CONSTRAINTS AND OPPORTUNITIES IN AGRICULTURAL UTILIZATION OF SOME WETLAND SOILS IN AKWA IBOM STATE

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ABSTRACT

A study was conducted to determine the constraints and opportunities in agricultural utilization of some wetland soils in Akwa Ibom State. Soil samples were made representing top (0 – 15cm) and subsoils (15 – 30cm) and were analysed. The soils were characterized by low PH ranged from 1.7 to 3.2, high electrical conductivity ranged from 9.20 to 41.00 dsm^{-1}, high organic carbon ranged from 6.29 to 9.38%, high total nitrogen 0.5 to 0.81%, low available P ranged from 2 to 7 mg kg^{-1}, high Exch. Na ranged from 2.83 to 8.65 cmolkg^{-1}, high Exch. AL ranged from 11.28 to 34.08 cmolkg^{-1}, high CEC ranged from 37.87 to 75.21 cmolkg^{-1}, low ESP ranged from 5 to 19, low SAR ranged from 1 to 3.8 and high percentage AL saturation ranged from 24 to 47.8%. Most of the soils were loamy sand in texture. The soils have great opportunities in agricultural utilization through reclamation, panning, application of rock phosphate, planting of promiscuous soybean variety, establishment of pastures, planting of acid tolerant crops and establishment of fruit tree crops.

INTRODUCTION

Wetland soils are those soils, which are water saturated during most of the months (Onyekwere and Akpan-Idiok 1999). Some of the soils support mangrove trees. Most of these soils are uncultivated because of their water logging and flooding conditions during rainy season.

Cultivated agricultural soils, which used to be fertile have become severely degraded by slash-and-burn agriculture, which is now being practiced with shortened fallow period because of high population growth rate. Farmers in Nigeria are increasingly interested in wetland soils, which are still fertile.

There is an urgent need for a sustainable utilization of the agricultural opportunities of Akwa Ibom wetland soils for increased food production. Efficient and effective management of wetland soils offers an acceptable alternative for sustainable food production.

The objective of the study was to determine the constraints and opportunities in agricultural utilization of some wetland soils in Akwa Ibom State.

MATERIALS AND METHODS

Soil Location:

Soil sample sites were located in the Mangrove soils along coastal areas of Oron and Ebughu in Akwa Ibom State. The soils are derived from fluvio-marine deposit and are washed with marine saline water during tides. The mean annual rainfall of the area ranges from 3,500 to 4,000mm with a mean relative humidity of 80 to 90%. The annual temperature of the area ranges from 26 to 27^{oc} (Bulktrade 1989).

Sample scheme:

Composite soil samples were collected at the depth of 0-15cm for top soils and 15-30cm for sub soils during low tide. The samples were preserved in polythene bags and were transported to the laboratory for preparation. The samples were air-dried, ground and screened through a 2mm- sieve and samples for organic carbon and total nitrogen were received through a 0.5mm sieve prior to laboratory analysis. Soil sampled locations were designated as OWLS 1, OWLS 2, OWLS 3, OWLS 4, EWLS 1,

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EWLS 2, EWLS 3 and EWLS 4 along the coastal areas of Oron and Ebughu.

Analytical Methods:

Soil pH was determined in 1:2 soil/water suspension using a glass electrode: electrical conductivity (EC) was measured in 1:2 soil/water extract using an electrical conductivity meter; organic carbon was determined by Walkey and Black titration method as outlined by Jackson (1969); available phosphorous was determined by Bray and Kurtz No 1 extraction method (Bray and Kurtz 1945); total nitrogen was determined by the 500 ml macro-kjeldahl digestion procedure Jackson (1969); exchangeable bases were extracted with neutral ammonium acetate solution. Ca and Mg were determined by the EDTA titration (Black et al 1973), and K and Na by flame photometery; exchange acidity was determined by KCl extraction methods (Mclean 1965) and particle size was carried out by Bouyoucous (1951) hydrometer method.

