Relative microbial strength in the study of sawdust and sewage stimulated contamination of the Lagos lagoon

$Min \sum_{i=1}^{n} w_i$ Ashade Olufemi Olukayode[1], Olumide Adedokun Odeyemi[2], Ogundipe Flora Olubunmi[1] and Okeke Evan[1]

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$$Min \sum_{i=1}^{n} w_i . x_i$$

$$s.t \quad y = A_{n \times n} X_{n \times 1} \geq b_{n \times 1}$$

ABSTRACT

An investigation was conducted to assess the concentration of heavy metals in sediments in four selected locations along Lagos lagoon comprising Iddo, Makoko, Okobaba and Epe zones and correlate the effect of metal concentrations on benthic microbial population vis a vis the open water bacterial population. Physico-chemical analysis revealed that the pH was generally alkaline for all zones with the sediments and areas along the shoreline being higher. The concentration of lead, Iron and Nickel was more in Makoko. Zinc was more concentrated in Iddo, while the value for copper was more in Okobaba sediments. ANOVA analysis shows that mean measurements for all metals across the four locations for sample A, (0.184) and sample B (0.548) had no significant difference at 95% level of significance. For organic nutrients, ANOVA also showed no significant difference for sample A, (0.190) but significant difference for sample B (0.026) across the four areas at 95% significance. The benthic microbial population (bacteria, coliform and fungi) was less than that of surface water. Okobaba had the highest bacterial mean cfu/ml for water and sediment and highest fungal mean cfu/ml for water and sediment while the mean cfu value for coliform is highest in Iddo for water and sediment. The microorganisms isolated and identified were among others *Pseudomonas putida, Citrobacter koseri, Escerichia coli, Enterobacter agglomerans, Neurospora sitophila, Aspergillus niger, Penicillium* sp. The presence of high heavy metals concentrations in sediments and the high nutrient levels increased the BOD and pH thereby reducing the population of benthic microorganisms in the sediments showing that there is high pollution. Heavy metals are of public health significance and pose a threat to the survival of both humans and aquatic life.

Introduction

Water is an indispensable raw material for a multitude of domestic and industrial purposes and occupies more than 71% of the earth's surface. (Fraser, 2010) Virtually all water contains living organisms like bacteria, viruses, protozoa, algae and others. (USEPA, 2013) Some of these organisms may be accidental contaminants which may be parasitic or commensalistic while others are aquatic organisms that normally live in predominantly aqueous environment.

Contaminants are substances released into the environment in sufficient concentration as to produce measurable effects on the soil, water, plants, animals, microbes, materials or human. (Anweiller *et al.*, 2000) The problem of water contamination is more severe in developing countries such as Nigeria especially when undesirable compounds or microbes enter the water and change its quality thereby endangering the balance of the community structure. Polluted or contaminated water contains large amounts of organic matter from feces, sewage, industrial waste and refuse dump. Polluted water can also be contaminated by microbes which utilize organic matter on impure or polluted water in their metabolism.

Heavy metals are also found in polluted water especially in sediments when untreated effluents are discharged from industries into the water body. The metals there rapidly become associated with particulates in the water before being incorporated in bottom sediments (Hanson *et al.*, 1993).

The waste water from homes, industries or communities is collectively called sewage. It contains millions or myriads of microorganisms in a predominantly aqueous medium. Sawdust is unwanted pieces of wood particle that are generated during sawmills processing of wood in saw mills. It is often heaped near carpenter's workshops, burnt or dumped into rivers. Consequently, it blocks the water ways and if burnt, produces very thick smoke with high environmental consequences or hazard. Sawdust has a negative effect on the environment. When sawdust gets into the water body it: increases organic matter load, increased turbidity, reduces dissolved oxygen content, emits foul odor of hydrogen sulphide, enhances fungal and bacterial population, imparts a black or blue-black coloring in the water body presumably caused by lignin and exudates sporadic occurrence of opportunistic species. (Akpata, 1980)

