Scientia Africana, Vol. 22 (No. 1), April, 2023. Pp 297-310 https://dx.doi.org/10.4314/sa.v22i1.25

ISSN 1118 – 1931

ASSESSMENT OF PHYSICOCHEMICAL PROPERTIES OF SOME CULTIVATED FLOODPLAINS IN EKITI STATE, SOUTHWEST NIGERIA

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Received: 03-04-2023
Accepted: 14-04-2023

ABSTRACT

Crop productivity depends to a large extent on the physicochemical properties of soil on which it is grown because the later has direct relationship to the nutrient requirements and uptake of crops. Floodplains are notable for seasonal utilization to produce crops especially fruits and vegetables for our teeming population. However, the floodplains can be affected by rainfall/storm regime in a way that can impact nutrients availability negatively. It is on this premise that this research was conducted to investigate physicochemical properties of some floodplains in Ekiti State, Nigeria to ascertain their suitability for crop production. Soil samples (0-30 cm) were collected at 5 m, 25 m and 45 m perpendicular distance to each of the three river parts at upper, middle and lower portion of the river channel. The samples were air-dried, milled, sieved and subjected to physicochemical analyses using standard methods. The ranges of the physicochemical properties are pH (5.02-7.13), electrical conductivity (34.00-571.00 µS/cm), organic matter (0.14-3.77 %), nitrogen (0.03-1.47 %), Ca^{2+} (0.23-4.94 cmol/kg), Mg^{2+} (0.15-4.64 cmol/kg), Na^{+} (1.20-3.62 cmol/kg), K^{+} (2.15-19.75 cmol/kg), Al^{3+} (0.41-23.02 cmol/kg), H^{+} (0.34-28.71 cmol/kg) and CEC (9.53-65.32 cmol/kg). In general, the floodplains are slightly acidic with low organic matter content typical of West African sub-region, sandy loam with moderate cation exchange capacity. It is recommended that the floodplains under study be treated to reduce the exchangeable sodium percentage for better crop production. The acidic soils are also recommended to be limed in order to prevent the possibility of pollutants like heavy metals from entering into the food chain. Recommendations are made to improve the soils' physicochemical condition for increased food production.

Keywords: Physicochemical properties, Soil nutrients, Crop production, Floodplains, Ekiti State, Nigeria

INTRODUCTION

The world population has been projected to be about 8.5billion by year 2030 (UNDP, 2015). The figure has created a lot of concerns for many world economies, Nigeria inclusive. This is because the bogus figure would involve increased resources to meet the demands of the people, one of which is food. Unfortunately, agriculture which is an important sector that could have helped in increasing food production is facing constraints of scarcity of land and decline in soil fertility (Udo *et al*., 2009). It was in realization of the above that Nigerian government encouraged farmers to cultivate floodplains for growing food crops that can be planted and harvested within the dry season in order to boost the food security of the nation (Akpan *et al*., 2017).

Floodplains are seasonally flooded areas of land adjacent to streams and rivers that stretch from the river bank to the base of the enclosing valley walls (Osakwe *et al*., 2014) and which experience flooding during periods of high discharge of rainfall (Olawale *et al*., 2017).

Flooding encourages overbank depositions which add to the fertility of the floodplain soils or otherwise by altering their physicochemical properties (Visher *et al*., 2009; Hector, 2011; Olawale *et al*., 2017; Fomenky *et al*., 2018). The physicochemical properties of soil play important roles in determining the type of vegetation; being very complex, non-linearly related and are usually spatially and temporally dynamic (Rakesh *et al*., 2012; Osakwe, 2014).

For example, soil texture and acidity serve to indicate the absorption and accumulation pattern of mineral elements by plants and thus play a very important role in vegetation establishment and development (Mamun *et al*., 2011; Triphati and Mistra, 2012). The value of soil pH depends on the type of parent materials from which the soil was formed and it is affected by rainfall, due to leaching of basic nutrients such as Ca^{2+} and Mg^{2+} from the soil and their replacement by acidic elements such as Al^{3+} and Fe^{3+} (Michael and Arguin, 2010; Ovai and Eko, 2020). The pH greatly affects trace metal complexation, either through solubility equilibria or due to complexation by soluble surface ligands (Ovai and Eko, 2020). The organic matter helps in binding trace metals and serves to move metallic ions in the soil and in making the metals available to the plants (Rakesh *et al*., 2012). It is also known to play a role in the water holding ability of a soil.

A lot of research works on soil physicochemical characteristics have been carried out worldwide (Hector *et al*., 2011; Rai *et al*., 2012, Tukura *et al*., 2013; Osakwe, 2014; Afu *et al*., 2019) but information on physicochemical properties of cultivated floodplains in Nigeria is scanty. The aim of this study is to evaluate the physicochemical characteristics of some cultivated floodplains in Ekiti State, Southwest Nigeria with a view to determining the suitability of the floodplain for planting food crops and to generate data to complement the existing ones.

MATERIALS AND METHODS

Description of the Study Area

The "FADAMA" farms are located at Irintan (Ogbese, Ise-Ekiti), Omi-Eye (Erio-Ekiti) and Egbigbu (Ayetoro-Ekiti) floodplains located at southern, central and northern senatorial districts of Ekiti State respectively. The coordinates of the farms' locations taken with GPS e-trek 10 are: Longitude – 05^0 22.019' E, Latitude - 07^0 30.528' N (Altitude – 420 m); Longitude – 04^0 52.882' E Latitude - 07^0 43.450'N (Altitude – 417 m); Longitude - 05^0 09.131' E, Latitude - 07^0 55.457' N (Altitude – 531 m) respectively.

