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Microbiological and Physicochemical Studies of Wetland Soils in Alimosho Local Government Area, Lagos, Nigeria

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ABSTRACT

The Microbiological and Physicochemical characteristics of wetland soils in Alimosho Local Government Area, Nigeria were studied during the dry season in 2015. Total Heterotrophic Bacterial Counts (THBC) and Total Fungal Counts (TFC) were determined using standard procedures from four locations at 2-20cm depths during the dry season. Microbial isolates were characterized and identified. Chemical parameters were also determined using UV-VIS Spectrophotometer. THBC ranged from 7.0×103cfu/g to 2.0×10^{3}cfu/g for the different locations of the site. The THBC for the control site was 5.0×10^{3}cfu/g, Site 1 was 2.0×10^{3}cfu/g, Site 2 was 7.0×10^{3}cfu/g and Site 3 was 3.0×10^{3}cfu/g. TFC ranged from 8.0×10^{3}cfu/g to 3.0×103cfu/g for different locations of the site. The TFC for the control site was 4.0×10^{3}cfu/g, Site1 was 3.0×10^{3}cfu/g, Site2 was 8.0×10^{3}cfu/g, and Site3 was 3.0×10^{3}cfu/g respectively. Bacillus sp, Staphylococcus sp, Pseudomonas sp, Klebsiella sp, Escherichia coli, Proteus mirabilis and Streptococcus species which were identified by biochemical test were predominate bacteria while Aspergillus sp, Penicillium sp, Rhizopus sp, Mucor sp and Fusarium sp which were also identified macroscopically and microscopically were the dominant fungi genera isolated. The physicochemical results showed values which ranged from 1957.33mg/kg to 2703.88mg/kg for Iron, 122.87mg/kg to 172.95mg/kg for Zinc, 24250.12mg/kg to 31832.45mg/kg for Potassium, 8078.48mg/kg to 12269.17mg/kg for Calcium, 0.17ppm to 0.30ppm for Phosphate and 0.04ppm to 0.8ppm for Nitrite. The pH ranged from 5.14 to 6.52 and Temperature ranged from 25°C to 27.3°C. It was observed that the pH was generally acidic at all locations. Potassium dominated the exchangeable bases among the elements while phosphate and nitrite have the least occurrence. Though the presence of some minerals in higher amount in the soil may lead to increase in bacterial load and help the organisms in degrading a wide variety of organic material which will eventually lead to high yield productivity of agricultural products from the wetland. These results provide the baseline data of Alimosho wetland soils for its management and sustainable agriculture.

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Wetland; Sustainable Agriculture; Microbiological; Physicochemical parameters

Introduction

In Nigeria, Wetland is estimated to cover about 28,000 km^2 which are about 3% of the 923,768 km^2 land surface area of the country [1]. Wetlands are rich in soil nutrients, producing good soil conditions which favour the growth of various vegetation. They rank among the most productive and valuable ecosystems in the world and performs numerous important functions like farming, groundwater research etc. They are generally rich in mineral salts due to water supply from the surroundings via runoff and/or groundwater [2].

Some of the human activities which can lead to soil contamination include discharge of industrial

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Table 1. Total heterotrophic bacterial and fungal counts (Logarithm of mean value) of each sample isolated from wetland soil.

SAMPLING LOCATIONS	TOTAL HETEROTROPHIC BACTERIAL COUNT (log cfu/g)	TOTAL HETEROTROPHIC FUNGAL COUNT (log cfu/g)
C	3.6989	3.6021
S1	3.3010	3.4771
S2	3.8451	3.9031
S3	3.4771	3.4771

KEY: S1, S2, S3 and Control (C) represent different sample locations.

and domestic waste, mining, smelting operations, and vehicular emission [3]. Toxic heavy metals arising from human activities accumulate in the soils which have the tendency to absorb physiologically toxic metals and these ultimately get to a human when plants grown on such soil are consumed. The chemical nature of a soil affects the type and size of its microbial population. The soil also acts as a buffer, reducing the range of physical conditions as compared with those found on and above its surface. Its effectiveness as a buffer will depend on its chemical composition and physical make-up [4].

Few studies have also demonstrated the marked differences in chemical properties between the well-drained and poorly drained soil from Southern Nigeria. The most comprehensive study of hydromorphic soils was carried out on the fresh water marsh supporting raffia palms in Southern Nigeria [5]. Although most of the nutrients were found to be low in these soils, the available forms were much higher in the waterlogged than in the dry conditions. It has also been established that wet soils formed on the basement complex rocks had better fertility status than those on sedimentary coastal plain sands. Information on the microbiology of hydromorphic soils of Lagos State is scanty; however, the trace metal concentrations in wetland soils in Alimosho area of Lagos state of Nigeria have not been previously studied.