The Lagos lagoon is the largest of the four lagoon systems of the Gulf of Guinea (Webb, 1958). It stretches for about 257km from Cotonou in the Republic of Benin to the western edge of the Niger Delta. The lagoon borders the forest belt and receives a number of important large rivers that is, Yewa, Ogun-Ona and Oshun rivers. Draining more than 103,626km across the country, it empties into the Atlantic Ocean at Cotonou and Lagos. The lagoon opening is far the largest and forms an extensive harbor which serves as the major outlet of freshwater from the lagoon system during the rainy season. (Dosunmu and Ajayi, 2002)

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Aims and objectives
- To isolate and characterize microorganisms present in sewage and sawdust contaminated water.
- To analyze sediments of sewage and sawdust contaminated water for heavy metals.
- To analyze sediments of sewage and sawdust contaminated water for organic matter / nutrient content.

Materials and methodology

Equipment used

Microscopes, Hot air oven, Hot plate and magnetic stirrer, Incubator, Weighing balance, pH meter, Atomic Absorption Spectrophotometer (AAS), Autoclave.

Glasswares used

Petri dishes, Testubes, Pipettes, Conical flask, Beaker, Measuring cylinder, Glass spreader, Glass slides and cover slip.

Media used

Potato Dextrose Agar (PDA), Nutrient Agar (NA), MacConkey Agar

Reagent used

Lactophenol, Ethanol, HACH reagent, Crystal violet, Iodine, Safrannin

Others

Ice packs, Paper tape, Gram staining reagents, Syringes, Cotton wool, Wire loop, Spirit lamp, Aluminium foil, Distilled water, Filter paper, HACH instrument (HACH DR 2000 direct reading spectrophotometer)

Description of sample stations

Sample station 1: Okobaba

Okobaba is a giant timber market in the west. It is a riverine community on the Lagos mainland and is unarguably a point of call for consumers of wood for furnitures, firewood and sawdust. It is a community populated by people from diverse places who come there to make a living through importing, cutting and selling of timber for consumer use. The by-product that results from the cutting of timber is known as sawdust. Most of these wood shavings find their way into the Lagos lagoon causing pollution.

Sample station 2: Iddo

Iddo is located on the Lagos Mainland and is accessible to Mushin, Yaba, Ebute- Metta, Surulere and so on. It is a faeces disposal point near the Carter Bridge on the mainland end. The rationale for disposal of raw faeces into the Lagos lagoon at Iddo was that the waste would be washed into the sea and diluted to extinction such that the waste would not be seen and there would be no visible or apparent impact on the aquatic ecosystem. It mostly comprises of sewage contaminants.

Sample station 3: Makoko

Makoko a fishing community is a slum neighbourhood located in Lagos, Nigeria. Established in the 18th century primarily as a fishing village, much of Makoko rests in structures of stilts above the Lagos lagoon. Makoko has a mixed contaminant of sewage and sawdust because it is found in between Iddo and Okobaba.

Sample station 4: Epe

Epe, is relatively not contaminated as much as the other lagoons. It is also a fishing community located on the outskirts of Lagos. Aside from fishing boats, transport boats are found on the lagoon transporting travelers to various places such as Ogun state, Lagos Island, Oyo state and Osun states.

Sample Collection

Sample collection was done during the month of July which was a rainy season. Water and sediment samples each of two points A and B were collected from each location. Point A is the area closer to the shore line while point B is the area farther away from the shore line. Water samples and sediments were collected in plastic sample bottles. The plastics were thoroughly washed to avoid contamination of samples. A total of 16 samples were collected from the four locations, that is, 4 samples from each location which is the water and sediment of point A and the water and sediment of point B of that location. Subsequent concentrations of the different parametric indices were then analyzed.

Methods

The pH of each sample was determined using the pH meter. The BOD was also determined. This is the quantity of oxygen required by bacteria and other microorganisms during the biochemical degradation and transformation of organic matter present in waste water under aerobic conditions over a five day period. The BOD of a sample is the DO of the first and fifth day.

Microbiological analysis of water and sediment was carried out using serial dilution. 0.1 ml aliquot of the 10^{-1}, 10^{-2} and 10^{-4} dilutions of the water and stock, 10^{-2} and 10^{-4} dilutions of the sediment was plated on three different media for growth using the spread plate method. The Nutrient agar and maconkey plates were incubated at 37°C for 24 hours for bacterial growth while the Potato dextrose agar plates were incubated at 27°C for 3-7 days for fungal growth.

