ISSN 0794-1293

MICROBIOLOGICAL AND PHYSICOCHEMICAL STUDIES OF WETLAND SOILS IN ITU, NIGERIA

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The microbiological and physico-chemical characteristics of wetland soils in Itu LGA were determined between May 2001 and June 2003. Total heterotrophic bacterial counts (THBC), total fungal counts (TFC) and total Actinomycetes counts (TAC) were determined from soil samples taken at two depths (0-15 and 15-30cm) from Uyo Itam, Okon Itam, Odiok Itam and Ntak Inyang in the dry and wet seasons. Microbial isolates were characterized and identified. THBC of Itu wetland soils ranged from 5.6 ($\pm$0.01) x 10^6 to 1.8 ($\pm$0.15) x 10^7 cfu/g in the wet season, and from 3.0 ($\pm$0.03) x 10^6 to 1.5 ($\pm$0.03) x 10^7 cfu/g in the dry season. TFC ranged from 1.4 ($\pm$0.15) x 10^6 to 6.6 ($\pm$0.02) x 10^6 cfu/g in the wet season and 1.0 ($\pm$0.33) x 10^6 to 4.8 ($\pm$0.02) x 10^6 cfu/g in the dry season. TAC ranged from 1.0 ($\pm$0.44) X 10^6 to 6.2 ($\pm$0.18) x 10^6 cfu/g in the wet season and from 0.4 ($\pm$0.01) x 10^6 to 3.0 ($\pm$0.03) X 10^6 cfu/g in the dry season. *Alcaligenes, Arthrobacter, Flavobacterium, Bacillus, Clostridium, Enterobacter, Micrococus, Serratia, Staphylococcus, Enterococcus and Pseudomonas* were predominant bacteria, while *Aspergillus, Cladosporium, Fusarium, Penicillium* and *Rhizopus* were the dominant fungal genera isolated. *Streptomyces* and *Norcardia* were the actinomycetes isolated. Particle size and chemical parameters (pH, organic matter, %N, available phosphorus, exchangeable acids, ECEC, % base saturation and micro-nutrients) were also determined using standard methods. The particle size analysis showed high sand fraction and low silt and clay. The pH was generally acidic and % organic matter generally low at all locations. The soil showed low to moderate available phosphorus that ranged between 28.2 ($\pm$0.04) and 51.81 ($\pm$0.12) mg/kg in both seasons. Calcium dominated the exchangeable bases with low electrical conductivity and micronutrients. These results could contribute to baseline data of the microbiological and physicochemical characteristics of Itu wetland soils thus providing the basis for its management for sustainable agricultural practices.

Key word: Wetland soils, Microbiological and physico-chemical characteristics, baseline data

INTRODUCTION

Wetlands are regarded as important transitional ecosystems between open water and terrestrial ecosystems. They comprise soils with impeded drainage either because of flooding or because of a relatively high ground water table (Andriesse, 1986; Edwards, 1990). In Nigeria, wetlands cover over 24,009km^2, with the largest concentrations of natural wetlands in Southern Nigeria. The Nigerian wetlands stand out as reservoirs for different categories of wild life, marsh plants and mineral resources (Akpata and Okoli, 1990; Eshiett, 1992, 1994) and are generally unexploited.

Wetlands represent a complex habitat where physiographic, edaptic (soil factors), biotic and climatic factors interact according to set natural laws. The knowledge of these laws is r agricultural practices, there is a need to expand arable crop cultivation into these unexploited wetland resources in order to boost food production for Nigeria's teeming population.

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basic to the use of wetlands, for man must be able to control all of these factors in one environment in order to exploit this vast but hitherto neglected resource in a scientific or sustainable manner to satisfy his wants (Farahbakshazad *et al, 2000).* These days where there is declining productivity from upland agriculture because of continuous cropping as a result of limited land area for agricultural practices, there is a need to expand arable crop cultivation into these unexploited wetland resources in order to boost food production for Nigeria's teeming population.

This study was necessitated by the paucity of information on the microbiological and physicochemical characteristics of the wetland soils in Itu, Nigeria. Field sampling of the study area lasted two years (from May 2001 to June 2003) with a view to documenting the baseline microbiological and physico-chemical characteristics of this largely neglected and hence unexploited ecosystem.