RESULT AND DISCUSSION:

The physical/chemical properties of the soils are shown in Table 1. While the mean location values of the physical/chemical properties of top and subsoils are shown in Table 2. The texture of the soil ranged from sand to loamy sand. The soil pH ranged from 1.7 to 3.2. Oron wetland soils had the lower pH mean location value of 2.2 in the topsoils and 2.4 in the subsoils while Ebughu wetland soils had mean location values of 2.7 and 2.8 in the top and sub soils respectively. This shows that the soils may have pyretic materials (FeS_2) that oxidize to Fe^{3+} and sulphuric acid (H_2SO_4) when drained. Such soils having pH value of less than 3.5 can be characterized as "potential acid sulphate soils" (Boul et al 1973).

Both wetland soils were characterized with high electrical conductivity values ranging from 9.20 to 41.0dsm^{-1} with Oron having the higher mean location value of 30.0 dsm^{-1} and 18.5dsm^{-1} in the top and subsoils respectively and Ebughu wetland soils had mean location values of 27.0 and 16.0 and in top and subsoils respectively, exceeding 4dsm-1 indicating that the soils were probably saline and had soluble salts (Donahue et al 1990).

Organic carbon content varied from 6.29 to 9.38% with Oron wetland soils having higher mean location values of 7.4 and 8.2% in the top and subsoils respectively. Ebughu had mean location values of 6.91 and 7.78% in the top and established for the ecological zone by Holland et al (1989). This might be due to slow decomposition rate of litter phase, fibrous mangrove rootlets and slow rate of slighting under water logging condition (Moorman and Pons 1974).

Total Nitrogen content were high ranging from 0.5 to 0.8 to 0.81% with Oron wetland soils having mean location value of 0.7% in the sub soils. Ebughu wetland soils had mean location value of 0.69% in the top soils, exceeding 0.2%, the critical value where response is unlikely and fertilizer may not be necessary (FPDD 1989). The high amount of total Nitrogen in the soils reflects the organic carbon contents of the soils.

The level of C/N ratio ranged from 8.9 to 12.6, with Oron wetland soils having higher mean location value of 11.5 at both top and subsoils and Ebughu 11.4 in top subsoils respectively. This shows that there was net mineralization of nitrogen in the soils (Paul and Clark 1989).

Available P determined by Bray P-I method values were generally low with a range of 2 to 7mgkg^{-1}, with Ebughu having higher mean location values of 4.3 and 5.3 while Oron wetland soils had mean location values of 4.0 and 4.8 in the top and subsoils respectively, having P values less than 10mgkg^{-1} considered suitable for crop production (FAO 1976) and far less than 15mgkg-1 established for all crops in the ecological zone (EPDD 1989). The low available P value content in the soils might be attributed to the fixation of P by Iron and aluminium sesquoxide under drained and acidic condition in the soils (Akpan-Idiok et al 1996).

The level f exchangeable Ca ranged from 6.80 to 16.84 cmolkg^{-1} with Ebughu wetland soils having higher mean location

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value of 12.1 in the topsoils and 8.80 in the subsoils while Oron had mean location value of 11.7 and 9.4 in the top and sub soils respectively. All had exchangeable Ca value higher than 4cmolkg-1 regarded as the lower limit for fertile soils (FAO, 1976). The exchangeable Mg values ranged from 3.41 to 13.8 cmolkg^{-1}, with Ebughu wetland soils having a higher mean location value of 8.3 in the top soils and mean location value of 5.3 in the subsoils while Oron had mean location value of 8.2 and 5.5 in top subsoils respectively. All values were above 0.5cmolkg^{-1} regarded as the critical level of exchangeable Mg (FAO 1976). Exchangeable K in the wetland soils studied ranged 0.16 to 3.39cmolkg^{-1}. Both Oron and Eburghu in the wetland had mean location K value of 1cmolk^{-1} in the top soils and Oron wetland soils had mean location value of 0.7cmolk^{-1} and Ebughu wetland soils 0.4 in the subsoils. Considering that 0.20cmolkg^{-1} is the critical limit of exchangeable K (Unamba-Opara 1985) only Ebughu wetland soil location 3 subsoils and Oron wetland soils location 1 subsoils were not well endowed with K. Exchangeable Na ranged from 2.83 to 8.65cmlkg-1, with Oron wetland soils having higher mean location of 5.0 and 6.5 at the top and subsoils respectively, while Ebughu wetland had mean location values of 4.4 and 6.1 in the top and subsoils respectively. Similar result were obtained in coastal wetland soils of Niger Delta (Anderson 1967). The high exchangeable bases might be attributed to the soluble salts in sea water that floods the swamps at high tides.