This study was carried out to examine and compare the bacteriological quality and concentration of some major elements of soil samples from Wetland soils in Alimosho Local Government area in Lagos State, South-West, Nigeria.

Materials and Methods

Study Area

Abule Odu Wetland River is located at Abule Odu in Egbeda, Iyana Ipaja, Alimosho Local Government area of Lagos State Nigeria. It is a freshwater and free flowing river during the rainy season while slow-moving at the beginning of dry season. The river is at first straight, free-flowing and free of floating debris, it then curves and in some places with very deep gully and waterfalls as a result of erosion along the bank and main course of the river. Human activities found by the bank of the river are three cement block-making industries and religious activities. Various types of birds including ducks, pigeons, and egrets were seen on the river. There are also well-constructed drainages leading into the water. There are some agricultural activities around the area such as plantations of Sugar cane, Bamboo, and Banana. The coordinate of Abule Odu Wetland River is between N06035.433` E003$^0$16.409` and N06^{0}35 68` E003$^0$16.421`.

Table 2. Frequency of occurrence of fungal isolates from the wetland soils.

FUNGAL ISOLATES	% FREQUENCY OF OCCURRENCE
Aspergillus sp.	20.0 ± 0.00
Penicillium sp.	20.1 ±0.00
Rhizopus sp.	15.7 ±0.02
Mucor sp.	4.9 ± 0.01
Fusarium sp.	2.3 ± 0.03
UNIDENTIFIED	37 ± 0.02

Collection of Samples

Soil samples were collected from four locations (S1, S2, S3, and C, the control). Five soil samples were collected from each sampling points into sterile polythene bags with soil auger at the depth of 20cm [6]. The well labeled sterile polyethylene bags were taken in ice-packed coolers to the Laboratory for microbiological and physicochemical analysis.

Microbiological Analysis

Enumeration and Isolation of microbial isolates

One gram of each sample was added to 9 ml of sterile prepared peptone water diluent and mixed gently under aseptic conditions. The soil samples were serially diluted and subcultured on nutrient agar using pour plate techniques and the total

Table 3. Characterization and Identification of pure bacterial isolates.

Colony shape	Colony size	Elevation	Colony edge	Optical characteristics	Colony surface	Pigmentation	Consistency	Organisms
Rhizoid	Large	Flat	Entire	Translucent	Smooth	Golden Yellow	Butyrous	*Staphylococcus aureus*
Irregular	Small	Flat	Entire	Opaque	Wrinkled	Green	Mucoid	*Pseudomonas aeruginosa*
Circular	Large	Flat	Entire	Translucent	Smooth	Creamy	Butyrous	*Escherichia coli*
Circular	Large	Raised	Entire	Translucent	Slimy	Creamy	Mucoid	*Klebsiella pneumoniae*
Circular	Medium	Flat	Irregular	Opaque	Wrinkled	Creamy	Butyrous	*Bacillus* sp
Fishy odour	Small	Raised	Even	Translucent	Rough	Creamy	Butyrous	*Proteus* sp
Circular	Large	Flat	Entire	Opaque	Smooth	Creamy	Mucoid	*Streptococcus faecalis*
Circular	Large	Flat	Irregular	Opaque	Smooth	Creamy	Mucoid	*Bacillus* sp

Table 4. Biochemical test of pure bacterial isolates.

Colonial Characteristics	Gram Stain	Motility	Catalase	Coagulase	Citrate	Indole	Methyl Red	Organism
Small milky white colonies	+ Rods	+	+	-	+	-	-	Bacillus sp
Large white colonies	+ Rods	+	+	-	+	-	+	Bacillus sp
Large gray colonies	- Rod	-	-	-	+	-	-	Klebsiella sp
Large golden yellow colonies	+ Cocci	-	+	+	+	-	-	Staphylococcus sp
Large milky white colonies	-Rod	+	+	-	+	-	+	Proteus mirabilis
Small white colonies	-Rod	+	+	-	-	+	+	Escherichia coli
Blue-green colonies	- Rod	+	+	-	+	-	+	Pseudomonas sp
Large milky rhizoid colonies	+ Cocci	-	-	-	-	-	+	Streptococcus sp

Key: + refers to positive, - refers to negative

bacterial count determined after 24 hours of incubation at ambient condition using the method as described by [7]. After incubation, bacterial and fungal counts were determined [8, 9].