MATERIALS AND METHOD

STUDY AREA

The study area comprises wetland sites distributed along Uyo Itam, Okon Itam, Odiok Itam and Ntak Inyang in Itu Local Government Area (Fig. 1). Topography of the sampling locations can be described as being nearly level to gently undulating slopes of 0-3°, which provides a very stable physiographic environment for relatively uniform parent material (Peters, 1989). Within this study area is the proposed Ibom Science Park and Akwa Ibom State Government (AKSG) Sanitary Landfill. The study area is therefore significant industrially.

SAMPLE COLLECTION

Soil samples were collected at (2) depths (0-15cm and 15-30cm) from 4 locations: Uyo Itam (UT), Okon Itam (KT), Odiok Itam (DT), and Ntak Inyang (NT) along a transect (Table 1) in Itu Local Government Area according to the method of Anderson and Ingram (1993). The samples were collected during the wet and dry seasons into labelled polyethylene bags and taken in ice-packed coolers to the laboratory for microbiological and physicochemical analyses.

MICROBIOLOGICAL ANALYSIS

(i) Serial dilution

Serial ten-fold dilutions of the soil samples were made according to the methods of Collins and Lyne (1976) and Harrigan and McCance (1976).

(ii) Inoculation and Incubation

One milliliter of appropriate ten-fold serial dilutions of the soil samples were inoculated unto nutrient agar (Oxoid, CM 314), Reinforced Clostridial Agar (Oxoid CM 149, 151), Malt Extract Agar (Oxoid CM 151) and Sabouraud Dextrose Agar plates in triplicate using the pour plate methods of Collins and Lyne (1976), Harrigan and McCance (1976), and the spread plate methods of Demain and Davies (1999). Soil plate technique of Eka and Forgathy (1972) and Demain and Davies (1999) were also used for the isolation of actinomycetes using Starch Nitrate Agar. Inoculated plates were incubated at 37°C for 18-24 h and at ambient temperature (28±2°C) for 48-72 h for the enumeration of total heterotrophic bacterial, fungal and actinomycetes counts. Visible and discrete colonies in incubated plates were counted and expressed as colony forming units per gram (cfu/g) of soil samples.

(iii) Maintenance of Pure Culture

Discrete colonies were purified by repeated sub-culture unto appropriate agar media. Pure cultures were preserved on nutrient agar slants and stored in the refrigerator (4°C±2°C) and at ambient temperature (28± 2°C) for further tests.