The shape, size, pigmentation, elevation and marginal characteristics of the bacterial, fungal and coliform bacterial species were examined on agar plates after incubation and recorded. Distinct colonies were then sub-cultured separately into fresh plates to get pure cultures of organisms. The pure cultures of the bacterial isolates were then gram stained and preserved on slants for biochemical analysis while the fungal isolates were stained with lactophenol and viewed microscopically. The biochemical tests carried out were catalase, oxidase, voges proskauer's, indole, urease, methyl red test, gelatin hydrolysis, starch hydrolysis.

Heavy metals of the samples were analyzed using Atomic Absorption Spectrophotometer (AAS). The Results was then presented as mean ± SD. Analysis of Variance (ANOVA) and the student t-test was used for the statistical analyses of results obtained at 95% confidence level using Microsoft Excel 2007 package.

HACH instrument was also used to analyze for the various organic nutrients.

Results and discussion

Results

The following were the results obtained from the four sites with Epe lagoon used here as control site.

Table showing the relationship between the pH of water and sediments for all locations

Sample	A	B	Mean	Std. Deviation
Iddo water	9.1	9.3	9.20	0.1414
Iddo sediment	12.9	10.3	11.60	1.8385
Makoko water	8.8	8.8	8.80	0.0000
Makoko sediment	9.7	9.0	9.35	0.4950
Okobaba water	8.9	9.0	8.95	0.0707
Okobaba sediment	9.5	9.1	9.30	0.2828
Epe water	8.5	8.0	8.25	0.3536
Epe sediment	9.0	8.8	8.90	0.1414

From the table above, the standard deviation between A and B was not high except for Iddo sediment which had a significant value of 1.8385. A noticeable phenomenon among all the samples is their alkaline content. Epe water (B) was slightly alkaline with a value of 8.0 while Iddo sediment A had a peak value of 12.9. There was no difference between the values

obtained for Makoko water A and B. The values for areas along the shoreline (A) were greater than areas farther away from the shoreline (B) for all samples except Iddo and Okobaba water where B was greater than A.
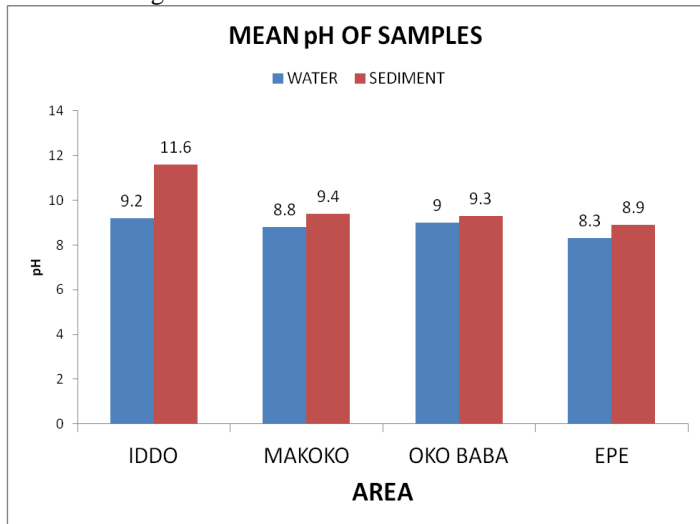

Figure 1: **Graph showing the mean pH of samples of the four locations**

The figure above shows that the sediment had higher pH values than the water. Iddo sediment has the highest alkaline content with 11.6 while Epe water has the lowest with 8.3.