Maintenance of Pure Culture

Pure cultures were obtained by repeated subculture onto appropriate agar media. Pure cultures were preserved on Nutrient agar slants and stored in the refrigerator (4°C) and at ambient temperature 27±1°C for further tests.

Characterization and identification of bacteria

Bacteria are known to exhibit distinctive biochemical reaction or characteristics when supplied with certain biochemical substances. Their ability to exhibit these biochemical characteristics is inherent in bacteria ability to elaborate necessary enzymes. Therefore, for bacteria to be fully identified and characterized Biochemical tests are very essential. Biochemical tests used to determine bacteria in this study include Glucose, lactose, Hydrogen sulphide gas production, catalase, coagulase, motility, indole, urease, citrate and oxidase, Gram staining and methyl red test.

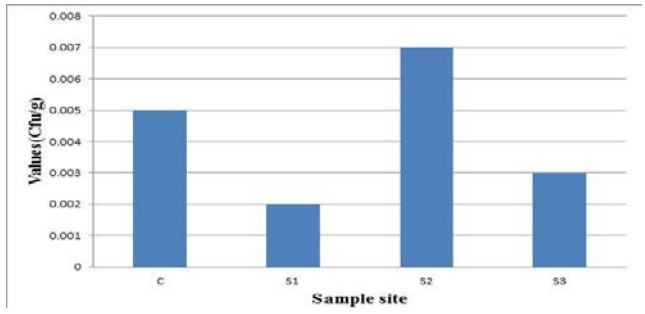

Figure 1. Total heterotrophic bacterial counts (mean value) of each sample isolated from wetland soil.

Physicochemical Analysis of Soil Samples

The pH was measured as described [10]. The temperature was taken using mercury-bulb thermometer. Soil samples were digested by a method described by [11]. One gram of soil sample was

Table 5. Physicochemical parameters of all the sampling points.

PARAMETERS	S1	S2	S3	C
PH	5.41	5.92	6.14	6.52
Temp (^{0}C)	25	26.1	27.3	25
Fe (mg/kg)	1957.33	2405.90	2502.29	2703.88
Zn (mg/kg)	122.87	144.70	156.42	172.95
K (mg/kg)	24250.12	29032.02	28492.06	31832.45
Ca (mg/kg)	8078.48	12269.17	9288.68	8690.71
PO_4 (ppm)	0.2390	0.1700	0.27840	0.3030
NO^{3-} (ppm)	0.0710	0.0480	0.0760	0.880

KEY: S1, S2, S3 and C represent sampling points while C represents control. Temp- Temperature, Fe- Iron, Zn-Zinc, K-Potassium, Ca-Calcium, PO_4-Phosphate and NO_3—Nitrate.

weighed into a dried 250 cm^3 beaker and was digested with a mixture of (3:1 v/v) of HNO_3 and HCl. Samples were digested on the hot plate until a clear solution was obtained, cooled and a little amount of distilled water added. It was then filtered through a Whatman No. 40 filter paper into a 100cm^3 volumetric flask. The residue was washed with warm distilled water and the solution made to mark with distilled water and transferred into 100cm^3 clean plastic container for the metal analysis using UV-VIS Spectrophotometer and UNICAM AA 919 Atomic Absorption Spectrophotometer (AAS).

Results

Total heterotrophic bacterial counts (mean value) of each sample isolated from wetland soil

The result for the Total Heterotrophic Bacterial Count (mean values) of each sample isolated from wetland soil is presented in figure 1. It was observed that Site 2 has the highest bacterial count of 7.0×10^3cfu/g while Site 1 had the least count of 2.0×10^3cfu/g. The bacterial count for Site 3 was 3.0×10^3cfu/g while control site was 5.0×10^3cfu/g respectively.

Total Heterotrophic Fungal Counts (Mean Values) of Each Sample Isolated from Wetland Soil

The result for the Total Heterotrophic Fungal Count (mean values) of each sample isolated from wetland soil is presented in figure 2. It was shown that Site 2 had the highest fungal count of 8.0×10^3cfu/g while Site 1 had the least count of 3.0×10^3cfu/g. Site3 also had a lower value of 3.0×10^3cfu/g while the control site was 4.0×10^3 cfu/g.

Frequency of occurrence of bacterial isolates from Alimosho wetland soils

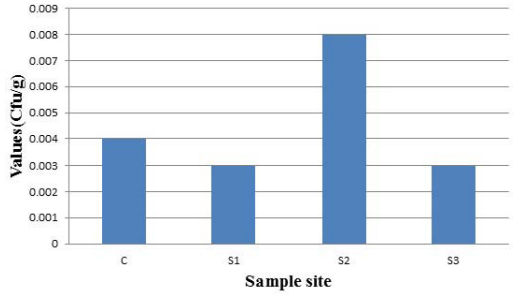

Figure 1. Total Heterotrophic Fungal Counts (mean value) of each sample isolated from wetland soil.