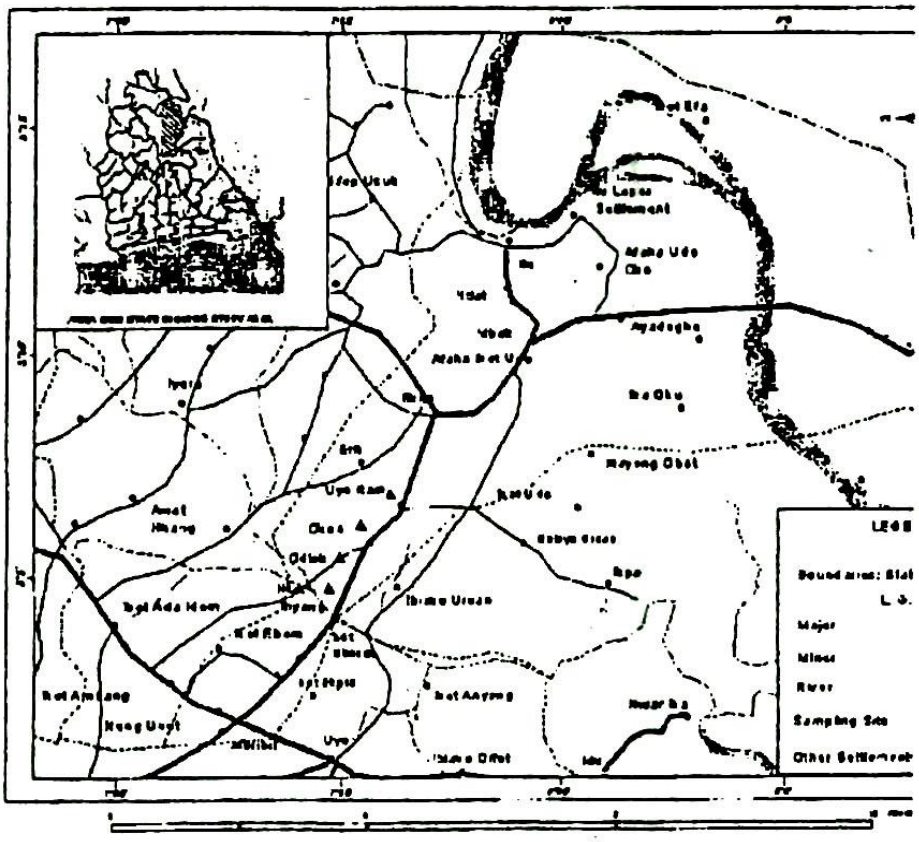

Fig. 1: Itu Local Government Area showing Sampling Sites

Table 1 Sample Points and their and their coordinates

S/No	Sampling Point	Sample Location/Code	Coordinates	
			Latitude	Longitude
1	Upper slope	Uyo Itam (UT)	$7^0 56^1 53''$	$5^0 06^1 53''$
2	Middle slope	Okón Itam (KT)	$7^0 56^1 28''$	$5^0 06^1 12''$
3	Lower slope	Odiok Itam (DT)	$7^0 55^1 47''$	$5^0 05^1 36''$
4	Bottom slope	Ntak Inyag (NT)	$7^0 55^1 26''$	$5^0 04^1 27''$

(Iv) **Characterization and Identification of Microbial Isolates**

Pure cultures of microbial isolates were characterized based on cultural parameters, microscopic techniques and biochemical tests including carbohydrate utilization as described by Cruickshank *et al.* (1975). Identification of bacteria was accomplished by comparing the characteristics of the culture with those of known taxa using Bergey's Manual of Determinative Bacteriology (Holt *et al*, 1994). Characterization and identification of fungal isolates was done according to Domsch *et al* (1980) and Barnett and Hunter (1987). Actinomycetes were characterized and identified according to the methods of Eka & Fogathy (1972).

PHYSICOCHEMICAL ANALYSIS OF SOIL SAMPLES

Particle size analysis was done using the Bouyoucous Hydrometer method (Bouyoucous, 1962). The pH of soil samples was determined according to the method of Udo and Ogunwale (1986) while electrical conductivity of the soil samples were determined according to Jackson (1962). Exchangeable cations were determined according to the methods of Jackson (1962) and the Association of Official Analytical Chemists, AOAC (1990). Total nitrogen in the soil sample was determined by Microkjedahl digestion and distillation methods of Jackson (1962). Available phosphorus was determined by the Bray No.1 method (Bray and Kurtz, 1945) and blue Molybdocolorimetric method (Murphy and Riley, 1962). Effective cations exchange capacity was determined using the method of Peters (1989). Total organic matter contents were determined using the method of Walkley and Black (1989), while the micronutrients (heavy metals) content of the soil were determined using atomic absorption spectrophotometer, AAS (UNICAM AA 919 model) (AOAC, 1990).

STATISTICAL ANALYSIS

The statistical analysis employed in this work included standard deviation, analysis of variance and correlation analysis (Sokal and Rohlf, 1981).

RESULTS

MICROBIOLOGICAL ANALYSIS

(a) Microbial counts

The microbial counts of the wetland soils of Itu are as shown in Table 2. Total heterotrophic bacterial counts (THBC) ranged from 5.6 ($\pm$0.01) x 10^6 to 1.8 ($\pm$0.15) x 10^7 cfu/g in the wet season and from 3.0 ($\pm$0.03) x 10^6 to 1.5 (+0.03) x 10 in the dry season. Total fungal counts (TFC) ranged from 1.4 ($\pm$0.15) x 10^6 to 6.6 ($\pm$0.02) x 10^6 cfu/g in the wet season and from 1.0 ($\pm$0.33) x 10^6 to 4.8 ($\pm$0.02) x 10^6 cfu/g in the dry season. Total actinomycetes counts (TAC) ranged from 6.6 ($\pm$0.02) x 10^6 cfu/g in the wet season and from 1.0 ($\pm$0.33) x 10^6 to 4.8 ($\pm$0.02) x 10^6 cfu/g in the dry season. Total actinomycetes counts (TAC) ranged from 1.0 ($\pm$0.44) x 10^6 to 6.2 ($\pm$0.18) x 10^6 cfu/g in the wet season and from 0.4 ($\pm$0.01) x 10^6 to 3.0 ($\pm$0.03) x 10^6 cfu/g in the dry season. Microbial counts were found to be higher in surface soil samples (0 - 15cm) than sub-surface soil samples in both seasons.