Table showing heavy metals and organic nutrients present in the sediments of the various lagoons in mg/l

Sample	Ni	Fe	Pb	Zn	Cu	SO_4	NO_3	PO_4	NH_4
Okobaba A	0.07	0.20	0.08	0.25	0.26	13.40	14.50	3.40	ND
Okobaba B	0.06	0.14	0.05	0.27	0.13	7.80	6.90	2.70	ND
Iddo A	0.10	0.13	0.08	0.31	0.22	12.30	9.60	8.80	ND
Iddo B	0.09	0.09	0.04	0.27	0.22	11.60	8.90	5.70	ND
Makoko A	0.11	0.26	0.10	0.22	0.22	12.70	12.70	6.10	ND
Makoko B	0.11	0.11	0.03	0.21	0.15	10.11	8.80	3.90	ND
Epe A	0.09	0.11	0.06	0.22	0.16	9.10	9.10	1.96	ND
Epe B	0.09	0.09	0.04	0.18	0.17	8.90	5.70	4.60	ND

Note:

ND- Not detected   Ni- Nickel Zn- Zinc SO_4- Sulphate PO_4- Phosphate

Fe- Iron   Pb- Lead   Cu- Copper NO_3- Nitrate NH_4- Ammonia

The average concentrations of heavy metals are as follows in these sites in descending order:

Nickel: Makoko> Iddo> Epe> Okobaba
Iron: Makoko> Okobaba> Iddo> Epe
Lead: Makoko> Okobaba> Iddo> Epe
Zinc: Iddo> Okobaba> Makoko> Epe
Copper: Okobaba> Iddo> Makoko> Epe
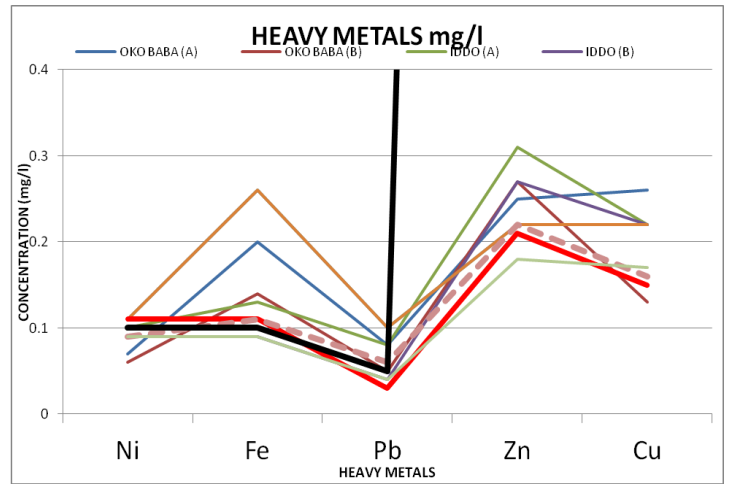Sulphate: Iddo> Makoko> Okobaba> Epe
Nitrate: Makoko> Okobaba> Iddo> Epe

Figure 2a: **Linegragh showing the concentration of heavy metals for Iddo, Makoko, Okobaba and Epe.**

Phosphate: Iddo> Makoko> Okobaba> Epe
Ammonia: Not detected
Comparison with Environmental Protection Agency (EPA) standard

Nickel- 0.02- 0.1 mg/l
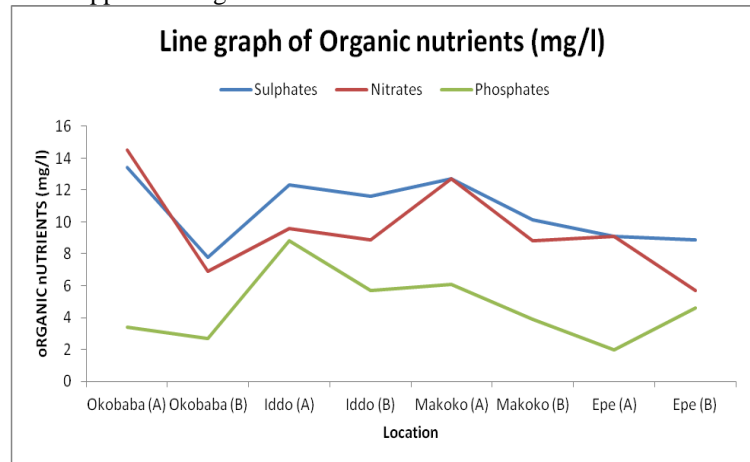Lead- 0.05 mg/l
Iron- 0.10 mg/l
Zinc- 5.0 mg/l
Copper- 1.0 mg/l

Figure 2b: **Linegragh showing the concentration of organic nutrients for Iddo, Makoko, Okobaba, Epe.**

