RESEARCH PAPER

ASSESSMENT OF WATER QUALITY PARAMETERS OF KPESHI LAGOON OF GHANA

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ABSTRACT:
A study was carried out on the Kpeshi Lagoon to identify the chemical and physical characteristics of the water. A lot of industrial activities are carried out around the Lagoon and it is being gradually turned into a place of refuse damp. Standard methods were used for determining of chemical and physical characteristics of water samples. Trace metal ions were determined by atomic absorption spectrometry. The lagoon recorded mean pH and conductivity values of 6.32± 2.20 and 87.31 ms/cm±19.14 respectively. Nutrient and organic matter were found to be the most frequent cause of pollution of the lagoon with mean sulphate, nitrate and phosphate concentrations of 11852 mg/l±2915.08, 2905.71 mg/l±616.52 and 487.14 mg/l±257.02 respectively. Iron (Fe) and aluminum (Al) recorded the highest concentration of 13.2 mg/l±3.47 and 13.6 mg/l± 4.29 respectively in water sample. Fish sample revealed calcium and potassium as having the highest concentration of 15709 mg/kg±75.35 and 5999.94 mg/kg±87.30 respectively with sodium and aluminum recording 3775.70 mg/kg± 24.80 and 708.47mg/kg ± 4.95 respectively. The results as compared to the WHO guidelines indicate that the Lagoon is highly contaminated.

Keywords: *Kpeshi lagoon, nutrients, trace metals.*

INTRODUCTION

Lagoons are shallow coastal bodies of water separated from the ocean by a series of barrier islands which lie parallel to the shoreline. Inlets, either natural or man-made, cut through barrier islands and permit tidal currents to transport water into and out of the lagoons. Because lagoons are characteristically shallow, they are strongly influenced by precipitation and evaporation, which results in fluctuating water temperature and salinity. Lagoons can also be fragile ecosystems susceptible to pollution effects from municipal, industrial and agricultural runoff.

Lagoons are classified into 3 main types: leaky lagoons, choked lagoons, and restricted lagoons. Leaky lagoons have wide tidal channels, fast currents and unimpaired exchange of water with the ocean. Choked lagoons occur along high energy coastlines and have one or more long narrow channels which restrict water exchange with the ocean. Circulation within this type of lagoon is dominated by wind pat-

terns. Restricted lagoons have multiple channels, well defined exchange with the ocean, and tend to show a net seaward transport of water. Wind patterns in restricted lagoons can also cause surface currents to develop, thus helping to transport large volumes of water downwind (Kjerfve 1986).

Lagoons are very important water bodies providing habitat for a wide range of flora and fauna. It provides a source of plant generic materials for research work (Ansah-Asare, *et al.*,1998). Lagoons and the vegetations that occur in them also improve evaporation and transpiration and thereby help stabilise the climate of the areas around them. Vegetation such as mangrove and forested wetlands also serve as wind-breaks and help to dissipate the force and impact of coastal storm surges (Dugan, 1990).

In Ghana, coastal wetlands are also centres for economic activities as they provide the environment for salt wining, fishing and vegetable growing.

Existing literature reveals that urbanization, high population growth, fuel wood gathering, salt and sand wining are among the major factors threatening mangrove and wetland ecosystems along the coast of Ghana. Some of these sites have come under the pressure of excessive human activity mainly estate development and uncontrolled ground water exploitation in the basins. (Ansah-Asare *et al.*, 2001).

The Kpeshie lagoon, located 11 km East of Accra was originally fed by the sea making the area hydrographic. As a result of increase in population and urbanization, portions of the lagoon have been reclaimed and developed for residential purposes. The aim of this work is to find out the extent to which the activities carried out around the lagoon has impacted on its physico-chemical parameters. The main aim is to determine the physical and chemical parameters as well as some trace metals from the lagoon.

