases, skin diseases, hernia and arthritis (Wilson, 1972) Burning of waste can contribute to greenhouse effect and global warming as well as acid rain..

Most Asian and African countries have insufficient physical conditions and resources thus contributing to poor sanitation and poor solid waste management (UNEP, 1988). In India, for example, over 40 percent of diurnal wastes generated in 60% of 34 municipalities were not collected (Quashie 1994). This was as a result of lack of adequate waste management facilities as well as funding.

In Ghana waste generation and management were identified as environmental problems as far back as colonial days, particularly in Cape Coast before the capital was moved to Accra (Kendie, 1998). Indiscriminate waste disposal into drains and open spaces created conditions for breeding of flies and rodents which migrated into various homes, domestic and industrial settings, spreading various enteric diseases among others (Consortium, 1992; Sey-Haizel, 1999). Sey-Haizel (1999) indicated that about 97% of solid waste generated were either burnt by households or dumped at one place or another. It was for this reason that Buabeng & Okyere (1997) contended that the waste management department of Accra Metropolitan Authority should be adequately resourced both financially and in terms of infrastructure to be able to confront the waste management problem engulfing the metropolis. According to the Ghana Living Standard Surveys (GLSS) only 11 percent of urban dwellers had access to flush toilet facilities while 96 percent of wastes generated in these areas were dumped (Ghana, Republic of, 1995). As a result Convery & Tutu (1990) and Kendie (1998) were of the view that 70 percent of health care costs in Ghana could be linked to environmental health conditions.

In the view of Addo (2005) the rise in standard of living in Ghana has brought about the emergence of polythelene, plastics and styrofoam products in domestic and commercial waste in the Ghanaian economy. He continued that the substitution of these materials at the expense of environmentally sustainable materials for items like straw materials, paper carrier bags, leave-wrappers, care settees and stools have added more stress on waste management efforts. In his observation, foam mattresses, plastic chairs, polyethylene carrier bags, "take-away" packaging, sachet water containments and other plastic materials for packaging have been excessively used in the country. In his opinion these materials have been indiscriminately and irresponsibly disposed, contributing to immense environmental hazards and its concomitant health problems among both young and old. As a municipality in Ghana, Cape Coast has continued to have its fair share of waste generation, disposal and management problems affecting its environment. For this reason, the Fosu lagoon, one of the major water bodies in the metropolis has continued to suffer from waste disposal attitude of inhabitants and institution in the metropolis. Various solid wastes find their way into the lagoon through drains directed into it and through natural run-off from some parts of the metropolis. Solid wastes such as night soil (resulting from open defecation), foam pieces, plastic materials, polyethelene carrier bags, waste 'take-away' packaging materials, waste sachet water containments, burnt organic and inorganic materials, and styrofoam products. These waste materials go a long way to pollute the lagoon.

2.2. Euthrophication in aquatic environments

Literary, euthrophication refers to good health, adequate nutrition or development; or good-eating (Shindler & Vallentyne, 2004). Ecologically, euthrophication is the response of aquatic ecosystems or natural aquatic environments to the increase or addition of mineral nutrients from either natural or artificial sources or origin. Increase of these substances may result from inflow of nitrate and phosphates from sewage or fertilizer from agricultural lands, domestic household or industrial settings (Shindler &Vallentyne, 2004) It is therefore mainly caused by the presence of phosphorus and nitrogen at elevated levels in aquatic environments. These elements are found in human excreta. They are also present in other organic cells, tissues and organs (Carpenter, Caraco & Smith, 1998).

Hochanadel (2010) explains that though eutrophication can be caused through both natural and anthropogenic activities, anthropogenic causes of euthrophication are of great concern since it is can be controlled and possibly prevented. He continues that the main causes of human related euthrophication are through human and animal waste (faeces) and fertilizer applications. In both cases these substances are transported as effluent into water bodies. He further explains that, generally, euthrophication encourages plant growth and decay in the aquatic environment with the result of reduction in pollutant content.

