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Evaluation and risk assessment of heavy metals in wetland soil in the University of Lagos

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Abstract

A study was conducted to evaluate the concentration of heavy metals, and the physicochemical and microbiological properties of wetland soils at the University of Lagos. Soil samples were randomly collected from the Faculty of Science (FSC), Lagoon Front, and Distance Learning Institute areas at depths of 5 cm, 10 cm, 15 cm, and 20 cm using a soil auger. The samples were stored in sterile nylon bags, appropriately labelled, and transported to the University of Lagos Central Research Laboratory for chemical analysis. The physicochemical characteristics measured included soil pH, determined using a pH meter, and moisture content, assessed through the oven-drying method. Heavy metal concentrations were analyzed using an Atomic Absorption Spectrophotometer. Microbial population diversity was examined using the disc diffusion method. Statistical analysis was performed using SPSS version 20, and mean values were evaluated using Tukey's multiple comparison test at a probability level of $P < 0.05$.

The results revealed that soil pH ranged from 7.20 to 8.81, with the highest value (8.81) recorded near the Faculty of Science (FSC-3). Eight heavy metals, including Pb, Ni, Cr, Cd, Fe, Cu, Mn, and Zn, were analyzed. Lead concentrations ranged from 0.02 to 0.29 ppm, followed by nickel, which ranged from 0.01 to 0.13 ppm. Chromium ranged from 0.0 to 0.25 ppm, cadmium from 0.03 to 0.08 ppm, iron from 1.02 to 2.96 ppm, copper from 3.31 to 4.60 ppm, manganese from 3.31 to 5.16 ppm, and zinc from 1.67 to 9.17 ppm. Lead and zinc concentrations were found to be below the permissible limit at all locations, while chromium and cadmium were within permissible limits. However, Zn, Mn, Cu, Fe, and Ni exceeded the permissible limits. Correlation analysis revealed a significant correlation ($P < 0.05$) between Pb and Zn, likely due to effluents from human waste and seepage from nearby dumpsites into the lagoon, streams, or beaches.

The isolated microbial flora included three bacterial genera, *Bacillus megaterium*, *Bacillus spp*, and *Enterobacter spp*, as well as four fungal genera, *Aspergillus*, *Penicillium*, *Aspergillus flavus*, and *Fusarium*. Bacterial counts were lower than fungal counts in polluted soils, likely due to the nutrient status of the soil. The isolates were found to be tolerant to slightly alkaline pH and heavy metal pollutants, with microbial variation attributed to the impact of pH and heavy metals on the microbial population.

Keywords: Wetland soil; Heavy metals; Microbial diversity; Physicochemical properties; Pollution

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1. Introduction

Nigeria is richly endowed with large numbers of wetlands ecosystem and the Lagos lagoon has been identified as one of the fourteen major wetland belts in the country [1, 2]. Wetlands are very important subsystem of the general ecosystem because of the functions and services that it provides to human society and its vital roles in the sustenance of both surface and ground water resources of the earth [3, 4]. The functions and services that wetland ecosystems provide to human society have been widely recognized. Some of the notably functions of wetlands include flood control, groundwater recharge, coastal protection, sediment traps, atmospheric equilibrium and waste treatments [3, 5]. However, the increasing intensity of agricultural activity, urbanization and industrialization have led to increase in pollution from landfill leachates, industrial effluents, vehicular emissions, fossil fuels, fertilizer erosion from agricultural run-off, herbicides and pesticides, sewage and municipal wastes. All these contributed to the accumulation of pollutants in wetland systems [6, 7]. Among the worst environmental contaminants are the heavy metals [8]. They are serious pollutants due to their toxicity, persistence in natural conditions and ability to be incorporated into food chains [9,10]. Studies by [11] have shown the risk of heavy metal pollution in wetland soils gradually increases, as these pollutants are toxic and slow to degrade and this may lead to serious environmental problems that may have severe noxious effects on living organisms. The accumulation of heavy metals in soils reduces environmental quality and threatens human health. As a consequence, heavy metal pollution of wetland soils is attracting increased attention [12, 13]. Therefore, it is necessary to understand the distribution characteristics of heavy metals in wetlands, their pollution risks and sources, and to take effective measures to protect the health of wetland ecosystems [14].