Exchangeable AL ranged from 11.28 to 34.08cmolkg^{-1}. Oron wetland soils had high mean location value of 21.8 in the top soils and a lower mean location value of 19.3 in the subsoils, while Ebughu wetland soils had mean location values of 20.1 and 19.6 in the top and subsoils respectively, all locations values exceeding 4cmolkg^{-1} established for the ecological zone (Holland et al 1989). Similarly the soils had high values of hydrogen ions ranging from 5.96 to 19.00cmolkg^{-1} and Oron wetland soils had higher mean location value of 11.0 in the top soils and lower mean location value of 11.9 in the subsoils, while Ebughu wetland soils had mean location value of 9.9 and 13.4 in the top and subsoils respectively.

Effective Cation Exchange Capacity of the soils ranged from 37.87 to 75.21cmolkg^{-1}. Oron wetland soils had a higher mean location value of 56.9cmolkg^{-1} in the top soils and Ebughu wetland soils had higher mean location value of 53.5 in the subsoils while Ebughu wetland soils had mean location value of 55.6 soils had CEC value above 20cmolkg-1 regarded as being suitable for crop production if other factors are favourable (FAO 1976).

The percentage base saturation of the soils ranged from 32 to 63%. With both wetland soils having mean location value of 46% in the topsoils while the subsoils mean location values were 39 for Ebughu wetland soils and 45.5% for Oron wetland soils. Only Oron wetland soils location 4 subsoils exceeded the critical limit of 60% established for the ecological zone (Holland et al 1989).

ESP content varied from 5 to 19. With Ebughu wetland soi : h ving higher mean location value of 8 in the op soils and lower mean value of 11.8 in the subsoils while Oron had mean location value of 7.8% and 13.5% in the top and subsols. The values of SAR ranged from 1 to 3.8 with Oron wetland soil having a higher mean location value of 1.7 while Ebughu had lower value of 1.5 in their topsoils and both had mean value of 2.4 in subsoils. Only Ebughu wetland soils location 2 subsoils, Oron wetland soils, location 3 and 4 subsoils exceeded ESP of 15 and all the locations had SAR far less than 13. These give the indication that all the top soils and most of the subsoils were probably saline and had high soluble salt (Donahue et al 1990).

Percentage aluminium saturation values were generally high ranging from 24 to 47.8%. With Oron wetland soils having higher mean location of 35.9 and 34.3% in the top and subsoils while Ebughu wetland soils had mean location values of 35 and 34% in the top and subsoils respectively. Using Fageria et al (1988) critical toxic level of percentage aluminium saturation of 30%, most of the wetland soils of Oron and Ebughu studied may have problem of aluminium toxicity.

Constraints to Agricultural Production:

Although these wetland soils have enormous agricultural potentials from the studies so far, farmers prefer to cultivate the more easily exploitable uplands. Also policy makers and researchers have neglected these wetland soils. Several factors have been identified to be responsible for the constraints on these soils for agricultural utilization.