The stimulation of organic activity by micro-organisms on the organic waste increases the growth of algae and plankton. These algae and plankton feed on the required nutrient for the growth of other plants and animals. The decomposition of the algae and plankton, when they die, at the base of lagoon bed, requires great amounts of oxygen for the conversion of their organic cells into inorganic substances. In the process the water body is deprived of oxygen in quantities sufficient to sustain the life of both quantity and quality of fish and other aquatic animals. Nutrients of decomposed algae and phytoplankton also become deficient at the surface of the water where they are rather needed for photosynthesis to take place. Consequently, aquatic algae populations become stunted (Barotse Floodplain, 2003; Smith, Tilman & Nekola, 1999)).

In a nut shell, eutrophication which causes increased growth in aquatic vegetation and algae bloom, rather eventually disturbs the normal functioning of the aquatic ecosystem by reducing the quantity of oxygen required for sustenance of fish and other aquatic animals and their survival. According to Bartram et al (1999), euthrophic water is not potable and aesthetically unattractive. It may be red, brown, green or yellow in color with repulsive smell. When drank it may cause health problems.

Ecological effects of euthophication on lagoons are manifold. About 375 coastal zones around the world have been identified to be hypoxic (Selman, 2007). Although these are concentrated in the southern coasts of the US, eastern coast of US, East Asia and Western Europe, there are others in parts of the globe including Africa (Rodhe, 1969; ILEC, 1993). Effects of euthrophication include decreased biodiversity, changes in species composition and dominance and toxicity effects among others (Bertness et al, 2001). Euthrophication of coastal lagoons should therefore be of great concern to both public and private entities. In a situation where the lagoon is a 'choked' type, such as the Fosu lagoon, the effects of euthrophication should rather be given a more particular attention.

2.3 Leachate formation

Most countries in the world, both advanced and developing, including the United Kingdom, are confronted with leachate problems (Hansard, 1972). Leachate is any liquid containing suspended solids, extracted solutes or any other part of a material as a result of percolation through matter composing same substances (Essumang, 2000). The dissolved substances may be environmentally harmful when exposed to the environment; they drain from land or stockpiled materials, usually landfill sites and usually contain significantly high concentrations of suspended solids and solutes ((Henry & Heinke, 1996) In landfills for instance, leachates contain various kinds of both elements and compounds. This however depends on the type of waste in the landfill (Young, 1992). They may flow from the generation point under gravity to other environments.

In Landfills, leachates are generated when water, particularly rain water, percolates through waste materials. When water comes into contact with the waste material that is decomposing, the water becomes contaminated by dissolving or suspending solid materials in the waste (WSDE, 1987). In the process further decomposition occurs with the release of fungi and bacteria. More water is released during the decomposition process. The leachate so produced also reacts with non-decomposible materials such as heavy metals. If the landfill is composed of industrial, commercial and municipal wastes, various kinds of contaminants and pollutants could be dissolved and suspended. For example, dissolved organic matter such as acids and polycyclic aromatic hydrocarbons (PAH's), inorganic macro components including sulphates, ammonia, chloride, iron, aluminium and heavy metals such as lead, nickel, mercury, cadmium and copper could be found in leachates (Kjeldsen, Morton, Barlaz, Rooker, Ledin & Thomas, 2002).

Leachates from landfills appear straight black, yellow or orange in color. It also appears cloudy with strong acidic and repulsive smell due to relatively abundant presence of hydrogen, sulfur and nitrogen. The presence of toxic metals and organics can render the leachate chronically toxic and accumulate within the local and external environment (Kjeldsen et al. 2002). When found in water bodies, such as lagoons, they may disturb the ecological balance of the environment. The water may be rendered impotable and incapable of sustaining aquatic life including fishes. In choked lagoons such as the Fosu lagoon, the process and its effect and impact could be more devastating in the short, medium and long terms.

2.4 Mineralization of organic matter

Mineralization of organic matter is a very important factor that influences many transformations associated with elements in relation to the organic matter (Stahlberg, 2006). It is a microbiological process by which microbes decompose organic nitrogen from crop residues, manure and organic matter into ammonium. Mineralization rate depends on moisture content of organic matter (Hardman, Waite & McEldowney, 1993). It therefore depends on availability and quantity of water in the organic matter, temperature and the quantum of oxygen available. For this reason, the rate of minerization increases in warm environments, well-aerated conditions and moist environments (Johnson, Albrecht, Ketterings, Beckman & Stockin, 2005).