(b) Microbial Isolates

Bacterial isolates of wetland soils in Itu LGA, Nigeria were predominantly of the genera *Alcaligenes, Arthrobacter, Flavobacterium, Bacillus. Clostridium, Enterobacter, Micrococcus, Serrati Staphylococcus, Enterococcus* and *Pseudomonas.* The fungal isolates were mostly of the genera *Aspergillus, Cladosporium, Fusarium, Penicillium* and *Rhizopus* while *Actinomycetes* were of the genera *Streptomyces* and *Nocardia.* These isolates have also been isolated from normal agricultural soils of the Niger Delta Region (RPI, 1985; Udotong, 2000).

PHYSICO-CHEMICAL ANALYSES

(a) Particle Size Distribution

The particle size distribution of the wetland soils is as shown in Table 3. It revealed the wetland soil as having high sand fraction that ranged between 72.0($\pm$0.15) and 91.6($\pm$0.17)%, with clay that range of 5.6 ($\pm$0.01) to 18.4 ($\pm$0.05) % in both seasons silt that ranged between 2.(($\pm$0.03) and 11.0 ($\pm$0.04)%.

(b) Chemical Analysis

Tables 4a, and 5 show the result of chemical analyses of Itu wetland soils in the wet and dry seasons. The pH ranged between 5.4 ($\pm$0.01) to 5.8 ($\pm$0.02), organic matter ranged from 1.06 ($\pm$0.06) to 5.33 ($\pm$0.2) % while % nitrogen ranged from 0.03 ($\pm$0.01) to 0.15 ($\pm$0.03) %. It also showed moderate available phosphorus that ranged between 28.2 ($\pm$0.04) and 51.81 ($\pm$0.12) mg/kg and low micronutrients.

TABLE 2: MICROBIAL COUNT OF ISOLATES FROM ITU WETLAND SOIL: (WET AND DRY SEASONS)

Sample Code	Depth (CM)	(THBC) ($X10^6$, 10^7 cfu/g)		(TAC) ($X10^6$ CFU/g)		(TFC) ($X10^6$ cfu/g)	
		Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
UT	0 – 15	1.2±0.22 x10^7	9.2±0.06 x10^6	2.6±0.06	1.8±0.22	4.2±0.21	1.4±0.02
UT	15 – 30	5.6±0.01 x10^6	3.0±0.03 x10^6	1.4 ±0.02	0.6±0.01	2.0 ± 0.26	1.0 ± 0.33
KT	0 – 15	1.5±0.29 x10^7	1.2±0.01 x10^7	3.4±0.04	2.0 ± 0.01	5.0 ±0.21	2.8 ± 0.22
KT	15 – 30	7.4±0.19 x10^6	4.2±0.03 x10^6	1.8±0.01	1.0 ± 0.01	1.4 ± 0.27	1.4 ± 0.14
DT	0 – 15	1.7±0.27 x10^7	1.3±0.01 x10^7	6.2±0.18	3.0 ± 0.03	6.6 ± 0.02	4.0± 0.28
DT	15 – 30	9.2±0.03 x10^6	5.6±0.01 x10^6	2.0±0.04	1.2 ± 0.04	3.4 ± 0.19	2.0 ±0.01
NT	0 – 15	1.8±0.15 x10^7	1.5±0.03 x10^7	2.2±0.22	1.4 ± 0.02	3.8 ± 0.23	4.8± 0.02
NT	15 – 30	1.1±0.02x10^7	7.2±0.01 x10^6	1.0±0.44	0.4± 0.01	1.4 ± 0.15	2.6 ± 0.04

UT = Uyo Itam; KT = Okon Itam; DT = Odiok Itam; NT = Ntak Inyang; THBC = total Heterotrophic Bacterial Count; TFC = Total Fungal Count; TAC = Total Actinomycetes Count.