Water Logging Condition of these Wetland Soils:

Wetland soils usually have hydromorphic soils, that is, soils whose development and properties were determined by permanent or seasonal water logging which resulted in soil gleying. Gleying takes place when water saturates a soil filling all the pore spaces and driving out the air. This combines with the activities of microorganisms to create anaerobic condition. Although the agricultural potential of hydromorphic soil is usually high or at least higher than that of adjacent well drained soil, are complex and not well understood.

Low P^H Value:

The pH values of both wetland soils were low ranging from 1.7 to 3.2. This gives the indication that the soils were acidic. In tropical soils such as Oxisols and Ultisoils with PH value below 5.0 exchangeable aluminium plays a dominant role in soil acidity which in turn influences crop growth due to its toxicity. Aluminium toxicity is a major limitation to plant growth in acid soils (Bell and Edwards 1987).

High Exchangeable Aluminium Values/Percentage Aluminium Saturation:

Exchangeable aluminium values of both wetland soils were high which resulted to high percentage. aluminium saturation. Using Fageria et al (1988) critical toxic level of percentage aluminium saturation of 30%, most of the soils exceeded percentage aluminium saturation of 30%, which is not tolerant to crop production.

LOW P VALUES:

The available P values of the wetland soil studied were low, which is less than FAO (1976) and FPDD (1989) recommended values. This low P value of the soils makes it difficult for effective agricultural crop production in plant crop growth.

PROBLEM OF SALINITY:

From the data obtained the electrical conductivity of all the locations in both wetland soils studied were high exceeding 4 dsm^{-1}. The ESP of almost all the wetland soils were less than 15 and SAR of all the soils were far less than 13. These give the indication that the soils were probably saline and had high soluble salts. This is injurious to plant root and it inhibits crop growth.

FERTILITY CAPABILITY CLASSIFICATION:

In order to fully explore the potentials of those agricultural lands, the fertility classification for wetlands developed by Robinson and Steele (1972) were used to classify those wetland soils. The scheme groups soils according to their suitability for paddy rice production.

The two wetland soils fall into group P-3 soils moderately suited for paddy with moderate limitation, such limitation, includes one or more of the following, unfavourable texture, salinity or acidity that reduces yield slightly, risk or damage by water shortage or rapid floods.

OPPORTUNITIES FOR AGRICULTURAL UTILIZATION:

Although some constraints of these soils have been discussed earlier, there are a lot of opportunities for agricultural utilization of these wetland soils. They include the following:

GENERAL USAGE:

Wetland soils are productive agricultural ecosystems and feeding grounds for fishes. They are natural resources for fishes, wildlife (including birds) and numerous plant species because of their abundant water resources even in the dry season. Their flora and fauna depend on their structure and the various abiotic and biotic

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forces operating on them. These wetland soils have evolved functional patterns, which tend to join features from both land and water environments. When the seasonal floodwater recedes they leave behind many ponds which contain many algal species and other plant and animal species.

Flooding brings nutrients, which increase the growth rates of microorganisms, and invertebrates which may be consumed directly by fish. Also as the water volume increase in the forest area during flooding, the water engulfs small organisms such as insects, larvae of insects, molluscs etc as well as higher plants and plant materials. These increase the quality and quantity of food for most tropical flood-river fish species (Akachukwu 2000).

Rizipisiculture:

These wetland soils can be utilized for rice/fish-integrated farming. This type of production system has been found to be a low cost method of producing rice and fish (Noble 1996). The fish provides an environmentally friendly natural method of controlling pests and grass weeds in the rice farm. The fish in turn are fed with agricultural wastes. This has been found to promote maximum utilization of the farm resources. In this system, ponds are constructed by the sides of the paddy. The ponds are then stocked with fish. The fish forage the whole paddy at the peak of the rainy season and retire to the ponds during rice harvest (Ano, 2000).

For more agricultural utilization of these soils, the following management practices are further recommended.