Heavy metals like Copper (Cu) and Zinc (Zn) are essential metals for plant growth and productivity However, plants may accumulate toxic heavy metals like Pb, Cd, Hg, Cr, Ni, and as present in soil water [15, 16]. These "pollution elements" are produced through modern urban, industrial, and agricultural processes [17, 18]. In wetland systems, heavy metals are concentrated in sediments via adsorption and precipitation, and are transported and enriched in the food chain through biological absorption. At the same time, when external conditions are suitable, the heavy metals in wetland sediments are released into soils and water in the form of secondary pollutants [17]. Therefore, the heavy metal content of sediments is often used as an important reference indicator for judging the environmental quality of wetlands.

The University Wetland is a rare marsh wetland in Lagos. The wetland plays important role in water storage regulation, replenishing groundwater, maintaining regional water balance, regulating climate, purifying the environment, and supporting biodiversity [19, 5]. However, due to the dual function of the wetland for both nature and human use, in recent years this environmental 'treasure trove' has become increasingly degraded [20, 21]. Natural and anthropogenic sources of pollution can enter the low-lying wetlands, accumulating and contaminating the soil, and affecting the wetland organisms [22]. Existing research on heavy metal pollution in different wetland ecosystems show that the degree of heavy metal pollution varies between wetland types and the potential ecological risk of heavy metals in wetlands becomes progressively enhanced [23, 24]. With respect to significant cumulative bio toxicity and persistence, heavy metals pose a potentially serious threat to human health and the environment [22]. Therefore, in view of the importance of this wetland ecosystem and the seriousness of the consequences of its pollution, an accurate analysis of the patterns and sources of heavy metal pollutants in the soils of the University Wetland is urgently needed.

The University wetland is vastly impacted by numerous wastes that posed a stern threat to the communities that largely depends on it for the source of income, especially the masses selling along the wetlands' edge. Wastes of anthropogenic origin often contaminate the wetland [25]. Majority of the debris are largely plastics, nylon bags, empty cans of food and drinks, glass bottles, used needles and syringes etc [26, 27]. Several authors have employed Enrichment Factor, Contamination Factor, Pollution Load Index (PLI) and degree of contamination, geo-accumulation Index, Potential Ecological Risk Index and Potential Contamination Index to evaluate elemental concentrations in the environment. The evaluation of microbial communities and levels of heavy metal level in wetland soil is therefore essential for ensuring soil health and quality [28,29, 30].

The main objectives of this study were: (a) to evaluate the physicochemical properties of wetland soil in the University of Lagos; (b) to assess the composition and levels of heavy metals such as lead (Pb), iron (Fe), cadmium (Cd), zinc (Zn), arsenic (As), mercury (Hg), chromium (Cr), copper (Cu), and nickel (Ni) in the wetland soils; and (c) to determine the microbial population in the wetland soils of the University of Lagos. The study aimed to provide essential data that could inform environmental management and pollution control measures within the university and contribute to broader assessments of wetland pollution in urban areas.

2. Material and methods

2.1. Study area

The University of Lagos, Akoka North, Nigeria, is largely surrounded by the scenic view of the Lagos Lagoon and with an area of 802 acres of land and it lies between latitude 03.2343°E - 03.34554°E and longitude 06.2135°N - 06.4323°N. It is bounded on the North by Bariga, at the South by Onike and Iwaya, the East by Lagos Lagoon and at the West by Yaba.