TABLE 3: PARTICLE SIZE DISTRIBUTION OF ITU WETLAND SOIL IN THE WET AND DRY SEASONS

Sample Code	Depth (CM)	SAND (%)		CLAY (%)		SILT (%)	
		Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
UT	0 – 15	91.6±0.17	91.4±0.06	6.8±0.01	5.6±0.01	2.0±0.03	3.4±0.04
UT	15 – 30	89.6 ±0.12	89.0 ± 0.04	8.4 ± 0.05	7.2±0.03	2.0 ± 0.2	3.8 ± 0.02
KT	0 – 15	87.6± 0.17	87.6± 0.11	10.4± 0.06	9.4 ± 0.02	2.0±0.2	3.0± 0.04
KT	15 – 30	81,6±0.12	81.0 ± 0.12	14.4 ± 0.08	12.0 ± 0.04	4.0 ± 0.2	5.0± 0.10
DT	0 – 15	84.6±0.01	84.6 ± 0.10	10.6 ± 0.05	9.6 ± 0.02	4.8 ± 0.05	5.8 ± 0.5
DT	15 – 30	77.6±0.03	77.6 ± 0.03	15.4 ± 0.12	14.0 ± 0.10	7.0 ± 0.02	8.4 ± 0.06
NT	0 – 15	78.2±0.04	78.2 ± 0.04	12.4 ± 0.01	11.6 ± 0.02	9.0 ± 0.01	10.2 ± 0.02
NT	15 – 30	72.0±0.5	72.0 ± 0.15	18.4 ± 0.05	17.0± 0.03	10.0± 0.10	11.0 +0.04

UT = Uyo Itam; KT = Okon Itam; DT = Odiok Itam; NT = Ntak Inyang;

TABLE 4A: CHEMICAL ANALYSIS OF ITU WETLAND SOIL (WET SEASON)

Sample Code	DEPTH (cm)	pH	EC ds/m	Organic Matter (%)	N (%)	AV.P (Mg/Kg)	Ca (cmol/kg)	Mg	Na	K	EA	ECEC	B.S (%)
UT	0 – 15	5.6±0.01	0.04±0.01	3.29±0.00	0.04±0.00	38.76±0.00	1.96±0.00	1.3±0.00 0	0.07±0.02	0.06±0.00	3.24±0.00	6.68±0.00	50.75±0.00
UT	15 – 30	5.6±0.02	0.02±0.00	1.76±0.02	0.03±0.01	33.33±0.01	0.96±0.02	0.48±0.02	0.05±0.00	0.04+0.02	2.9±0.00	4.52±0.08	34.51+0.04
KT	0 – 15	5.7±0.01	0.03±0.00	3.39±0.00	0.05±0.00	38.93±0.00	2.40±0.00	1.4±0.00	0.05±0.00	0.08+0.00	1.81±0.00	5.74±0.00	68.47+0.00
KT	15 – 30	5.7±0.01	0.02±0.00	1.94±0.00	0.04±0.00	33.33±055	1.66±0.00	1.2±0.00	0.05±0.00	0.14+0.00	1.07±0.00	5.04±0.01	60.71±0.00
DT	0 – 15	5.8±0.02	0.03±0.00	4.93±0.00	0.14±0.00	46.33±0.00	2.64±0.00	1.8±0.02	0.05±0.00	0.08+0.00	1.7±0.00	7.32±0.02	62.3±0.00
DT	15 – 30	5.8±0.00	0.02±0.00	2.06±0.00	0.06±0.00	41.99±0.00	1.68±0.00	1.1±0.00	0.04±0.01	0.08+0.00	1.7±0.00	5.1±0.00	51.79±0.00
NT	0 – 15	5.6±0.00	0.04±0.01	5.33±0.2	0.15±0.03	51.81±0.12	2.82±0.01	1.2±0.00	0.07±0.00	0.13+0.00	1.86±0.00	6.08±0.00	69.41±0.00
NT	15 – 30	5.6±0.00	0.03±0.01	3.42±0.00	0.06±0.00	46.39±0.00	2.4±0.00	1.08±0.00	0.08±0.02	0.17+0.01	1.26±0.00	4.99±0.00	74.95± 0.02

UT = Uyo Itam; KT = Okon Itam; DT = Odlok Itam; NT = Ntak Inyang;
N = Nitrogen; Av.P = available phosphorus; Ca = Calcium; Mg = Magnesium; Na = Sodium; K = Potassium; EA = exchangeable acids; ECEC = Exchangeable cation exchange capacity; B.S = Base saturation.