Nickel concentrations in Okobaba, Iddo and Epe was observed to be within the range of the acceptable contaminant level according to EPA standard of 0.02 - 0.1 mg/L except for Makoko showing a average value of 0.11 mg/L. The concentrations of lead obtained from all the samples analyzed were quite high especially in sample A of the four zones, that is, close to the shoreline. The highest being Okobaba and Makoko, with an average of 0.07 mg/L. The EPA maximum contamination level is 0.05 mg/L. Only Epe which is the control site falls within that range. The values of Iron obtained for all samples are above upper allowable limits, which is EPA 0.10 mg/l except for Epe (control site). Zinc and Copper concentrations in all samples fall below the EPA acceptable maximum of 5.0 and 1.0 mg/L respectively. Organic nutrients analyzed (sulphates, nitrates and phosphates) were high for the four sites although ammonia was surprisingly not detected because it was present at very low concentrations.

Table showing the Relationship between the Biological Oxygen Demand (BOD) of the water samples (A and B) for all zones in mg/l

Zones	A	B	Mean	Std. Deviation
Iddo	35.0	34.0	34.50	0.7071
Makoko	47.0	46.0	46.50	0.7071
Okobaba	33.0	38.0	35.50	3.5355
Epe	32.0	37.0	34.50	3.5355

Generally, the BOD was high for all zones, with the highest zones being Makoko, 46.50. The standard deviations of A and B in Okobaba and Epe were significantly high (3.5355) as compared with that of Iddo and Makoko (0.7071).
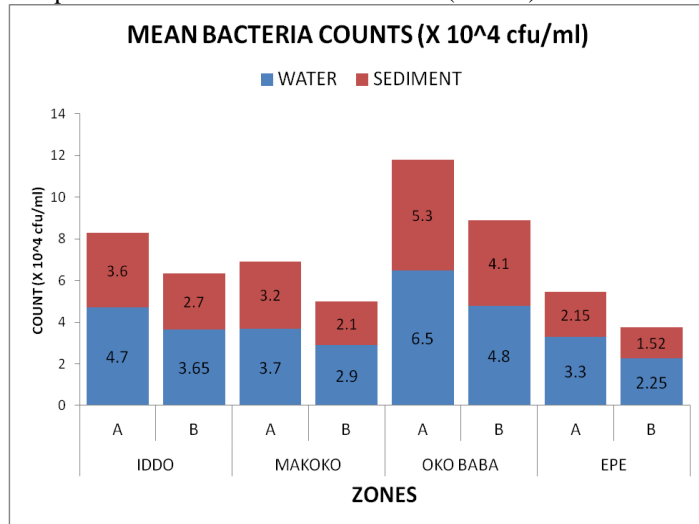
Figure 3: Graph showing the mean bacteria count for water and sediments of all locations.

From fig.3 above, Okobaba has the highest number of mean bacteria count for both water and sediment along the shoreline (6.5 and 5.3 x 10^4 cfu/ml) and farther away from the shoreline (4.8 and 4.1 x 10^4 cfu/ml) followed by Iddo A (4.7 and 3.6 x 10^4 cfu/ml) and Makoko A (3.7 and 3.2 x 10^4 cfu/ml) while the least is Epe B (2.2 and 1.52 x 10^4 cfu/ml).
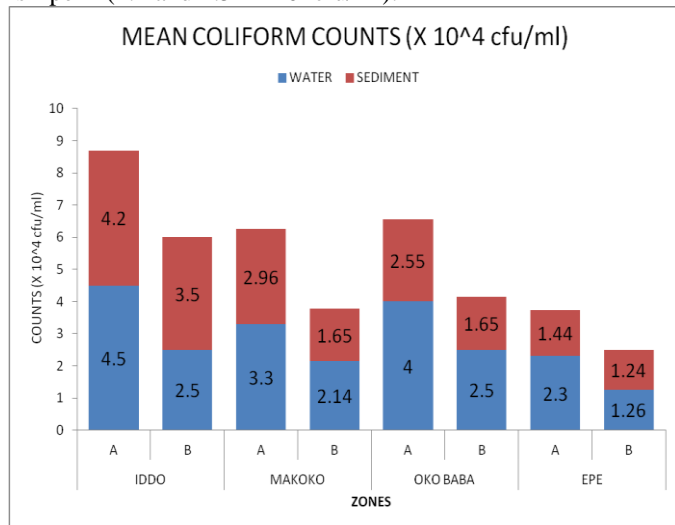
Figure 4: Graph showing the mean coliform count for water and sediment of all locations