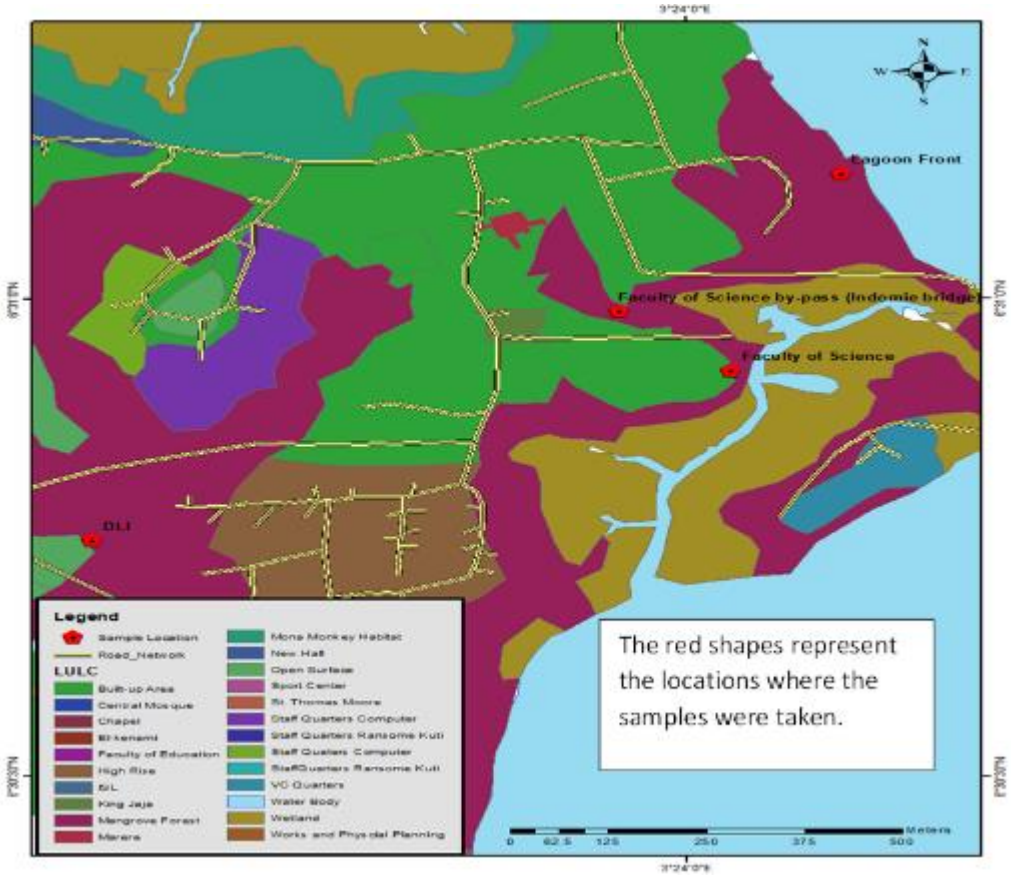


Figure 1 Existing digital map of UNILAG (Source: Department of Geography, University of Lagos)

2.2. Method of data collection

Four plots of land (A1, A2, A3, and A4) measuring 40 m by 40 m within the University of Lagos study area was established. Soil samples were taken at different depths diagonally along the plots at 5 m, 10 m, 15 m and 20 m respectively using soil Augar. Soil samples collected at different depths from a particular location were mixed to form a composite soil. The soil samples were labeled according to the plot from which they were obtained. The samples were collected in clean polythene bags and was sent to the University of Lagos central research laboratory and Federal Institute of Research Oshodi for analysis.

2.2.1. Pictures of sample location

Figure 2 Sample location at Faculty of Science

Figure 3 Sample location at Lagoon front

2.3. Quality control

All measuring instruments were calibrated before they were used following the manufacturers' guidelines. All the soil samples were maintained at 30 0C to control the microbial activity of the soil, until testing. All samples were analyzed within 24 to 48 hours.

2.4. Laboratory methods

2.4.1. Soil Physicochemical analysis

Determination of Moisture

Soil moisture was determined according to [31], 1.5 g of well-mixed sample was accurately weighed in clean, dried crucible (W). The crucible was allowed in an oven at 100-105 0C for 6-12 hours until a constant weight was obtained. Then the crucible was placed in the desiccator for 30 minutes to cool. After cooling it was weighed again (W2). The percent moisture was calculated by the formula:

$$\% \text{ Moisture } = \frac{W - W_2}{W_2} X\ 100$$

Were,

- W = Initial weight of crucible + Sample
- W2 = Final weight of crucible + Sample

Determination of soil pH/ Electrical Conductivity

Soil pH/Electrical conductivity was determined on a 1:1 (Volume/Volume) soil/water mixture composed of a 10 g soil scoop and 10 ml double-deionized water. Samples were stirred both before and after a 15 minutes equilibration period. The pH was measured on a Mettler Toledo Seven-Multi pH meter calibrated to pH buffers 4, 7, and 10.

Determination of Soil pH

The soil pH was calculated by the method of [32]. The pH meter was standardized with a Tris buffer solution every 3 hours of operation. 10 g of soil sample was air-dried and sieved through 2 mm mesh to remove the coarse soil fraction. Then 20 ml of distilled water was added to the soil sample placed into a glass container. The mixture was mixed thoroughly and allowed to stand for 1 hour. The sample were analyzed within 15 minutes after preparation. Temperature of the suspended soil samples were measured by setting the temperature dial on the pH meter to match the measured temperature in 0 0C. The probes were rinsed with distilled water and blotted dry. With the meter on, the electrode was placed in the partially settled sample suspension to be measured and the pH reading taken once the meter had stabilized. The temperature of the sample and calibration buffers was identical to ensure accuracy and the sample temperature was recorded with the pH value obtained.

Determination of soil phosphate content

The method of [45, 46] were used to determine the soil phosphate content. Soil sample (2.0 g) was weighed and 1 teaspoonful of carbon-black was added to the soil and 40 ml of the extraction solution to a 125 ml Erlenmeyer flask containing the soil and carbon black. The flask was shaken for 30 minutes on a mechanical shaker. The suspension was filtered and more carbon-black were added to get a clear supernatant. The filtrate was then used for phosphate determination using the colorimetric method (Ascorbic acid method).