RECLAMATION:

These soils can be reclaimed from the sea during dry season using embankments. This can be followed by flushing out the acidity by readmitting the saline water into the field through sluices of embankments. The sluices can then be closed to keep out the tidal water. The salts from the water can now be leached using fresh water (Anderson, 1966) cited by Onyekwere and Akpan-Idiok (1999).

LIMING:

The reclaimed soils stated above can be limed to neutralize the remaining acidity of the soils. Lime should be added to the soil to improve pH of the soil by inactivating soluble or reactive aluminium. This should be applied by an expert. After equilibrating a given weight of soil with increasing amount of $Ca(OH)_2$ measuring the equibrated suspension and plotting the pH values measured against the amount of $Ca(OH)_2$ added. The quantity of $Ca(OH)_2$ needed to raise the soil sample to pH value which is desired for the plough layer of the soils in question is then obtained from the graph (FDA 1979). Care should be taken while applying lime because if not well applied it will result in undesirable side-effects such as reduced availability of slow release fertilizer, micro nutrient deficiencies and heavy weed infestation (Sanchez and Salinas 1981, Kang and Okigbo 1981) cited by Kari et al (1994).

Application of Rock Phosphate Fertilizer:

The wetland soils studied had low P values and low PH values which are desirable for effective crop production. There is a need to increase the PH of the soils and increase the P availability. This can be achieved by the application of rock phosphate fertilizer a slow releasing fertilizer. Ali (1995) obtained the following result from the residual effect of rock phosphate on soil pH compared to single super phosphate.

Residual effect of rock phosphate on pH (H20) 2nd cropping

P Sources	0	100	200	300	400	Grand mean
TRP	5.50	5.60	6.50	6.20	5.70	5.90
SRP	5.50	5.50	6.20	6.60	6.70	6.10
SSP	5.50	5.70	5.40	4.90	5.50	5.40

TRP = Togo Rock Phosphate SRP = Sokoto Rock Phosphate

SSP = Single Super Phosphate.

The two-rock phosphate that is Togo and Sokoto rock phosphate gave better result compared to single super phosphate. Of greater significance is the P residual fertility of rock phosphate. It is suggested that once

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the P level in the soil is built up by the application of a basal dose of rock phosphate, reduced maintenance rates of the more expensive single super phosphate can be applied annually to maintain optimum yield (Mokwunya 1976). Khasawneh and Doll (1978) reported that rock phosphate has been known to persist in some soils for at least 40 years and therefore, the residual effect of rock phosphate are considerable.

Planting of Promiscuous Soybean Variety:

The reclaimed soils are acidic and with low available P content. The pH can be increased and available P content increased through planting of promiscuous soybean variety. Mohammed (2001) reported that the residual effect of promiscuous soybean apart from increasing soil Nitrogen content reduces the soil acidity by increasing the pH value increases the value of soil available P through symbiotic association with mycorrhizas. This management practice can make these wetland soils viable for increased crop production.

Establishment of Pasture for Livestock:

The reclaimed soils under drained condition is acidic which is as a result of oxidation of pyrite to Fe^{3+} and sulphric acid. These soils studied are extremely acidic and going by the values of the percentage aluminium saturation the soils may have problem of aluminium toxicity. Research has shown that some tropical pastures can tolerate high level of percentage aluminium saturation. The following species *Branchiaria humidicola, Andropogon. gayanus, Melinis minulifiora tolarate aluminium* saturation level of 70.90%. *Panicum maximum, Pennisetum purpureum* withstand 20-25%, *Stylosanthes Spp* 70-90% and *Leucaera lecocephala* tolerate 30% (Kari et al 1994). The soils can be used in the establishment of the above mentioned pastures for livestocks grazing.

Though livestock is part of farming system in Akwa Ibom State, there is no proper integration of livestock and crop production systems in the areas studied. Livestock systems directly or indirectly affect the following three aspects of nutrient cycling in the farming systems.

(i) Redistribution of nutrients: Nutrients are brought in or up from deeper soil level by trees whose leaves are fed to livestock.