In its natural form nitrogen exists as molecular nitrogen (N_2) in the atmosphere as one of the major components constituting air. In the soil, nitrogen occurs in organic form. Scientifically nitrogen is produced as nitrogen fertilizer as nutrient to crops in agricultural activities (Johnson, Albrecht, Ketterings, Beckman, & Stockin, 2005). Through industrial chemical fixation process nitrogen used in fertilizer production is derived from elemental atmospheric nitrogen. Elemental nitrogen is not useful to plants unless the plant has symbiotic associations with nitrogen-fixing micro organisms (Tandon, 1991; Black, 1965).

Organic nitrogen in aquatic environments such as lagoons exists as ammonium (NH_4^+), Nitrate (NO_2) and nitrite (NO_3). It is in these forms that nitrogen could become hazardous to aquatic matter (Hardman et al, 1993; Jeffrey, Madden, Rafferty, Dwyer, Wilson & Ilott, 1992; Tandon, 1991; Black, 1965).

The presence of nitrate is of environmental concern since its presence in water bodies at certain levels could render the water impotable for drinking, domestic and industrial purposes. Nitrogen products derived from amino acids such as nitroso-dimethylamin, $(CH3)_2NNO$ could be carcinogenic to several zoological species (Hardman et al, 1993; Etherington, 1975). For choked lagoons such as the Fosu lagoon the impact of the presence of nitrate could therefore be more disastrous to living biota in the lagoon as well as humans that feed on aquatic animals found in the lagoon.

2.5 Polycyclic aromatic hydrocarbons (PAH's) effects

Polycyclic aromatic hydrocarbons, poly-aromatic hydrocarbons or polynuclear aromatic hydrocarbons are fused aromatic rings that occur in oil, coal, and tar deposits, and are produced as by-products when fossil or biomass fuels are burnt (Fetzer, 2000). They are also found in processed fossil fuels and various edible oils (Roy, 1995). PAH's are the most widespread organic pollutants. They are produced when complex organic substances are exposed to high pressure or temperature. They are formed by incomplete combustion of organic fuels such as tobacco, fat, diesel, wood, coal and incense (Incense link to cancer, 2001). They are also found in cooked foods such as meat cooked at high temperatures such as grilling and barbecuing and in smoked fish; coal extracts, exhaust fumes, internal combustion engine fuels, marine sediments, cigarette smoke, soil, soot, smoke from firewood, etc. (EC, 2002; ATSDR, 1996; Larson, Sahlberg, Erikson & Busk, 1983). PAH's are made up of mainly carbon and hydrogen. They do not contain heteroatoms or carry substituents (Fetzer, 2000).

Factors that affect the persistence of PAH's in the environment include moisture, enzyme specificity, bacteria membrane permeability, oxygen, and sunlight. PAH's are biodegradable. While napthalene and anthracene are slightly soluble, chrysene and benzo (a) pyrene are relatively less soluble. Pyrene and fluorathene are more soluble than antracene. In the process of biodegradation some toxins may be produced from PAH's (Srivastava, Bhui, Shuka, Madhulika, Kulpreet & Yogeshwer, 2010; Akwansah-Gilbert, 2007).

Since PAH's are carcinogenic, mutagenic, teratogenic, lipophilic, and genotoxic they become of great concern when they enter the environment. Indeed they can cause preneoplastic change to the liver (Srivastava, Bhui, Shuka, Madhulika, Kulpreet & Yogeshwer, 2010; ATSDR, 1996; Larson, Sahlberg, Erikson & Busk, 1983). They could be attached to particulate matter in the atmosphere or be present in isolation. Some are highly volatile while others can readily decompose through interaction with other chemicals in the presence of sunlight within hours, days or weeks. In lagoons they can be found in solution or adsorbed onto particles present in the aquatic environment. Smaller compounds are more volatile and more soluble in water when found in aquatic environments. PAH's are usually linked to spills of oil, in seas, rivers, soil, lakes and lagoons. PAH compounds can therefore enter the food chain through botanical and zoological organisms such as fishes and subsequently to humans (Ortmann, Anders, Shelton, Gong, Moss & Condon, 2012; Schneyer 2010; Fetzer, 2000). Thus when found in aquatic environments such as lagoons, and specifically choked ones, the effects of PAH's could be of great health concern to biological entities.