Calculation: the phosphate content can be calculated as follows:

$$\text{Phosphate (ppm)} = \frac{\text{standard concentration}}{\text{Standard Abs}} \text{x} \frac{\text{sample Abs}}{\text{sample weight}} \text{x dilution factor}$$

Determination of total nitrate in the soil

The total nitrate in the soil was determined by the official method of analysis of Association of Official Analytical Chemists [33, 34]. 10 g of soil sample was air dried, ground to pass through 0.5mm sieve. The sample was weighed in a dry 500 ml Macro-Kjeldahl flask and 20 ml of distilled water was added. The flask was swirled for a few minutes and was allowed to stand for 30 minutes. One tablet of mercury catalyst was added to the mixture. After that, 30 ml of concentrated H2SO4 was also added to the mixture through an automatic pipette. And the flask was heated cautiously at the lower end of the digestion stand so as to remove excess water in the mixture. The mixture was boiled again for 5 hours so that the concentrated H2SO4 condensed about half way up the neck of the flask. The flask was allowed to cool and 100 mL of water was slowly added to the flask.

The digest was carefully transferred into another clean Macro-Kjeldahl flask (750 ml). After that, 50 ml of boric-acid indicator solution was added into a 500 mL Erlenmeyer flask which was then placed under the condenser of the distillation apparatus. Kjeldahl flask (750 ml) was attached to the distillation apparatus and 150 ml of Sodium Hydroxide (NaOH) (10 N) was poured through the distillation flask opening to commence distillation. The condenser was kept cool (below 30 0C) so as to allow sufficient cold water to flow through and regulate heat to prevent suck-back. About 150 ml of distillate was collected and the distillation was stopped.

The nitrogen content in the distillate was determined by titrating the distillate with 0.01 N standard Hydrochloric acid (HCl) using a 25 ml burette graduated at 0.1 ml intervals. The color change at the end point was from green to pink.

Calculation: the amount of nitrate can be calculated as follows

$$\text{Nitrate (mg/kg)} = \frac{\text{sample time} - \text{blank time}}{\text{Weight of sample}} \text{x } 0.014 \text{ x } 0.01 \text{ N } 1000$$

2.4.2. Digestion and heavy metal analysis

Digestion analysis

According to [35], 0.5 g of the soil was weighed into a beaker with 10ml of HNO3 added and gently heated on a hot plate. Heating was continued until the brown fumes turned to white. The mixture was allowed to cool and rinsed with 20ml of deionized water and filtered into a standard 25 ml volumetric flask and made up to mark in readiness for Atomic Absorption Spectrophotometer (AAS).

Heavy Metals Analysis

Iron, lead, copper, nickel, cobalt, zinc, manganese and cadmium (Fe, Pb, Cu, Ni, Co, Zn, Mn and Cd) were analyzed using the Atomic Absorption Spectrophotometer. The samples were crushed into powder and 0.2 g of the powdered samples were weighed into a beaker and were digested using the partial digested method using [36] standard procedures. 10ml of Aqua Regia (which is an acid mixture of Hydrochloric acid (HCl) and Trioxonitrate(v)acid (HNO3) in ratio 3:1 respectively). The mixture was heated up on hot plate or sand bath in a fume cupboard and heated to dryness. The procedure was repeated 4 times. After heating, the elements that were attached to the surface of the crystal lattice dissociated from it. The diluted Hydrochloric acid was added to the caked sediment which stuck to the wall of the beaker in order to dissolve it. Little quantity of distilled water was also added to the mixture and filtered. The filtrate was analyzed using Atomic Absorption Spectrophotometer (AAS), which analyses liquid minerals through partial digestion. The heavy metals were then analyzed and their concentrations recorded.