METHODOLOGY
Study area
The Kpeshi Lagoon lies on latitude 5.566 with latitude dimension of 5° 34' 0 N and longitude -0.133 with longitudinal dimension of 0° -8' 0 E (Fig. 1). The lagoon is characteristically located on a low lying plain i.e. between Whitller Baracks corridor, on the eastern side and the La-Trade Fair corridor to the west where it forms a marshy zone. Due to on-going road and bridge construction activities, the lagoon seems to be divided into two with a portion on the other side of the bridge joining the sea occasionally. There is another portion of the water body isolated along the La-Palm-Zenith College road. The wetland covers an area of 22 km^2 and comprises sand dune, open lagoon, marshy lands and scrublands. Due to recent developments, the wetland could be categorised into four sections. The first and second sections extend from La Trade-Fair centre to La-Palm Royal Hotel whereas the third section stretches from Teshie town. The fourth segment extends from Zenith College-Exopa lane. All four sections have various inlets into the lagoon. Unfortunately, the third and fourth sections are currently drying up due to pollution. The first and second have had their own fair share of the pollution but on a small scale compared to the former. Over the years, various educational and entertainment facilities as well as a gas filling station and a washing bay have been constructed around the vicinity. The more prominent constructions include Zenith College, La-Palm Royal Hotel, and Exopa Fashions. Fig. 2 are plates which shows portions of the Kpeshi Lagoon which has been turned to refuse dump through human activities.

A brief survey of the area was done and sampling points selected based on accessibility. Table 1 describes the sampling spots selected.

Hydrometeorology and Hydrological condition
Meteorological data from the Kotoka International Airport, Accra was used for the study. Due to its proximity to the lagoon, the data was
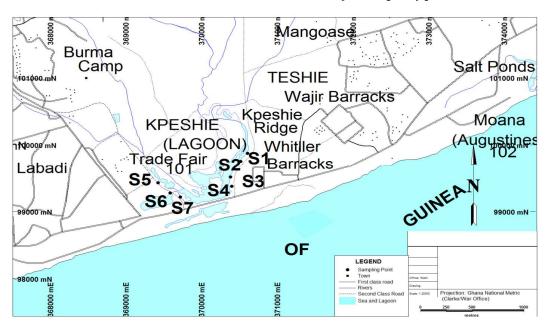
Fig.1: Map of Accra East showing the study area (Kpeshi Lagoon)

not expected to vary much although minor local variations are usually anticipated.

The study area lies in a semi-arid coastal savannah zone with mean annual rainfall of about 800 mm occurring in two rainy seasons. The first season accounts for about 65% of total rainfall and it usually begins in March and ends in late July while the second begins in mid-August and ends in October. Temperature variation is minimal throughout the year with a mean monthly temperature ranging between 24 ^{o}C in August and 28.1 ^{o}C in March.

Pan evaporation data from Accra indicates high evaporation rates occurring between March-April and also October-November with an estimated annual value of 1400 mm. Relative humidity is generally high varying from 65% in the afternoon and up to 95% at night.

Glass Ware
High density 1.5 l plastic containers were pre-treated by washing with acetone to get rid of organic substances such as grease and fat res-

dues. They were then washed with detergent and rinsed with deionised water before they were soaked in 0.1 M nitric acid solution for 48 hours. The containers were rinsed with deionised water and made ready for use.

Sampling Mode
Water samples were collected from the sampling sites using cleaned high density 1.5 l plastic bottles. At the sampling points, the bottles were lowered into the lagoon at a depth of about 30 cm below the water surface. Water samples for dissolved oxygen analysis were collected separately into 300 ml plastic BOD bottles. The dissolved oxygen was fixed on the spot by adding 2ml each of $MnSO_4$ and alkali-azide-iodide solution. Samples for Biochemical Oxygen Demand (BOD) were collected into other 300 ml plastic bottles for subsequent incubation. Samples were stored on ice pack in coolers and transported to the laboratory.