The **frequency of occurrence** of bacterial isolates from Alimosho wetland soils is represented in Figure 3. It was shown that *Bacillus* sp. had the highest frequency of bacterial isolates of 25% while *Proteus* sp. had the lowest frequency of bacterial isolates of 1%. It was also noted that the frequency of *Staphylococcus aureus* was 21%, *Pseudomonas aeruginosa* was 10%, *Escherichia coli* were 13%, *Bacillus* sp. was 20%, *Klebsiella pneumonia* was 7% while *Streptococcus* sp. was 3%.

Frequency of occurrence of fungal isolates from Alimosho wetland soils

The result of the **frequency of occurrence** of fungal isolates from Alimosho wetland soils was represented in Table 2. It was observed that the highest frequency of fungal isolates was *Penicillium* sp. which had the percentage of 20.1% while *Fusarium* sp. had the least percentage frequency of occurrence of 2.3%. The percentage frequency of *Aspergillus* sp. was 20.0% while *Rhizopus* sp. was 15.7%.

Frequency of occurrence of fungal isolates from Alimosho wetland soils

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Characteristics and Colonial morphology of pure bacterial isolates

The result for the characteristics and identification (colonial morphology) of pure bacterial isolates was based on colony surfaces, shape, consistency, pigmentation, elevation and edge respectively which are presented in Table 3. The total of eight different Genera of bacteria were isolated and identified from Alimosho wetland soils. These include *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Bacillus* sp., *Klebsiella pneumonia, Streptococcus* sp., *Proteus* sp. and *Bacillus* sp. respectively.

Biochemical test of pure bacterial isolates

Macroscopic and microscopic characteristics of pure fungal isolates

The pure fungal isolates were examined macroscopically and microscopically to determine their colonial and morphological characteristics. The organisms identified include *Aspergillus* sp., *Penicillium* sp., *Rhizopus* sp., *Mucorspand Fusarium* sp.

Physicochemical Analyses

Table 5 shows the chemical analyses of the wetland with the Temperature ranged between 25°C to 27.3°C, pH; 6.52 to 5.14, Iron; 1957 to 2704 mg/kg, Zinc; 123 to 173 mg/kg, Potassium; 24250 to 31832 mg/kg, Calcium; 8078 to 12269 mg/kg. It was observed that Potassium (K) had the highest value of metals in all the sampling sites which range from 24250.1267 mg/kg to 31832.4599mg/kg while Zinc (Zn) had the least value of metals in all the sampling points which were 122.8746 mg/kg to 172.9550mg/kg. The result also shows that Phosphate ranged between 0.1700 to 0.3030ppm and 0.0480 to 0.880ppm for Nitrate.

Discussion

This study of the microbiological and physicochemical analysis of wetland soils in Alimosho Local Government Area of Lagos State, Nigeria was designed to provide baseline data on which the potentials of this vast unexploited wetland soils can

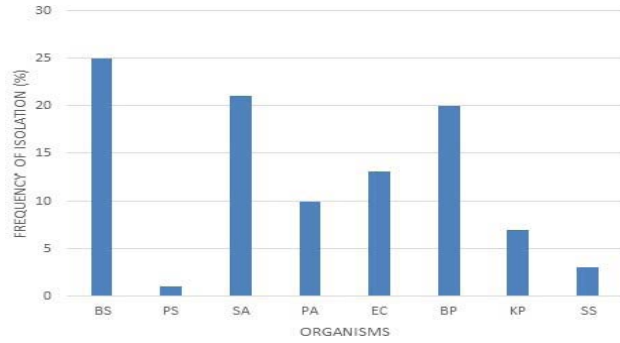

Figure 3. Frequency of occurrence of bacterial isolates from Alimosho wetland soils. KEY. SA- *Staphylococcus aureus*, PA- *Pseudomonas aeruginosa*, EC- *Escherichia coli*, BP- *Bacillus* sp., KP -*Klebsiella pneumonia*, SS- *Streptococcus faecalis*, PS- *Proteus* sp., BS- *Bacillus* sp.

be maximized for sustainable agriculture. The wetland soils understudy revealed the Heterotrophic bacteria as having the highest occurrence. Fungi constitute to the second highest number of microbes that inhabits the wetland soils. The occurrence of the heterotrophic bacteria as the highest occurring organisms could be attributed to the tolerance of these microbes to wide variations of the soil properties. The high fungal counts could be attributed to the acidic nature of these soils since fungal growth are enhanced by the acid nature of an environment. [12]. The result showed that there was a high range in the microbial counts from all the sampling points. This could be attributed to the higher availability of favourable growth factors, pH, and temperature of the soils [12].