2.6 Heavy metals in aquatic environments

Toxic effluents, water pollutants, and heaps of solid and hazardous waste are becoming devastating problems in both advanced and developing nations (Cunningham & Saigo, 1997). This is because millions of tons of dangerous substances including heavy metals are generated from wastes annually and exposed to the environment without recourse to the harm they may cause (Akwansah-Gilbert, 2007).

Heavy metals may be defined as any metallic element that has high relative density and can be toxic at relatively smaller concentrations. They are non-degradable and non-destructible. They enter into the human body through air, water and food including aquatic animals. These metals could be toxic to man, animals and plants through biochemical relationship that occur in living organisms (Akwansah-Gilbert, 2007). They are metals with relative density 5 or more. They could be very poisonous and can therefore cause many non-communicable and non-infectious diseases. Their entrance into human body could manifest either immediately or latter depending on the amount (Hart, 2008).

While some heavy metals (trace metals) in wee quantities may not cause deficiency disorders, others may cause toxic consequences to human beings in average concentrations. Their poisonous effects are portrayed when they compete for sites with essential metabolite groups thus destroying health cells (Anukwah, 2007). Examples are Mercury (Hg), Arsenic (As), Titanium (Ti), Uranium (U), Antimony (Sb), Lead (Pb) and Cadmium (Ed). Several medical conditions are caused by these metals (Bellinger, 2008; Kido, Nogawa, Honda, Tsuritani, Ishizaki & Yamada, 1990).

In aquatic environments heavy metals are made available to aquatic plants and animals. Humans could therefore be offered these metals through the food chain. This is because they are transferred via accumulation from the environment essentially through aquatic biota. Generally heavy metals are transferred from roots to leaves, fruits and seeds of plants when near water bodies (Anukwah, 2007; Hangi, 1996). They may therefore eventually become exposed to water bodies; the water body acting as a habitat or waste disposal unit to the plant. Through this process several aquatic organisms such as fishes in such environment may accumulate the metals when they use them as food. Accumulation may take place when made available in a continuous or continual manner over a long period of time. For this reason small ingestions by humans through fishes, for example, could be one of the fundamental ways by which humans ingest the metals (Baffour-Awuah, 2012; Hangi, 1996).

3. Research methodology

Content analysis was employed in the study, specifically relying on secondary data. It was used in order to explore the contents of literature so that the presentation of specific issues could be discovered and presented (Cole, 1988). As a systematic and objective way of describing and quantifying phenomena and activities it was employed in the determination of usage of words, figures, concepts, themes, phrases, characters or sentences related to sets of texts or within texts (Elo & Kynga, 2008; Doune-Wamboldt, 1992; Krippendorff, 1980). It was used to quantify usage of words in purposeful and objective manner without bias. As a qualitative research, the study primarily relied on text books, essays, book chapters, texts, journal and non-journal articles, historical documents, thesis and dissertations as well as informed interviews and observations in the data gathering process (Agyapong and Boohene, 2012). Secondary data was therefore extensively used during the study. The study analyzed secondary data within a twenty-year period from 1993 to 2013 by contrasting, comparing, inferring and drawing conclusions in relation to existing literature. Additional conclusions were drawn from data obtained through interviewing and observational methods employed. Informants interviewed include fishermen, owner-mechanics at the Siwdo workshops and garages as well as residents at Bakaano. Eleven informants aged between forty-four and eighty-one years were interviewed.

4. Discussion

By the close of 1992, the Fosu lagoon was considered as one of most polluted lagoons in Ghana (Mohammed, 1993). The importance of the lagoon had been documented by various researchers (Adjei 1991; Tay 1988; Hagan 1986; Allen, Grimshaw, Parkinson and Quarnby, 1974). The lagoon serves as a means of livelihood to fishermen and fishmongers. It has many rich and fresh water resources. It also serves as tourist attraction when viewed as an integrated tourism package that exists within the Cape Coast metropolis. It is of recreational and religious importance to both residents in the municipality and tourists alike (Mohammed, 1993). The particular religious and recreational value of the lagoon is seen during the annual *Fetu* festival which is a traditional festival celebrated in the first week of September each year. According to Mohammed (1993) water from the lagoon was used for livestock farming as well as vegetable cultivation by residents who lived in the suburbs near the lagoon i.e. Adisadel estate and Adisadel village, Siwdo compound apartments and Siwdo village, Antem, Ola estate and village as well as Bakaano. He recorded that residents would make their farm beds where they will cultivate their vegetables using the lagoon water for irrigation. Cattle, sheep and goat rearers would also send their livestock to the lagoon for drinking purposes. The lagoon water was also extensively used for washing purposes particularly during the dry seasons when tap water and well water could not be accessed in some parts of the metropolis.