TABLE 4B: CHEMICAL ANALYSIS OF ITU WETLAND SOIL (DRY SEASON)

Sample Code	DEPTH (cm)	pH	EC ds/m	Organic Matter (%)	N (%)	AV.P (Mg/Kg)	Ca (cmol/kg)	Mg	Na	K	EA	ECEC	B.S (%)
UT	0 – 15	5.4±0.02	0.04±0.01	2.32±0.03	0.05±0.00	35.7±0.00	1.68±0.03	1.2±0.01	0.5±0.02	0.14±0.02	1.97±0.00	5.04±0.00	60.9±0.00
UT	15 – 30	5.4±0.01	0.05±0.02	1.06±0.06	0.03±0.01	28.8±0.00	0.70±0.01	0.30±0.01	0.05±0.02	0.29±0.04	0.4±0.00	1.74±0.01	77.0±0.05
KT	0 – 15	5.5±0.01	0.04±0.01	1.4±0.04	0.03±0.01	30.3±0.00	1.2±0.01	1.2±0.01	0.07±0.00	0.08±0.00	23±0.00	5.68±0.00	60.7±0.00
KT	15 – 30	5.5±0.00	0.03±0.01	1.19±0.01	0.03±0.01	28.2±0.04	1.96±0.01	130±0.01	0.07±0.01	0.6±0.09	3.29±0.00	6.68±0.00	50.75±0.02
DT	0 – 15	5.6±0.01	0.03±0.03	3.51±0.01	0.10±0.00	42.3±0.00	2.51±0.00	121±0.01	0.09±0.01	0.16±0.01	2.2±0.00	6.37±0.00	65.4±0.00
DT	15 – 30	5.6±0.01	0.03±0.01	2.03±0.01	0.05±0.00	38.6±0.00	29±0.02	1.08±0.02	0.08±0.00	0.17±0.03	1.26±0.00	4.99±0.00	74.8±0.00
NT	0 – 15	5.5±0.00	0.03±0.01	4.02±0.01	0.13±0.05	45.8±0.01	2.6±0.02	1.8±0.03	0.05±0.02	0.8±0.01	2.76±0.00	7.32±0.06	62.3±0.00
NT	15 – 30	5.5±0.00	0.03±0.01	2.11±0.01	0.05±0.01	42.3±0.00	2.2±0.02	1.2±0.04	0.07±0.00	0.08±0.01	2.10±0.00	5.85±0.00	60.68±0.00

UT = Uyo Itam; KT = Okon Itam; DT = Odiok Itam; NT = Ntak Inyang;
N = Nitrogen; Av.P = available phosphorus; Ca = Calcium; Mg = Magnesium; Na = Sodium; K = Potassium; EA = exchangeable acids; ECEC = Exchangeable cation exchange capacity; B.S = Base saturation.

TABLE 5: MICRONUTRIENTS OF ITU WETLAND SOILS IN WET AND DRY SEASONS

Sample Code	DEPTH (CM)	COPPER (Cu) (mg/kg)		ZINC (Zn) (mg/kg)		IRON (Fe) (mg/kg)		MANGANESE (Mn) (mg/kg)	
		Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
UT	0 – 15	0.6 ±0.01	07±0.01	3.2±0.10	3.2±0.01	38.0±0.02	36.0±0.07	2.5±0.00	2.0±0.00
UT	15 – 30	0.7±0.00	0.7±001	3.3±0.00	3.2±0.01	38.0±0.02	36.2±0.01	1.6±0.00	1.8±0.01
KT	0 – 15	0.8 ± 0.00	0.7±0.01	3.6±0.01	3.2±0.02	39.2±0.00	36.2±0.05	4.7±0.03	4.2±0.00
KT	15 – 30	0.80± .00	0.7±0.01	3.4±0.00	3.2±0.05	39.2±0.07	36.2±0.01	4.7±0.07	4.2±0.00
DT	0 – 15	0.6±0.00	0.7±0.01	3.6±0.00	3.3±0.00	39.6±0.05	36.5±0.00	4.7±0.01	4.5±0.01
DT	15 – 30	0.7±0.00	0.8±0.01	3.4±0.00	3.4±0.04	39.6±0.05	36.5±0.01	4.7±0.02	4.5±0.07
NT	0 – 15	0.9±0.01	0.8±0.01	3.7±0.04	3.4±0.00	39.4±0.00	36.7±0.00	5.0±0.00	4.5±0.05
NT	15 – 30	0.8±0.00	0.8±0.01	3.7±0.04	3.5±0.04	39.4±0.00	36.9±0.02	5.1±0.09	4.7±0.05

UT = Uyo Itam; KT = Okon Itam; DT = Odiok Itam; NT = Ntak Inyang

DISCUSSION

The study was designed to document the microbiological and physicochemical characteristics of the wetland soils in Itu with a view to determining the potential use of such hitherto neglected natural resource/ecosystem.