Control site had the highest bacterial count because the soil is highly rich in humus which led to high decomposition of microorganisms which is similar to the research made by [12]. Site 1 had the least bacterial count which may be due to its high quantity of sand and stone particles. The presence of *Enterobacter* species and *Bacillus* species in the soil is supportive of those organisms being found in soil by [13], they stated that pollution of the soil sediment of the river could pose danger to its consumption by humans. There have been reported cases of waterborne enteric diseases as reported in the findings of [14]. Cases of gastroenteritis caused by *E. coli* and other protozoans in surface and drinking water have been reported by researchers such as [15].

These results indicated that the wetland was faecally contaminated and thus contain pathogens that can cause gastroenteritis, hence it is not fit for domestic and recreational activities. The higher microbial counts obtained was also due to increased

nutrients and aeration which enhanced decomposition of organic matter and hence increase in bacterial populations as supported by [16].

The presence of *Bacillus* species in drinking water and reservoir tanks in a study by [13] is supportive of those organisms being found in the soil of the wetland. Fungi Species of the various isolates from the wetland soils under this study include *Aspergillus* sp., *Penicillium* sp., *Mucor* sp. and *Rhizopus* sp. *Aspergillus* sp. was the most frequently isolated fungus occurring in all the samples in almost all the samples that were collected because *Aspergillus* sp is one of the major organisms which is dominant in most wetland soils [17]. *Penicillium* species also occurred abundantly in the samples which are similar to those obtained by [18]. The microbiological study of the Abule Odu wetland soils in Alimosho Local Government Area has revealed the wetland soils as playing host to various genera of bacteria and fungi. Soil microorganisms play subordinate roles to plants as they play a critical role in organic matter decomposition, stabilization of soil structure as well as mineral cycling [12].

It was observed that calcium and potassium had the highest range of mineral element in all the soil samples analyzed. It was observed that the pH was generally acidic at all locations indicating a variation from acidity to alkalinity in the samples this was similar to the research made by [18]. He suggested that the pH is required for aquatic microflora survival.

The increase in the physicochemical parameters of the Control site when compared with the other sampling points which indicate that the Control site is highly polluted than other points with these metals. This could be attributed to some human activities and vehicular deposition of some of these metals, as well as application of fertilizers and chemicals, deposited [19]. It was also observed that there was an increase in the temperature indicating an important factor in the survival of microorganisms in surface water as it affects the metabolic activities, the water activity of microbial cells [17].

Calcium, potassium, iron, zinc, phosphate and nitrate whose mean concentrations were determined in the wetland soil samples of Alimosho Local Government area shows that potassium was found to be the highest among the mineral metals determined. This metal in wetland soil samples was very high compared with the other metals while zinc was found to be the lowest in the soil samples of the wetland. This result is similar to the one obtained by [3] and the concentration of the zinc metal was very low and high in other metals due to the precipitation of these elements in this aquatic environment of Alimosho wetland which is also supported by the finding of [20]. This could also be attributed to some human activities and vehicular deposition of some of these metals.

Abule Odu wetland experiences non-point source pollution of the wetland with domestic wastes as well as feacal contamination from both animals and human beings. This becomes more noticeable at times with the physical observation along the bank of the wetland and inside the wetland.

Conclusion

The microbiological and physicochemical study of the wetland soils in Alimosho during the cause of this study revealed their microbiological and physicochemical characteristics as being suitable for arable crop cultivation. This involves the cultivation of major arable crops such as cassava, cocoyam, banana, sugarcane, and vegetables. The wetland soils have also proved to support the cultivation of bamboo. However, the planting of tree crops such as coconut and oil palms is also encouraged on these soils since these crops tolerate acidic conditions as revealed by soils in this study. This research work also reveals that the bacteria and fungi isolated play a vital role in the richness of the soil thereby suitable for aerobic and facultative anaerobic organisms. The presence of mineral metals was very high which have implications for a human when consumed or used for domestic purposes. Though the presence of some minerals in higher amount in the soil may lead to increase in bacterial load and help the organisms in degrading a wide variety of organic material which will eventually lead to high yield productivity of agricultural products from the wetland.

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