Coliform bacteria were present more in Iddo water and sediment closer to the shore line (A) with values of 4.5 and 4.2 x 10^4 cfu/ml followed by Okobaba water A, 4.0 x 10^4 cfu/ml and Iddo sediment B, 3.50 x 10^4 cfu/ml while the least is found in all samples of Epe.
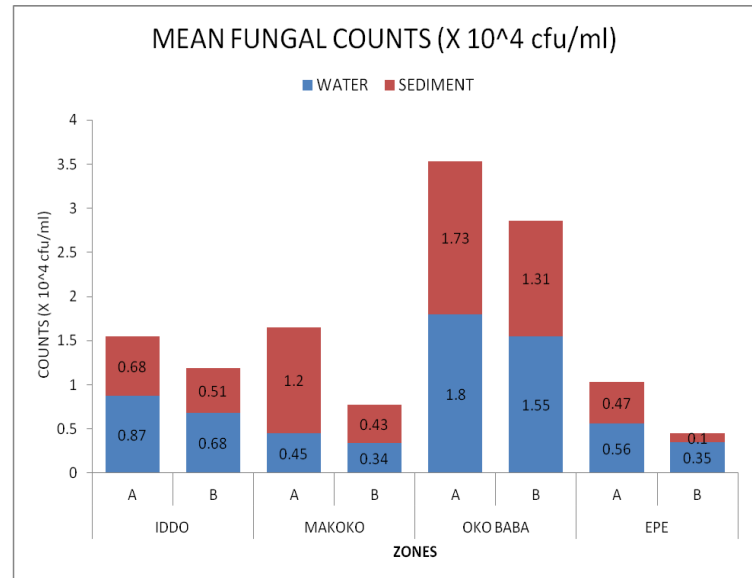
Figure 5: Graph showing mean fungal count for water and sediments of all locations.

This graph shows that all samples of Okobaba had the highest fungal count for sample A (1.8 and 1.73 x 10^4 cfu/ml) and sample B (1.55 and 1.31 x 10^4 cfu/ml) while the least was Epe B (0.35 and 0.1 x 10^4 cfu/ml) and Makoko B (0.34 and 0.43 x 10^4 cfu/ml).

Table showing bacterial and fungal isolates present in the four sites of the Lagos lagoon.

Sample	Bacteria	Fungi
Iddo water A	*Bacillus megaterium, Citrobacter koseri*	
Iddo water B	*Pseudomonas putida, P.pseudomallei, P.stutzeri, E.coli*	*Rhodotorula graminis*
Iddo sediment A	*B.megaterium, P.pseudomallei, P.stutzeri, Klebsiella ozaenae*	
Iddo sediment B	*P.pseudomallei, C.koseri, E. coli, P.putida*	*Sporothrix schenkii, Neurospora sitophila*
Makoko water A	*C.koseri, P.putida*	*Neurospora sitophila*
Makoko water B	*P.pseudomallei, C.koseri, Enterobacter agglomerans, P. stutzeri*	
Makoko sediment A	*Enterobacter cloacae, E.agglomerans, K.ozaenae*	*A.niger*
Makoko sediment B	*K.ozaenae, C.koseri, P. aeruginosa*	*Alternaris altenata, Aspergillus niger, R.graminis*
Okobaba water A	*P.pseudomallei*	*Geotrichum candidium*
Okobaba water B	*P.putida, C.koseri, P. aeruginosa, B.megaterium, P.stutzeri*	*Cephalosporium spp., A.niger*
Okobaba sediment A	*B.megaterium, E.agglomerans*	*Cephalosporium spp., Penicillium fellutanum*
Okobaba sediment B	*K.ozaenae*	*A.niger*
Epe water A	*B. subtilis, K.ozaenae, P. pseudomallei*	*Sporothrix schenkii, Monosporium apiospermum, Penicillium restrictus*
Epe water B	*E.agglomerans, K.ozaenae, P.pseudomallei*	
Epe sediment A	*P.putida*	
Epe sediment B	*P.pseudomallei, P.aeruginosa*	