The construction of recreational and entertainment centers near the lagoon for tourists added value to the lagoon. Playing grounds, drinking bars and restaurants near the lagoon went a long way to play important role in the tourism industry in the metropolis. During the *Fetu* festival religious rituals were performed close to the lagoon (Mohammed, 1993).

By the beginning of 1993, according to Mohammed (1993), the lagoon had started losing its attractiveness and importance. Fishing activities was already going down. Few fishermen and fishmongers could be seen involved in their various economic engagements. He observed that the lagoon had been polluted with various kinds of contaminants and pollutants. Land degradation and misuse as a result of increased construction and agricultural activities had added to the sources of lagoon pollution. The depth and surface area had also reduced at an alarming rate from the last twenty to thirty years. Unsustainable settlement planning was a major contributory factor to its pollution. The settlement sites consisting of St. Augustine's College, a second cycle institution, the metropolitan district hospital (formerly Cape Coast regional hospital) the Bakaano Township, were identified as the major sources of pollution of the lagoon. The Metro mass transport workshop and terminal (formerly Omnibus services workshop) and the Siwdo automobile garages and workshops also contributed immensely to the pollution of the lagoon (Mohammed 1993; Adjei 1991; Tay 1988; Hagan, 1986; Allen et al, 1974). Today the depth of the lagoon continuously appears to be reducing, fishing activities has further deteriorated and pollution of the lagoon is continuing.

By the beginning of 1993, various research works had shown that the Fosu lagoon was polluted with heavy metals (Mohammed, 1993). For example, Hagan (1986) had shown that there were high values of copper concentrations ranging from 90 to 102ppm in the lagoon water. He indicated that mercury concentration in lagoon water was 0.008ppm. Tay (1989) had also obtained copper concentrations in algae, ranging from 0.19 to 1.04ppm. Mercury concentrations in algae were also found to be between 0.397 and 1.0309ppm (Tay, 1989). Adjei (1991) researching on copper presence in lagoon water recognized that concentration levels had increased to 48.3 to 106.85ppm while lead concentrations was found to be between 0.04 and 1.12ppm. Key informants interviewed indicated that drinking bars and restaurants appear to be increasing around the lagoon. The metro mass transport terminal and workshop has also recently replaced the then omnibus transport workshop after over a couple of decade's dysfunction. Cattle, goats and sheep still use the lagoon water for drinking purposes while humans also use same for washing purposes, particularly during the dry season. According to the informants, some portions of the lagoon are currently used for playing soccer during the dry season when sediments are made bare and naked by the weather.

From the period between 1993 and 2013 various studies related to the lagoon continued to show that the lagoon water, sediments and fish in the lagoon were polluted (Dadson 1996; Adjei, 1991). Several miniature islands of weeds were being formed in the lagoon creating an indication of surface area reduction thus endangering aquatic life and consequential decrease in economic surface area of the lagoon with its sediments exposed to the naked eye during certain parts of the year, particularly during the dry season. This state of the lagoon had never been observed before by fishermen and inhabitants who lived close by it (Adjei, 1998). He observed that the state of the lagoon was as a result of waste disposal, made up of garbage and night solid due to lack and inadequate sanitary facilities in the Metropolis. Study informants were of the view that this condition started in a small way, increasing as the years went by. Today these islands appear to have greatly increased in size.

Avi (1998) recorded dissolved oxygen concentration of less than 1.0mg/l at the location near human settlement which was exposed to diurnal dumping of refuse. Mean value of 0.6mg/l of dissolved oxygen was further recorded. In his view this was an indication of high microbial activity, a sign of aerobic decomposition of refuse where organic nitrogen was converted into inorganic forms. This condition, he concluded, was a sign of high level of pollution in this part of the lagoon. He further concluded that the low dissolved oxygen content of lagoon water could lead to anoxia conditions that could eventually lead to fish death, particular during the night.