Experiments
Standard methods prescribed in American Public Health Association (APHA, 1998) and Env-

Fig. 2: Plates showing various sections along the lagoon

Table 1: Description of sampling points

Sampling point code	Location
S1	Up stream site 1 before bridge from Accra
S2	Up stream site 2 outlet from Labadi Hotel
S3	Up stream site 3 before bridge from Teshie
S4	Down stream 4 before bridge from Teshie
S5	Down stream 5 gas station outlet
S6	Down stream 6 outlet from Exopa Burg
S7	Down stream 7 opposite La-Palm Hotel

ironmental Protection Agency (EPA, 1983) were used to analyse water samples at the Chemistry Laboratories of the Ghana Atomic Energy Commission. All analyses were done in triplicates to ascertain reproducibility and quality assurance. The pH, temperature, conductivity and total dissolved solids (TDS) were determined on site. Portable Hach pH meter calibrated with buffers 4, 10, and 12 was used for the pH readings. Calibrated Portable Hach Sension 5 conductivity meter was used to measure the temperature, conductivity and total dissolved solids in the water. Alkalinity and total hardness were determined by titrimetric method and chloride was determined by the Mohr Argentometric method. Sulphate, phosphate and nitrate were determined by colorimetric method using colorimeter (HACH DR/890). Flame emission photometric method was used to determine sodium and potassium. Trace metals were analysed by flame atomic absorption spectrometer (Perkin 3110). The open reflux titrimetric method and Winkler's azide modification methods were used for chemical oxygen demand (COD) and dissolved oxygen (DO), respectively. Biochemical oxygen demand (BOD) was also determined using Winkler's azide modification method. The bottles with the water samples were incubated at 20 ^{o}C for 5 days. The difference between the dissolved oxygen obtained for day 1 and that on day 5 constitute BOD.

Sampling and Preparation for Fish Sample
Fish samples freshly brought to the shore of the lagoon were obtained from the fishermen. They were put into labelled polyethylene bags. The samples were transferred into a thermo-insulated box, kept on ice, transported to the laboratory and stored in a deep freezer at a temperature of 4°C. Fish and water sample collection was done weekly between the periods of December 2008 to January 2009.

Fish samples were washed several times with de-ionized water to clean them from sand and other entangled materials. The fish samples were cut into pieces with stainless steel knife into petri-dishes and kept in a deep freezer for about 48 h. The samples were then removed and freeze-dried using the freeze dryer (Christ freeze dryer) for 72 h. They were then ground and homogenized using a blender. Fish samples each weighing 200 mg was packaged into a polyethylene foil and wrapped with an ultra-clean polyethylene foil.

Sample Irradiation Counting and Analysis
Prepared samples and standards were irradiated using Ghana Research Reactor -1 (GHARR-1) facility at the Ghana Atomic Energy Commission. The reactor was operated at a half power

of 15 kW and at a thermal neutron flux of 5×10^{11} ncm^{-2}s^{-1}. The capsules were sent into the inner irradiation sites of the reactor by means of a pneumatic transfer system operating at a pressure of 0.25 atm. The irradiation time, decay time and counting time were chosen according to the half-life of element of interest. Irradiation times were 2 min, 1 h and 6 h with corresponding cooling times of 1 min, 24 h and 30 days respectively prior to counting. Samples and standards were irradiated and counted under same conditions. Counting of irradiated samples and standards were done using a PC-based gamma-ray spectroscopy system.   Accuracy and precision of the analytical techniques were assessed by the simultaneous activation of certified standard reference materials NIST-SRM 1566 Oyster tissue and NIST SRM 1547 Peach leaves.

RESULTS AND DISCUSSION
Hydrochemistry

The study shows that the electrical conductivity of the lagoon varied between 54.8 mS/cm and 114.6 mS/cm with mean value of 87±19.14. The pH values varied between 1.42 and 7.87 with mean value of 6.32±2.20. The highest pH of 7.87 was mainly due to the proximity and influence of the open ocean which normally has a pH range of 7.7 to 8.1 (WRC, 2003). In a lake or pond, the water pH is affected by its age and the chemical discharge by communities and industries (WRC, 2003). They become acidic with time due to the built up of organic material. As organic substances decay, carbon dioxide forms and combines with water to produce a weak acid called carbonic acid. Large amount of carbonic acid lowers the pH. This was clearly demonstrated at sampling point S7.