Since Makoko is in the middle of Iddo and Okobaba and has a measure of sewage and sawdust contaminants, it is not

surprising that Fungi like *Neurospora sitophila*, *A. niger* and *R. graminis*; Bacteria like *C. koseri*, *P. putida*, *P. pseudomallei*, *E. agglomerans*, *K. ozaenae* and *P. aeruginosa* were all present in Makoko, Iddo and Okobaba. Bacteria that are common in all zones are *P. putida*, *P. pseudomallei* and *K. ozaenae*. *E.coli* was found only in Iddo and *B. subtilis* in Epe. Fungi like *G. candidium*, *P. fellutanum* were found in Okobaba, *M. apiospermum* in Epe and *A. altenata* in Makoko.

Discussion

Generally, the obtained pH values fall above the World Health Organization's standard of 7.0 to 8.5 for drinking water and the water quality range of 6.5 to 8.5 for water meant for full contact recreation (DWAF, 1996b; WHO, 1984; 1989). The EU also sets pH protection limits of 6.0 to 9.0 for fisheries and aquatic life (Chapman, 1996). From figure 4.1 above, only Epe water falls within the range with pH 8.3. Epe sediment and Okobaba water were fairly okay based on EU standards with 8.9 and 9.0 respectively.

Anderson (1987) reported that the toxicity of heavy metals occur when present in superabundance. Allochthonous and autochthonous influences could make concentration of heavy metals in the water high enough to be of ecological significance. Moreover, bio-concentration and magnification could lead to toxic levels of these metals in organisms, even when the exposure level is low.

The ANOVA results for samples A and B with P- values of 0.184 and 0.548 respectively showed no significant difference in the heavy metals across the four areas at 95% confidence level (with P<=0.05 showing significant difference). Also, for organic nutrients, sample A showed no significant difference but sample B showed significant difference across the four areas at 95% confidence level.

The results obtained from this analysis revealed a high presence of Nickel, Lead and Iron which were above the upper permissible limits. When heavy metal is in excess, it can denature enzymes thus inhibiting microbial metabolism. This is comparable to what Uaboi-Egbenni et al. (2010) did on sediments of University of Lagos, Okobaba and Ijora zones in which concentrations of Iron and Lead were found to be the highest of the heavy metals analyzed and Okobaba also had the highest concentration among the three zones.

In this study also, Zinc and Copper fall below the maximum allowable concentration which is also comparable to the work done by Chimezie et al. (2011) on pharmaceutical effluents in nine companies in Nigeria with a high concentration of Nickel and Lead but low concentration of Zinc for all samples. The results obtained from O. U. Ezeronye et al. (2005) and the results obtained in the Niger Delta waters by Kakuku. (1985) had a low concentration of Zinc and copper and high levels of Lead and Iron. The low levels of metals determined could be ascribed to dilution, sedimentation and depuration.

Nitrate is an essential nutrient but at high concentration, becomes toxic and is capable of disturbing the aquatic environment but nitrate level less than 0.5ml/l will not pollute the water. The high organic nutrient levels in the areas along the shore line may be as a result of diffuse sources from settlement and agricultural runoff especially because the sample was collected during the rainy season.

The high sulphur content is an indication of the strong foul odour at the mill station in Okobaba and at the lagoon sites early in the morning suggestive of the presence of hydrogen sulphide gas.

Biological Oxygen Demand (BOD) is the measure of the oxygen required by microorganisms whilst breaking down organic matter. The BOD test measures the oxygen demand of biodegradable pollutants. Biological Oxygen Demand was higher in Makoko and areas along the shore line. This may be due to metabolic activities of bacteria, which shows that the water is highly polluted. The results of the pollution of Okobaba is due to the wood shavings from the sawmill plants that find their way into the Lagoon.