Soil Microbial Population Analysis

Standard pour plate technique described by [37] was employed for the analysis of the samples for total heterotrophic bacteria and fungi population in colony forming unit per milliliter (CFU/ml). The soil samples were collected in nylon bags from different locations and were taken to the Microbiology Laboratory of the University of Lagos for routine microbiological analysis. The samples were kept in a refrigerator at 4^0C prior to analysis. The samples were allowed to attain ambient temperature before analysis. 1g of the samples were taken and diluted serially in 9 ml of sterile water into six folds (10-1, to 10-6). One hundred microliter (100µl) of two different diluted samples were inoculated into sterile petri dishes in duplicates with the aid of micropipette fitted with sterile tips. Sterile molten nutrient agar and potato dextrose agar (which was supplemented with 1mg per ml of chloramphenicol to inhibit bacterial contaminants). The media were poured in the inoculated plates, swirled to ensure even distribution of the inoculum and left to solidify. The inoculated plates were then incubated aerobically at 37^0C for 24 hours (bacteria) and 28 ± 2^0C for 3-5 days (fungi). The developed colonies were counted in duplicates using colony counter. Average colonies of the dilutions that meet up with the standard pour plate technique were taken and multiplied by the corresponding dilution factor to give the total number of bacteria and fungi population per milliliter of the effluent analyzed.

The formula for calculating colony forming units were adopted for total bacteria and fungi population per ml of the samples.

$$\text{TBC/TFC (Colony forming units/ml)} = \frac{\text{Average number of colonies}}{\text{Inoculum size}} \text{x dilution factor}$$

Isolation of Microorganisms

Discrete colonies of bacteria and fungi were sub-cultured on to sterile, dried, molten nutrient agar plates (using streaking techniques) and potatoes dextrose agars plates (using cork-borer). Both plates were then incubated at 37^0C for 24 hours and room temperature for 3 days respectively. The pure cultures were then selected for biochemical identification after preliminary examination through microscopy (Patra et al., 2020).

Number of organisms were determined using the following formula:

$$Number\ of\ organisms = \frac{Number\ of\ colonies}{0.1} \times \frac{Dilution\ factor}{1}$$

Identification and Characterization of Microorganisms

The different isolates were identified on the basis of their morphological, microbiological and biochemical characteristics as outlined in [38,39]

2.5. Method of data analysis

Statistical analysis was performed using the T-test. Means of values determined from each point were evaluated using Tukey multiple comparison test at P< 0.05 probability level using statistical package for the social sciences (SPSS) version 20 and values at P < 0.05 were considered to be statistically significant. The statistical tool used was GraphPad prism 7.40.

3. Results

3.1. Soil Physiochemical Properties

The level of heavy metals in soils obtained from the wetlands, the soil pH collected at varying distances in wetlands soil area of University of Lagos and at varying depths 0 –5 cm, 5- 10 cm, 10 – 15 cm and 15-20 cm are shown in **Table 1.** The soil pH at varying distances and depths ranged 7.20 - 8.81 were mildly alkaline with no statistical significance at (P > 0.05). The phosphate of the soil at varying depths of 5cm, 10 cm, 15 cm and 20 cm at all sampling locations ranged 1.12 - 2.26 mg/kg and Nitrate ranged from 1.96-3.80 mg/kg respectively showed no significant difference at (P >0.05). However, moisture content of the sampled soil matter from the four locations showed statistical difference at (P <0.05), such that the depths of 5 cm,10 cm, 15 cm and 20 cm recorded moisture content ranging from 4.22% to 12.66%.

Table 1 Geochemical results of the University of Lagos wetland soil

Sample Code	Phosphate (mg/kg)	Nitrate (mg/kg)	Ph	Moisture content (%)
Lagoon Front	1.12	2.83	7.38	12.66
DLI	1.23	1.96	7.34	4.22
Faculty Science back	1.84	3.80	8.18	10.50
FSC-bye pass	2.26	3.03	7.20	10.80

Values expressed as Mean, *P<0.05 significantly different (Mean's t-test).

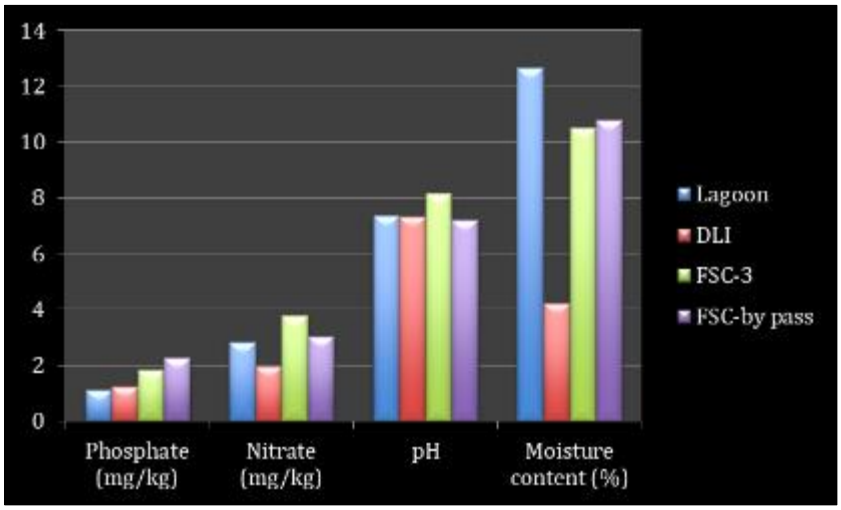


Figure 3a Soil physiochemical properties of wetland soil area of University of Lagos