Results from the study indicate high level of total dissolved solids (TDS), with mean value of 38.43±8.43 mg/l. The values exceed the recommended level of 0.5 g/l (US EPA, 2012) for aquatic life. Therefore aquatic life may suffer under these conditions

A high value for TDS was recorded for sampling points S1 and S6 resulting in an increase in turbidity at these points.

Sampling points S4 and S6 recorded the highest values of 45.4 g/l and 50 g/l respectively. These sites were located in highly populated residential areas. Effluents from domestic, municipal and small scale industry are suggested to have contributed to the enhanced TDS levels. The electrical conductivity (EC) of the water gradually increased up stream and then declined downstream. Two exceptions were reported for S3 and S6. Their conductivities vary between 74.6 mS/cm and 114.6 mS/cm. The conductivities of most fresh waters range from 10 to 1000 µS/cm (Chapman, 1992.). Alkalinity values ranged between 400 mg/l and 2000 mg/l with mean value of 1057.14±499.52. High HCO$_3^-$ alkalinity can only exist in the presence of Na$^+$ dominance.

Alkalinity is important for fish and aquatic life because it protects or buffers against pH changes and makes water less vulnerable to acid rains. Water plants need light for photosynthesis. If suspended particles and dissolved solids block out light, photosynthesis and the production of oxygen for aquatic life would be reduced.

All seven locations measured nitrate levels above the limit of 10 mg/l recommended by WHO (WRC, 2003).

Nitrite causes a serious illness (brown blood disease) in fish, even though they do not exist for long in the environment (WRC, 2003). More intensive agricultural production, poor drainage, the spreading of animal manure, sewage sludge effluent all contributed to nitrate leaching. The concentrations of phosphate were very high. The natural background level of PO$_4^{3-}$ - P in waters usually ranges from 0.005 – 10 mg/l (WRC, 2003). High phosphorus availability is generally believed to be a critical factor in eutrophication. The recommended limit for sulphate (SO$_4^{2-}$) ion is 250 mg/l for standing and drinking water (US EPA, 2011). The sulphate concentration of the lagoon

Table 2: Values of physico-chemical parameters in the Kpeshi lagoon

Parameter	S1	S2	S3	S4	S5	S6	S7	Mean	Range	Stddev
pH	7.01	6.92	7.27	6.60	7.17	7.87	1.42	6.32	1.42 -7.87	2.20
Temp	31.40	30.20	31.70	30.70	32.10	32.10	33.00	31.60	30.20 -33.00	0.94
cond(mS/cm)	54.80	88.20	74.60	101.80	91.80	114.60	85.40	87.31	54.80-114.60	19.14
TDS (g/l)	24.10	39.90	32.90	45.40	40.00	50.00	36.70	38.43	24.10-50.00	8.43
BOD (mg/L)	6.58	8.74	27.91	9.96	9.35	13.61	27.63	14.83	6.58-27.91	9.09
Alk	800.00	400.00	1000.00	800.00	1200.00	1200.00	2000.00	1057.14	400-2000	499.52
HCO_3	976.00	488	1220.00	976.00	1464.00	1464.00	2440.00	1289.71	488-2440	609.42
Cl	7012.00	10074.00	9550.00	13596.00	9354.00	11528.00	7726.00	9834.29	7012-13596	2228.54
Na	11700.00	15920.00	14660.00	19640.00	14420.00	17920.00	11900.00	15165.71	11700-19640	2934.34
K	510.00	620.00	600.00	980.00	640.00	860.00	500.00	672.86	500-980	180.25
SO_4 (mg/l)	7820.00	12218.00	11702.00	16598.00	11024.00	14184.00	9418.00	11852.00	7820-16598	2915.08
NO_3	3200.00	2020.00	3240.00	3480.00	3440.00	2880.00	2080.00	2905.71	2020-3480	616.52
PO_4	270.00	700.00	880.00	290.00	670.00	240.00	360.00	487.14	240-880	257.02
Mg	184.00	266.00	252.00	364.00	238.00	312.00	190.00	258.00	184-364	64.23
Ca	340.00	320.00	260.00	520.00	240.00	340.00	300.00	331.43	240-520	91.55
turb (NTU)	91.00	14.00	23.00	21.00	16.00	33.00	14.00	30.29	14.00 -91.00	27.59
TSS	97	16	17	23	13	23	13	28.86	13-97	30.33

ranged from 7820 to 16598 mg/l with S1 and S4 having the lowest and highest values respectively.