(ii) Increasing nutrient availability: Nutrients from crop residues and other feeds become more available for the plant when converted to manure.

(iii) Increasing in nitrogen supply: Livestock require protein and other nutrients to meet their requirement, legumes are brought outside to feed the livestock. This causes an increase of nitrogen in the system (Ano 1997).

It therefore followed that proper integration of livestock and crop production systems would be beneficial to the farming system of these wetland soils.

PLANTING OF CROP SPECIES AND CULTIVARS THAT ARE ACID TOLERANT:

Some species and even different cultivars of the same species differ considerably in their tolerance to excess aluminium and low level of available P in acid soils. According to Spain et al (1975) rice and cassava have been found to tolerate up to 68 to 75% aluminium saturation. Cowpeas, maize and black beans 31 to 45%. According to Karl (1994) some crops generally known for withstanding aluminium toxicity include cassava, cowpea and rice. These soils can be used in low land rice production and the reclaimed soils can be used in production of cassava, cowpea, maize and black beans or if not reclaimed they can be planted during dry season.

Establishment of Tree/Fruit Crops:

These wetland soils can be used in the establishment of tree/fruit crops. Research had shown that some tree/fruit crops can withstand high percentage aluminium saturation. According to Spain et al (1975), mango, cashew, citrus and pineapple have been found to tolerate up to 68 to 75 aluminium saturation and plantain 45 to 58%. Relatively, aluminium tolerant fruits include

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the passion fruit, pineapple, guava and mango, while some trees that tolerate aluminium are heave, coffee, the peach palms, oil palms, raffia palms and Gmelina.

CONCLUSION:

From the above account it could be concluded that the wetland soils studied though characterized by low pH, low P, high percentage aluminium saturation and being saline their agricultural utilization is high following proper management practices.

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TABLE I **PHYSICAL/CHEMICAL PROPERTIES OF ORON WETLAND SOILS**

LOCATION	DEPTH	pH	EC	OR OC	TOTAL N	C/N	BRAY P-I	EXCH. BASES (cmolk-1)				EXCH ACID (cmol kg⁻¹)			BS
			dsm^{-1}	%	%	RATIO	$mgkg^{-1}$	Ca	mg	K	Na	Al	H	ECEC	%
OWLS 1															
	A	2.1	41.0	8.38	0.72	11.6	7	10.24	4.98	0.18	7.79	34.08	14.00	71.27	33
	B	2.1	9.80	7.78	0.70	11.1	5	11.20	9.96	0.10	5.91	32.04	19.00	75.21	32
OWLS 2															
	A	2.7	20.14	6.89	0.67	10.3	5	6.80	3.40	3.40	2.83	12.20	11.22	46.85	43
	B	2.2	22.14	8.99	0.78	11.5	7	7.68	4.98	0.18	3.35	11.28	10.40	37.87	43
OWLS 3															
	A	1.7	26.13	6.29	0.50	12.6	3	12.80	13.80	0.20	3.26	19.68	12.24	61.98	48
	B	2.3	13.01	6.68	0.58	11.5	3	7.04	3.80	0.40	8.65	13.92	12.04	46.94	44
OWLS 4															
	A	22	32.51	7.98	0.70	11.4	2	16.80	10.52	0.21	6.30	21.40	6.40	56.63	60
	B	3.0	28.97	9.38	0.80	11.7	4	11.54	6.08	2.21	8.21	19.96	5.96	57.60	63

A = 0 - 15CM
B = 15 - 30CM
OWLS = Oron Wetland Soils

S = Sand
LS = Loamy sand
SL = Sandy loam.