PH values ranging between 7.37 and 7.37 recorded was appropriate for oxidation of ammonium; encouraging the proliferation of autotrophic ammonium oxidizing organisms (Avi, 1998). Results obtained by Avi during the dry season (1998) further showed that there was predominant existence of nitrogen in the form of nitrate. The mean rate of mineralization, $0.48m^{-2}h^{-1}$, of nitrate into nitrogen from the sediments was an indication that the main product of organic nitrogen mineralization was nitrate. He found that nitrate-nitrogen was not released during the rainy season (-28.13mgm^{-2}h^{-1}) leading to his conclusion that nitrate could leach into deeper anaerobic layers of lagoon water through denitrification and assimilation by microorganisms into organic nitrogen. The main product of mineralization was found to be ammonium-nitrogen.

In his conclusion, Avi (1998) indicated that the depth of the lagoon was decreasing due to increase in rate of sedimentation. Vegetation in lagoon was also increasing. He further observed the formation of green scum made up of algal decomposition on the surface of lagoon water during the research period. Furthermore he observed that pollution of the lagoon was caused by dumping of refuse near the water body. There was aerobic decomposition of the refuse leading to reduction of dissolved oxygen in lagoon water which in effect frequently led to killing of fish (Avi, 1998).

Researching on the topic "the effect of leachate from solid waste disposal sites on the Cape Coast Municipal Environment" Essumang (2000) found the concentrations of iron, sulfate, phosphate, dissolved organic matter, nitrate-nitrogen, nitrite- nitrogen chloride and ammonium-nitrogen as 2.34-720 pm; 1.6-21600; 2.0-1433; 65.5-3655.4; 8.01-720; 0.7-81.0; 6.0-1520 and 13-1140 ppm respectively. Plate count was between 10^4 and 10^7 while conductivity ranged from 10200 to 199,900µs/cm. He stated that "we have observed from this analysis that apart from chloride concentration levels, all the other eleven parameters studied has higher levels compared with waste characteristics and leachate limits for various types of landfills". He continued that "there is no doubt that leachate pollution for both ground and surface water is inevitable if solid waste is not properly handled"; and solid waste still appear not to have been properly handled. These wastes according to him carried effluents in the form of leachates with high concentrations of nutrients and toxic substances. Out of the four waste disposal sites studied, i.e. Ankaful junction, Adisadel, Esuakyir and Nkanfoa main disposal sites, the Nkanfoa site was the most polluted, taking about 90% of the total solid waste collected from the metropolis (Essumang, 2000). Bearing in mind that these sites were some of the path sources of the Fosu lagoon, it appears pollution of the lagoon was partly contributed by leachates from these sources (Essumang, 2000;). During this study it was observed that these sources are still functional. They could therefore continue to be contributing to the pollution of the lagoon.

Gingold et al. (2005) after determining the concentrations of cadmium and other trace metals observed that concentrations in water had considerable effects on both fishes and water in the lagoon. The level of cadmium, for instance in blackchin tilapia in the lagoon, was found to be higher than international standards for both aquatic health and human consumption.

Akwansah-Gilbert (2007) researching on the topic "Distribution of polycyclic aromatic hydrocarbons and heavy metals in the Fosu lagoon of Cape Coast, Ghana" studied the concentrations of iron (Fe), manganese (Mn), Cadmium (Cd), Zinc (Zn) and nickel (Ni) as well as 15 PAH's. He found that the lagoon was highly contaminated with cadmium and nickel, particularly close to where there were higher concentrations of industrial activities. It was also observed that 50% of the samples collected from sediments were higher than cadmium guidelines for the protection of aquatic lives. He indicated that the summation of PAH concentrations in the samples of sediments were between 254 and 558mg/kg. The mean concentration was obtained as 359.4mg/kg. From these findings he concluded that though the concentrations of PAHs and the heavy metals were comparatively lower, they provided an outlet for continuous pollution to the lagoon environment. He opined that the mechanical workshops and garages in the northeastern sector of the lagoon was the main source of cadmium and its associated PAH compounds such as nickel. He further opined that the residential area in the northern sector was the source of manganese and its related PAH compounds such as benzo (a) pyrene, anthracene and phenanthrene. He was also of the opinion that PAH that enter the lagoon were as a result of wood or coal. He was of the view that the exposure of these substances could be dangerous to aquatic organisms, domestic animals and humans.