All seven sampling points recorded high BOD values ranging from 6.5 mg/l to 27 mg/l with mean value of 14.83±9.09 mg/l. This was suggested to be as a result of high input of organic matter from domestic and municipal waste which consumed the oxygen in the water as it decayed. Micro organism present in these waste consume dissolved oxygen in the water, making it oxygen deficient thereby threatening aquatic life.

water (Karikari *et al.*, 2004).

Table 3 shows the concentration of metals in the lagoon with iron having the highest in all the sampling sites.

Table 4 presents the concentration of trace metals in edible muscle of fish caught with cast net from the southern zone of the lagoon. All the metals were above the maximum permissible limits (UK MAFF (Ministry of Agriculture Fisheries and Food), 1998) for fish. Fish from the Kpeshi lagoon are therefore not safe for human consumption with respect to the metals analysed.

Table 3: Values of heavy metal concentration in the lagoon (mg/l)

	S1	S2	S3	S4	S5	S6	S7	Mean	Range	Stddev
Fe	8.40	7.20	13.20	6.00	12.00	3.00	8.20	8.29	3.00-13.20	3.47
Mn	0.60	0.43	0.47	0.41	0.45	1.20	1.28	0.69	0.41-1.28	0.38
Pb	11.60	8.60	6.00	2.00	2.60	1.80	2.10	4.96	1.80 -11.60	3.89
Cr	1.60	1.40	1.80	0.20	1.00	3.00	4.00	1.86	0.20 - 4.00	1.27
Ni	2.80	9.20	6.00	4.00	4.20	4.00	2.80	4.71	2.80 - 9.20	2.25
Cd	0.40	0.42	0.41	0.45	1.00	1.40	0.80	0.70	0.40 -1.40	0.39
Al	6.00	12.00	9.40	13.60	5.60	4.20	1.80	7.51	1.80 -13.60	4.29

Studies carried out in 1968 (EPA, IAB, 1968) on the same lagoon revealed a BOD load of 2.78 mg/l, indicating the intense human activities that have taken place over the last 40 years. Maximum tolerated BOD value should not be more than 20 mg/l (WRC, 2003).

Chloride concentrations for all seven sampling points were considerably high with mean value of 9834.29±2228.54 mg/l. However, maximum level for fresh water aquatic life is 230 mg/l (US EPA, 1988); higher concentration has no adverse effect.

The Kpeshi Lagoon varied considerably in terms of its chemical and physical parameters. Organic matter was the most frequent cause of water quality problem. From Table 2, the ionic dominance of the lagoon was Na>K>Ca>Mg and SO_4>CI>NO_3>HCO_3>PO_4. This did not agree with ionic patterns for most tropical fresh

Table 4: Metals in fish samples

Element	Concentration (mg/kg)
Ca	15709.91±75.35
Al	708.47±4.95
Mg	5171±92.07
Mn	39.28±5.43
V	3.34±0.05
K	5999.94±87.30
Na	3775.70±24.80

CONCLUSION

The results of the study that characterized the Kpeshi lagoon in terms of the physico-chemical properties revealed severe pollution of the lagoon especially with respect to organic matter. The highly polluted sites were those located close to the urbanized, agricultural and industrialized areas. Pollution of this proportion can destroy the aquatic ecosystem of the exposed

sections of the lagoon. The relatively high concentration of nitrate and phosphate as well as the alkaline nature of the lagoon indicated that it was quite eutrophic.

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