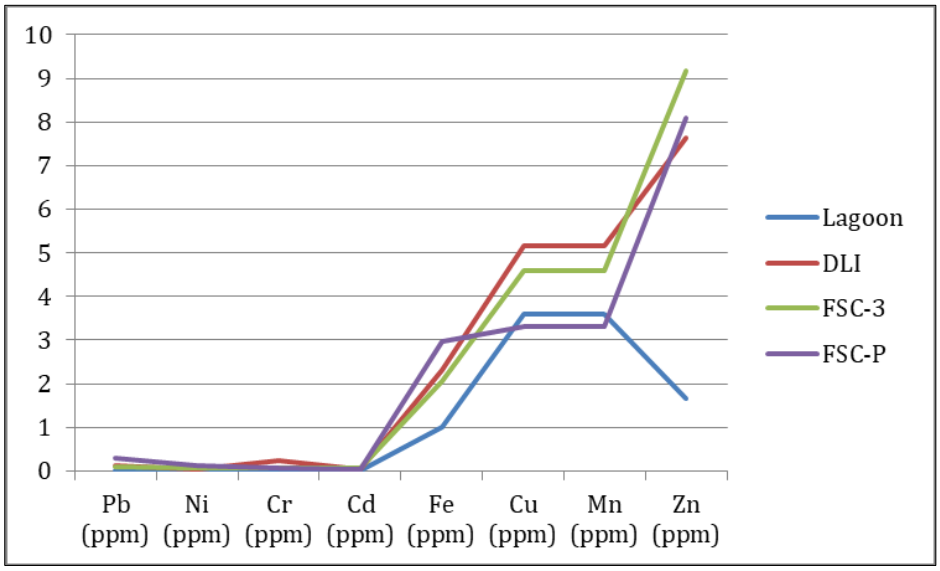
3.2. Heavy Metals Concentration

The mean concentration of Pb, Ni, Cr, Cd, Fe, Cu, Mn, and Zn in the wetland soils are summarized in Figure 3a. The mean concentrations ranged from 0.02-0.29 ppm for Pb, 0.01- 0.13 ppm for Ni, 0.0-0.25 ppm for Cr, 0.03-0.08 ppm for Cd, 1.02-2.96 ppm for Fe, 3.31-4.60 ppm for Cu, 3.31-5.16 ppm for Mn and 1.67-9.17 ppm for Zn respectively. However, the concentrations of Pb and Zn were below the permissible limit in all locations, Cr and Cd were within the permissible limit while Zn, Mn, Cu, Fe, and Ni were above the permissible limit as shown in Table 2. Also, the correlation analysis showed that Pb and Zn are significantly correlated (p < 0.05) as shown in Table 3.

Table 2 Heavy metal concentrations in wetland soil samples

Sample Code	Pb (ppm)	Ni (ppm)	Cr (ppm)	Cd (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)
Lagoon front	0.02	0.01	0.00	ND	1.02	3.59	3.59	1.67
DLI	0.12	0.04	0.25	0.03	2.33	5.16	5.16	7.64
FOS	0.11	0.07	0.06	0.08	2.05	4.60	4.60	9.17
FSP	0.29	0.13	0.07	0.05	2.96	3.31	3.31	8.10
FAO/WHO Max. Limit	0.05	0.02	0.05	0.05	0.03	1.5	0.5	15

Values expressed as Mean, *P<0.05 significantly different (Mean's t-test)



Pb = lead Ni = Nickel Cr =Chromium Cd = cadmium Fe= iron Cu= copper Mn= manganese Zn= Zinc. Ppm= parts per million. FSP= Faculty of Science byepass, FOS= Faculty of Science, DLI= Distance Learning Institute. WHO= World Health Organization FAO= food and agriculture organization, ND= Not Detected

Figure 3b Concentration of wetland soils of university of Lagos

Table 3 Correlation matrix among physicochemical parameters in the wetland soils

Pb	Ni	Cr	Cd	Fe	Cu	Mn	Zn
	0.961*	0.153	-0.163	0.934	-0.315	-0.315	0.630
0.961*		-0.027	0.216	0.878	-0.351	-0.351	0.685
0.153	-0.027		-0.829	0.452	0.768	0.768	0.459
-0.163	0.216	-0.829		-0.407	-0.183	-0.183	0.993
0.934	0.878	0.452	-0.407		0.044	0.044	0.821
-0.315	-0.351	0.768	-0.183	0.044		1	0.423
-0.315	-0.351	0.768	-0.183	0.044	1		0.423
0.630	0.685	0.459	0.993	0.821	0.423	0.423	

*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).; Pb = lead Ni = Nickel Cr = Chromium Cd = cadmium Fe = iron Cu= copper Mn = manganese Zn = Zinc.