During the study it was observed that people burn waste vehicle tires at refuse dumps near the lagoon. This researcher is therefore of the view that the presence of PAH compounds could be as a result of vehicle scrap-tire combustion around and near the automobile workshops and garages and could also contribute to lagoon pollution (Fetzer, 2000). People burn these vehicle tires as a way of extracting the steel wires used as reinforcement in its manufacture. To such people this activity is an economic means of making a living.

Another observation by Akwansah-Gilbert (2007) was that there were some interrelationship between the mechanical workshop activities at Siwdo and the southern sectors of the lagoon; that the mechanical workshops (in the northern part of the lagoon) could be a contributing factor to pollution in the southern portions of the lagoon. Though it could be easier for waste from the automobile workshops and garages to get into the southern part of the lagoon, the few fitting shops in the southern portion could also partially contribute. Cadmium, Nickel, Zinc, Manganese and Iron concentrations of 0.78 – 33mg/kg, 0.31 – 0.14mg/kg, 2.66 – 0.24mg/kg and 0.36 – 0.37g/kg respectively were also recorded by Akwansah-Gilbert (2007). The study further concluded that though the cadmium value was higher than 0.7mg/kg being the Canadian Interim Marine/Estuarine sediment Guidelines for the protection of aquatic lives, those for the other metals were within the threshold value.

According to Agyapong (2008) a large portion of the lagoon dries up during the dry season such that these parts of the lagoon are used as football pitch, particularly among children. He observed that many buildings have sprung up around the catchment area where previously was not. He attributed pollution of the lagoon to economic activities from and around the lagoon (Agyapong, 2008). Today, these observations still persist and appear to be more intense.

Armah, Luginaah, Kuitunen, and Mkandawire, (2012) on a study titled 'Ecological Health Status of the Fosu lagoon, Southern Ghana II: Environmental and Human Health Risk Assessment,' concluded that the carcinogenic risk level due to ingestion of Arsenic and manganese through sediments of the lagoon should be a concern for human health and also that the concentrations of polycyclic hydrocarbons were quite high. Contamination of heavy metals was also found to be considerable. It was realized that the ingestion and dermal absorption of heavy metals in the lagoon sediment was higher than the generally acceptable risk level for individual chemicals in terms of carcinogenic risks. These conclusions are in agreement with those made by earlier researchers (Agyapong, 2008; Ahuahey, 2007; Akwansah-Gilbert, 2007; Avi, 1998; Forson, 2005; Gingold et al, 2005; Mohammed, 1993). Mangroves in the lagoon wetlands are virtually extinct (Darkwa & Smardon, 2010). Sustainability of fishing in the lagoon is also at risk (Baffour-Awuah, 2014). As findings of the most recent studies on the lagoon indicate, pollution of the Fosu lagoon needs to be of great concern to all stake-holders as never before.

5.0 Conclusion and Recommendations

From the time when the Fosu lagoon was identified as polluted various recommendations have been suggested by corresponding researchers with the aim of preventing or curtailing this unwanted and undesirable phenomenon and to mitigate the harm already been done. For example Mohammed (1993) recommended that the EPA should be given a legislature support so that environmental conditions within and around the lagoon could be improved. He also recommended using communication channels such as radio, television, mobile cinema vans, newspapers, workshops and posters to educate the public within the municipality and conscientize them on the harmful effects of pollution. He also suggested the removal of all industries and sawmills whose effluents were toxic from their current location (Mohammed, 1993) for relocation outside the sphere of influence of the lagoon without pollution translation (Baffour-Awuah, 2014). Other recommendations were the treatment of effluents from domestic source, schools, hospitals and industries being discharged into the lagoon; with specialized personnel to take this responsibility. He further suggested conservation of the lagoon and the cessation of the practice of throwing copper coins and fishing-net lead into the lagoon (Mohammed, 1993).
Agyapong (2008) on the other hand recommended concreting all drains entering the lagoon or shielding the lagoon from all drains, dredging the lagoon, opening the sand bar between the lagoon and the sea, construction of jetties to influence wave current in order to prevent depositon of sand. He also recommended the encouragement of the private sector to develop tourist sites around the lagoon. He was of the view that such a development would check pollution of the lagoon since those owners will take responsibility of the sanity of the lagoon. He further recommended an integrated management for protection and sustenance of the lagoon. Furthermore he recommended the formation of policies and laws and education as remedial measures to protect the lagoon in consonance with some of the recommendations made by Mohammed (1993). Studies on lagoon pollution carried by Bentum, Anang, Boadu, Koranteng-Addo, & Owusu-Antwi, (2011), Eshun (2011), and Obodai et al (2011) appear to suggest that the causative factors of pollution recorded before 2008 by Agyapong (2008) were still relevant since they were indicative that the lagoon continues to be polluted in one way or another.