The microbial counts obtained from this study compared favourably with microbial counts of wetland soils in Eket, Nigeria (Udotong and Akpanekon, 2006a) and Ikot Ekpene (Udotong & Akpanekon, 2006b) in particular and the Niger Delta Region (RPI, 1985; Udotong, 2000) in general. The results from these studies showed a decrease in the microbial counts with increase in soil depth: microbial counts were higher in surface soils (0 - 15cm) than in the sub-surface soils (15-30cm). This could be attributed to the higher availability of favourable growth factors such as organic matter and oxygen at the surface soil (0-15cm) than at the sub-surface soil levels (15-30cm). It also showed increase in the microbial counts during the wet season and a decrease in the dry season. This also could be attributed to the slight variations in the properties of the wetland soils due to climatic changes in both seasons (Higashida and Takao, 1985).

The bacteria, fungi and actinomycetes isolated from the wetland soils of Itu Local Government Area, Nigeria, compared favourably with the microbial isolates from the wetland soils of Eket, Nigeria (Udotong and Akpanekon, 2006a) and Ikot Ekpene (Udotong & Akpanekon, 2006b) in particular and the Niger Delta region (RPI, 1985; Udotong 2000) in general. The microbial isolates obtained from the wetland soil under study in both seasons have been shown to play important roles in plant development as in relation to organic matter decomposition, soil stabilization and mineral cycling activities (Atlas and Bartha, 1998). Species of the genera *Bacillus, Pseudomonas, Proteus, Alcaligenes. Clostridium* and *Arthrobacter* have been involved in mineral cycling activities (Nelson and Myers, 1992; Atlas and Bartha, 1998. The occurrence of some of these isolates like *Pseudomonas, Bacillus* and *Micrococcus* have implicated in crude oil biodegradation (Antai and Mgbomo, 1982; Udotong, 2000).

The particle size distribution of the wetland soil showed that the soil texture provides good drainage and good rooting environment for crops as well as good aerobic conditions for the proliferation of microbes (Landon, 1984). Since the surface soil is fragile and is prone to erosion, minimum or zero tillage, contour tillage, strip cropping and terracing could be employed along the slopes of these wetland soils (Akinsanmi, 1991). The pH of the wetland soils under study also showed the soils to be generally acidic, th pH range of 5.4 at Uyo Itam, Okon Itam, Odio Itam and Ntak Inyang is known to favour the growth of most crops and major biogeochemical cycling processes. Most importantly the soil with this pH, range will favour the cultivation of upland rice.

Chemical analyses results of the wetland soils showed low levels of organic matter as well as total available nitrogen. To help maintain a high level of soil organic matter and nitrogen, crop rotation practices during which cover crops are ploughed into the soil should be encouraged. Crop residues should also be ploughed into the soil after harvesting. The application of nitrogen fertilizers to these soils would also help correct this deficiency. Available phosphorus, potassium and sodium in the wetland soils under study ar typical of some agricultural soils in the Niger Delta Region and can therefore support extensive sustainable agricultural practices (Fagbami, 1994; Obi, 1984). The soils also showed high percentage base saturation, which expresses low degree of leaching indicating its suitability for crop production, if properly managed.

Statistically, there was significant difference between the microbes isolated from the wetland soils under study at $P>0.05$. Interactions between microbes and seasons as well as microbes and soil depths were significantly different at $P>0.05$ and $P>0.01$ respectively. Interactions between microbes and

the wetland soils under study at P>0.05. Interactions between microbes and seasons as well as microbes and soil depths were significantly different at P>O.O5 and P>O.O1 respectively. Interactions between microbes and sampling locations were significantly different P>O.O5. Micronutrients of the wetland soils were significantly different P>O.O1 while interactions between micronutrients and seasons as well as micronutrients and sampling locations were significantly different at P>O.O1 and P:>O.OO1 respectively. There was no correlation in interactions involving soil pH and seasons as well as soil particle size distribution and seasons.

CONCLUSION

A paucity of information on the microbiological and physicochemical characteristics of wetland soils in Itu, Nigeria had contributed to the neglect of this important ecosystem. The result of this study has however provided some baseline data on the microbiological and physicochemical characteristics of wetland soils in Itu, thus providing the basis for the management of wetland soils in Itu for sustainable agricultural development.

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