The average bacterial population in the control sample (water) and areas along the shore line was more for all the zones as compared with what was obtained for the sediments and areas farther away from the shoreline in all zones. This is in line with the work done by Uaboi-Egbenni et al. (2010). The variation in the population of benthic bacteria in the Lagoon water column as observed in this study may be ascribed to the concentration of heavy metals in the sediments and areas along the shore line. Often the inhibitory effect of heavy metals is a common phenomenon that occurs in the biological treatment of waste water and sewage (Filali et al., 2000). It could also be as a result of dilution enhanced by the season (rainy). Low microbial density observed at the sediments could also be as a result of the higher pH which can make the hydrolyzed speciation forms of the metals bind to the surface of the microorganisms and alter the net charge of the cell.

From the figure 5 above, all samples of Okobaba had the highest fungal count which is not surprising as fungi are required for the degradation of sawdust. The fungi isolated from Okobaba are well known wastes degraders like *Penicilium sp.* and *Aspergillus sp.* (Eze and Okpokwasili, 2010). The presence of these fungal isolates should be of concern to avoid the outbreak of gastro enteritis and aspergillosis. This is in comparison with the work done by J. A. Lennox et al. (2010) who isolated bacteria like *Pseudomonas* and *Bacillus* species from sawdust and fungi like *Penicillium* and *Aspergillus* species and concluded that these isolates are able to utilize sawdust as its source of carbon and energy for growth. This corroborates the findings of Godliving and Yoshitoshi (2002) that bacteria and fungi degrade wood sawdust. Nwodo-Chinedu *et al*. (2005) and Ibok. (2012) also isolated Aspergillus and Penicillium species from Okobaba.

It was also observed that some organisms found in Epe were also common in other zones which could be as a result of movement of the water during the rainy season.

The presence of Enterobacter shows that the water has been contaminated at some time. The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated recently with the fecal material of man or other animals with a high probability of the presence of pathogens in the water. The presence of *Enterobacter species*, *Escherichia coli* and *Klebsiella* indicates the possibility of fecal contamination of the sawdust waste which was also confirmed by Ibok. (2012). this could have been enhanced by unhygienic practices and well as poor sanitary conditions generated by sawmill processes (Deeble and Lee 2007).

The result obtained from the study stations shows that the area is polluted. Pollution of the Okobaba area of the Lagos Lagoon is mostly from the sawmill plant, the sawmill station has large quantity of wood shavings from logs, domestic sewage and debris thrown in by food vendors, hawkers and inhabitants around the area. Pollution of the Iddo and Makoko area of the Lagos lagoon is as a result of the fishing, domestic and even

industrial activities going on while Epe lagoon is less polluted as a result of the reduced human activities.

Conclusion and Recommendation

Water is essential for sustainability of life. Unfortunately, the degradation of water is largely by human activities that impede the natural ability of quality autochthonous microbes to effect self purification of water. The analysis has shown High presence of heavy metals above the upper permissible limit, low bacterial population in the sediments as compared to the water, high pH values especially at the sediments, high BOD and high nutrient levels. The inference which can be derived from the analysis is that the low microbial density observed could be as a result of the concentration of heavy metals, dilution because of the season, high nutrient levels which then increased the pH and BOD in these sites. The presence of all these shows that there is high pollution in these sites which are of public health significance and pose a threat to the survival of microorganisms.

Recommendation

Based on the research done in this study, I hereby recommend that:

1. Combustion of vehicles and generating sets especially at urban centers should be controlled to reduce the buildup of Lead.

2. Battery workshops or galvanized iron sheets should not be close to the lagoon to avoid the inflow of Lead.

3. Government agency should control illegal disposal of sawdust and sewage to avoid water pollution, environmental and air pollution.

4. By enforcing strict laws on indiscriminate disposal of refuse and sewage into the Lagoon by the inhabitants and dwellers of Makoko and Iddo community.

5. Since high heavy metal concentration may pose adverse consequences on health and environment, there is a need for government to enforce effluent treatment to reduce such environmental and health risks.

6. There is need for the intervention of appropriate regulatory agencies to ensure production of high quality treated final effluent by waste water treatment facilities.

7. Human activities should be reduced in these lagoons especially by relocating those living around the lagoon so as to reduce pollution.

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