Though the implementation of polluter pay principle (PPP) policy, in the latter parts of 2000's,in the metropolis pioneered by Zoomlion Company Limited, and the collection of metal scraps and wastes as well as plastic bags and containers for commercial purposes appears to have reduced the rate of pollution of the lagoon, it still continues to a large extent. This is because many of the recommendations have not been implemented to the detriment of the fate of the lagoon and those who depend on it for their livelihood. The lagoon is still being polluted on one way or another affecting its development as an economic entity, recreational facility, tourist opportunity and cultural heritage among others. The question now is, why have stakeholders failed as nation and metropolis, in the sustainable development of the lagoon?

This author is of the opinion that the nation as a macroscopic entity and its individuals, have failed in its prevention efforts of the pollution of the lagoon since it was discovered that it was being polluted. Various governments from Rawlings'National Democratic Congress (NDC) to Kuffour's New Patriotic Party (NPP), from 1992 to 2008, have failed to achieve the development and growth the people of Cape Coast, particularly Fosu lagoon fishermen, had wished for as far as the Fosu lagoon is concerned. The National Democratic Congress (NDC) II government also appears to be following similar tracks in neglecting the maintenance and management of the Fosu lagoon and its environment. Though these governments have made some efforts, very little results have been achieved in dealing with the pollution issue. The protection, restoration, conservation and preservation of the lagoon appear not to be of concern to stakeholders. The vision for the lagoon has not been achieved and this might be attributed to improper planning, absence of visionary leadership, mismanagement by greedy and selfish political and public service leadership, bribery and corruption, bad governance and over-reliance on foreign donors for budgetary assistance on the part of political parties, the traditional council, town and country planning, central government, ministry in charge of environment, Metropolitan and (past) Municipal and District Assemblies, Environmental Protection Agency and Non-governmental organizations. The current state of the Fosu lagoon could also be attributed to irrelevant formal education to environmental aspirations (Amegashie-Viglo, 2009).

Education should not be formal alone. It appears the nation has relegated to the background its moral, religious, cultural and virtuous education, which are aspects of African traditional oral education. Environmental education imbibed in African informal oral education has been relegated to the background. Though efforts are being made, the pace is too sluggish and inadequate in quantum to catch up with the developmental aspirations of the people in the maintenance of the lagoon.

For example, African cultural education does not permit any enterprise that has the ability to pollute a water body to be sited near it. African virtuous education teaches the individual that a water body polluted could be a drinkable source for another downstream and for that matter one should desist and prevent the pollution of water bodies. Morally it is wrong to destroy what nature has given free unto humans and therefore moral education teaches how not to pollute but preserve what nature has provided. It is a religious command by both Christians and Moslems, for example, to protect and sustain natural resources, commodities and properties. Religious and moral commands detest greed, selfishness and egocentrism, bribery as well as corruption that have crippled several, if not all facets and sectors of the economy. The best way to manage and develop the lagoon is to restructure all aspects of the nation's educational system to direct and gear formal environmental education, cultural, moral, religious and virtuous education to a new orientation that will educate stakeholders to be collective, patriotic, and caring in all endeavors in the management of the lagoon. Supporting good governance, cultivating the required and appropriate administrative and political will as well as detesting bribery and corruption at the national and metropolitan level could also help restore the Fosu lagoon and its environment to its natural state.

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