3.3. Microbial Analysis

Table 4 showed the microbial counts in the soil from the sampling areas. The isolated microbes were characterized and identified as heterotrophic bacteria and fungi, hydrocarbon utilizing bacteria and fungi. The total heterotrophic bacterial count at varying locations ranged from 1.5 x10^6- 7.6 x 10^6, while the heterotrophic fungal count ranged from 3.9 x 10^5 – 5.6 x 10^5 from the University wetland areas showed statistical difference at (P<0.05) significant level.

Table 4 Total heterotrophic bacteria and fungi isolated from the wetland soils

Sample	THB *CFU/g*	THF *CFU/g*
FSP	2.1 x 10^6	4.0 x10^5
FOS	1.5 x10^6	5.6 x10^5
Lagoon	3.4 x 10^6	4.2 x10^5
DLI	7.6x 10^6	3.9 x10^5

Values expressed as Mean *P<0.05 significantly different from control (Mean's t-test); THB= total heterotrophic bacteria and THF= total heterotrophic fungi. FSP= Faculty of Science bye pass, FOS= Faculty of Science, DLI= Distance Learning Institute.

Table 5 Microbial biomass identified from the University of Lagos wetland areas

FSP	FOS	Lagoon	DLI
Bacillus spp	*Bacillus subtilis*	*Bacillus megaterium*	*Enterobacter spp*
Fusarium spp	*Aspergillus spp*	*Penicillium spp*	*Aspergillus spp*
Aspergillus flavus			*Fusarium sp*
Penicillium spp			

FSP= Faculty of Science bypass, FOS= Faculty of Science, DLI= Distance Learning Institute

3.4. Physiological Morphological and Biochemical Characteristics of Pure Culture

The characteristics of the culture media of the various isolates subjected to various test is shown in Table 6. The initial screening showed that the bacteria were dominated by isolates with cream colour. Gram reactions showed that they were all gram positive with the exception of isolate in DLI soil which is gram -ve. All soil 3 isolates were gram +ve. The cellular morphologies of all bacteria were all rods in shape. Biochemical test detected the presence of catalase in all isolates, oxidase in some of the isolates. Methyl red was absent in almost all the isolates. Generally, the selected four isolates from soil 1, 2, and 3 (lagoon, FSC, and FSC P) were gram positive except DLI (gram negative); rods in shape; catalase positive; oxidase negative except FSC P and DLI (negative); Methyl Red were all negative and Voges Proskauer were negative except lagoon (positive).

Table 6 Physiological, Morphological and Biochemical characteristics of the pure culture

Isolate code	Colour/ Pigment	Gram reaction	Cellular morphology	Catalase test	Oxidase test	MR-	VR-	Motility test	Probable Identity
Lagoon	CREAM	G+VE	RODS	+VE	+VE	+	+	+	*Bacillus cereus*
FOS	CREAM	G+VE	RODS	+VE	+VE	+	-	+	*Bacillus cereus*
FSP	CREAM	G+VE	RODS	+VE	-VE	-	-	-	*Corynebacterium kutscheri*
DLI	CREAM	G-VE	RODS	+VE	-VE	-	-	-	*Acinetobacter calcoaceticus*

Numbers and alphabets showed the codes for the soil, G+VE: gram positive; G-VE: gram negative; -VE: negative; +VE: positive; +: present; -: absent; MR- Methyl Red; VP- Voges Proskauer; FSP= Faculty of Science bypass, FOS= Faculty of Science, DLI= Distance Learning Institute

4. Discussion

The study of physicochemical and microbiological properties of wetland soil in the University of Lagos revealed a strong influence by the pollutants that have settled on the wetland soil. It can be seen that the effect of pollutants on soil heavy metal content, moisture content and the pH of soil depended on the level on contamination. There was alteration in the soil properties arising from the cement dust. The cement dust particles entering the soil decreased the pH of the soil, making it slightly acidic. The highest pH observed in this study was 8.18 and this was from wetland soil collected at Faculty of Science FSC-3, due to increased degradation of particulates by microorganism in the soil, resulting in accumulation of alkaline metabolites. [40] reported that changes in soil pH is connected with content of the pollutants in the soil, affecting soil pH directly, and affecting soil alkaline phosphatase enzyme activity indirectly. However, the moisture content of wetland soil was lower in DLI than that of other wetland soils. This may be due to the fact that pollutants in that area can coat the soil and consequently prevent the penetration of water [32].