TABLE 1

PHYSICAL/CHEMICAL PROPERTIES OF EBUGHU WETLAND SOILS

S/N	LOCATION	DEPTH	hH	EC dsm^{-1}	ORG C %	TOTAL N %	C/N RATIO %	BRAY P-1 mgKg^{-1}	EXCH. BASES (cmol Kg^{-1}) Ca	mg	K	Na	EXCH ACID (cmol kg^{-1}) Al	H	ECEC	BS %
	EWLS 1															
1		A	2.7	30.05	6.79	0.75	9.1	4	11.66	8.18	0.23	4.50	19.79	10.58	54.74	45
2		B	2.9	18.50	7.20	0.81	8.9	5	9.40	5.46	0.75	5.22	17.05	11.85	49.73	42
	EWLS 2															
3		A	2.2	26.78	6.49	0.52	12.5	4	12.85	10.80	0.31	3.25	19.04	12.25	58.50	47
4		B	2.8.	14.01	6.88	0.60	11.5	4	7.00	3.80	0.52	8.63	13.90	12.06	45.91	43
	EWLS 3															
5		A	2.7	30.52	7.79	0.71	11.0	3	16.84	10.52	0.21	6.30	30.11	6.33	70.31	48
6		B	2.6	9.20	7.98	0.69	11.6	S5	11.11	6.96	0.10	5.91	28.13	19.00	71.21	34
	EWLS 4															
7		A	3.2	20.44	6.59	0.74	8.9	6	6.83	3.41	3.39	3.35	11.29	10.40	38.67	44
8		B	2.7	22.54	8.67	0.68	12.6	7	7.70	4.96	0.20	4.50	19.29	10.58	47.23	37

A = 0 15CM
B = 15 – 30CM
EWLS = Ebughu Wetland Soils

S = Sand
LS = Loamy sand
SL = Sandy loam

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MEAN LOCATION VALUES OF THE PHYSICAL/CHEMICAL PROPERTIES OF ORON WETLAND SOIL

SOIL PROPERTIES	TOP SOILS	SUB SOILS
PH	2.2	2.4
Electrical conductivity (Ec) dsm^{-1}	30.0	18.5
Organic Carbon (%)	7.4	8.2
Total Nitrogen (%)	0.6	0.7
C/N Ratio	11.5	11.5
Bray P – 1 (mg kg^{-1})	4.0	4.8
Exchangeable Basis (cmol Kg^{-1})		
Ca	11.7	9.4
Mg	8.2	5.5
K	1.0	6.7
Na	5.0	4.8
Exchangeable Acid (cmol kg^{-1})		
A1	21.8	19.3
H	11.0	11.9
Effective Cation Exchange capacity (cmol kg^{-1})	56.9	51.2
Percentage Bases Saturation (%BS)	46	45.5
Sodium Adsorption Ratio (SAR)	1.7	2.4
Exchange Sodium percentage (Esp)	7.8	13.5
Percentage Aluminium Saturation		
Particular Size Analysis (% of 2mm)	35.9	34.3
Sand	77.3	84.9
Silt	13.5	6.8
Clay	9.2	8.3
PH	2.7	2.8
Electrical conductivity (Ec) dsm^{-1}	27.0	16.0
Organic Carbon (%)	6.9	7.7
Total Nitrogen (%)	0.7	0.70
C/N Ratio	10.5	11.1
Bray P – 1 (Mg Kg^{-1})	4.3	5.3
Exchangeable Basis (cmol kg^{-1})		
Ca	12.1	8.8
Mg	8.3	5.3
K	1.0	0.4
Na	4.4	6.1
Exchangeable Acid (cmol Kg^{-1})		
A1	20.1	19.6
H	9.9	13.4
Effective Cation Exchange capacity (cmol kg^{-1})	55.6	53.5
Percentage Bases Saturation (%BS)	46	39
Sodium Adsorption Ratio (SAR)	1.5	2.4
Exchange Sodium percentage (Esp)	8.0	11.8
Percentage Aliminium Saturation	35	34
Particular Size Analysis (% of 2mm)		
Sand	80.6	85.5
Silt	11.5	7.1
Clay	7.9	7.4

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