The levels of all the metals except Pb, Zn, Cd and Ni were higher than the permissible limit. The result also revealed that the level of Cr, Fe, Cu and Mn were significantly below the permissible limit than in the sampling areas. This finding agreed with the report of [41] in their study of environmental media in the study area, but it differs from the findings of [32] who reported higher values in the agricultural soil than at other sampling sites close to lagoon. The level of Fe, Cu and Mn were significantly higher in all sampling sites, similar to the findings of [32]. Ni, Pb and Zn maintained almost the same concentration at all the standard permissible limit. The concentrations of most metals analyzed in the wetland soil samples were within permissible limits for soil [42] but their accumulation over time can adversely affect the type and number of the soil microorganisms.

The present study indicated that the Total Heterotrophic Bacteria (THB) counts varied in all sampling areas. The difference in counts may be due to changes in the physiochemical properties of the soil. However, the difference in the counts of THB and Total Heterotrophic Fungi THF between the polluted soils were high in some areas, probably is due to the rapid biodegradation of the pollutants in the soil. The counts of THB in polluted soils were lower in FOS (1.5×10^6). The reason for lower count in polluted soils may be due to the presence of residual pollutants in the soils which reduced carbon supply in the soil, hence favors the growth of fungi. The bacterial counts in wetland soils were lower than the fungal counts in the sample sites soils. The lower counts of bacteria compared to fungi may be as a result of nutrient status of the soil and the presence of some toxic compound which do not favor bacteria growth.

Isolated microbial flora from university wetland soil consists of 3 bacteria genera belonging to *Bacillus megaterium, Bacillus spp,* and *Enterobacter spp and* 4 fungal genera belonging to *Aspergillus*, *Penicillium*, *Aspergillus flavus* and *Fusarium*. Fungal species belonging to four genera reported in this study have been isolated from cement polluted soil (Sowunmi et al., 2020). The microbial diversity from soil samples from the University wetlands and adjourning areas were scanty. Two *Bacillus* sp., were able to grow in soils which is in concordance with the studies of [31,43] who reported that isolated obligate neutrophiles are belonging to the genera *Bacillus, Aspergillus* and *Fusarium.* The fungal isolates found in the wetland impacted soils were more in number and in types than the bacterial isolates. Findings showed that soil impacted by the pollutants hindered neutrophile organisms. This is in concordance with the works of [32] who reported that the soil pH is affected by the heavy metals and the hydrogen concentration. The mild soil pH is as a result of the negative impacts of the pollutants on the soil microbial populations (slowed) and the metabolic activities.

4.1.1. Characteristics of the Pure Culture

The finally selected four isolated strains showed typical morphological and biochemical characteristics of bacteria i.e. gram-positive, rod-shaped, catalase-positive and oxidase (cytochrome) negative [44]. It is clear from this study, that the University of Lagos wetlands are dominated by Gram positive and rod-shaped bacteria. Moreover, the high growth of the four isolates in the specific wetland makes them suitable for remediation of contaminated environment. Studies have shown that one of the criteria for selecting an organism for remediation of a contaminant is its ability to establish itself fast in the contaminated medium. Therefore, this organism may possibly possess the quality for degradation.

5. Conclusion

Heavy metals have been proved to be toxic to both human and environmental health. Owing to their toxicity and their possible bioaccumulation, the compounds of heavy metals should be subjected to mandatory routine monitoring. The adverse effect of this is noticeable by the population and diversity of the soil bacteria, which were generally low. An indicator of the soil health is the soil pH, which was impacted by the pollutants. Since human activities are going on in this area, important plant species could be greatly affected. Although the present levels of the heavy metal's pollutants

do not pose immediate threat to animal lives, accumulation over time can lead to great danger. Further studies on the effect of the pollutants on the rhizosphere microorganisms needs to be conducted.

Compliance with ethical standards

Disclosure of conflict of interest

Authors have declared that no competing interests exist.

Statement of Ethical Approval

This study was conducted in compliance with ethical standards and guidelines for environmental research. The collection of soil samples from the University of Lagos wetlands was carried out with appropriate permissions from relevant authorities. No human or animal subjects were involved in this study, and thus ethical approval for human or animal research was not required.

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