Scientia Africana, Vol. 22 (No. 1), April, 2023. Pp 297-310 https://dx.doi.org/10.4314/sa.v22i1.25
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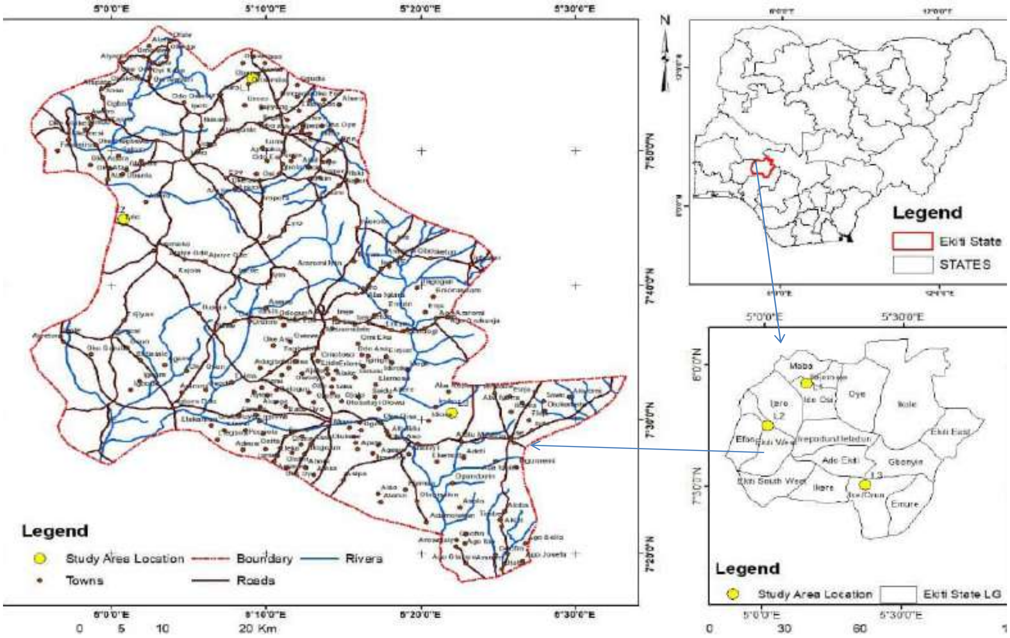

Fig. 1: Map of Ekiti State of the Sampling Sites

The area lies within the humid environment characterized by two distinct seasons (dry and wet seasons). The wet season also known as rainy season spans between April and October while the dry season lasts between November and March. The area has annual rainfall of about 1600 mm and 2100 mm. The mean daily maximum temperature ranges from 30-35 ^{0}C while the mean daily minimum temperature ranges from 21-26 ^{0}C (Akinyemi *et al*, 2013). Cultivation of crops like maize, vegetables, pepper, rice and garden egg takes place on these floodplains.

Soil Sample Collection, Treatment and Analysis

Soil samples (0-30 cm) were collected at 5 m, 25 m and 45 m perpendicular distance to each of the three river paths at upper, middle and lower portion of the river channel. A control sample was taken at a distance of a kilometer away from the farm. In the laboratory, soil samples were spread on plastic trays and allowed to air dry in dust free open laboratory until they were loose, then disaggregated using mortar and pestle, sieved through 2.0 mm BS mesh and kept in PET bottles pending analysis.

The pH of the soil sample was determined using glass electrode pH meter in a solid-liquid ratio of 1:2 following the procedure outlined by SERAS, (2002). Electrical conductivity (EC), organic matter and total nitrogen were determined using methods described by Osakwe and Okolie, (2015). Exchangeable bases were determined by extraction method with 1 M ammonium acetate at pH 7 (Afu *et al*., 2019). The Ca^{2+} and Mg^{2+} in the leachate were analysed by Ethylene Diamine Tetra Acetic acid (EDTA) titration while K^+ and Na^+in the leachate were analysed by flame photometer (Osakwe 2014). Exchangeable acidity (H^+ and Al^{3+}) were determined by titrimetric method using 1 M KCl extract (Afu *et al*., 2019).

Quality Assurance

All glass wares were first soaked in 14 % HNO_3 for 24 hours to remove possible contaminants, washed with detergent and rinsed with de-ionized water before commencing analysis. Quality control was assured through replicate samples, use of pure analytical grade reagents and procedural blanks (Olawale *et al*., 2017).

RESULTS AND DISCUSSION

The soil physicochemical properties at Irintan, Omi-Eye and Egbigbu floodplains are presented in Tables 1, 2 and 3 respectively. The soil pH ranged between 5.05 and 6.41 at the depth of 0-10 cm, 5.65 and 6.67 at depth 10-20 cm, 6.19 and 6.83 at depth 20-30 cm in Irintan floodplain (Table 1); 6.01 and 7.04 at the depth of 0-10 cm, 6.38 and 7.08 at depth 10-20 cm, 6.45 and 7.13 at 20-30 cm in Omi-Eye floodplain (Table 2); 5.14 and 6.65 at depth 0-10 cm, 5.02 and 6.62 at 10-20 cm, 5.41 and 6.77 at 20-30 cm in Egbigbu floodplain (Table 3). This suggests that the soil pH increase from acidic towards alkaline as the depth increased down the soil profile.

Table 1: Physicochemical Characteristics of soil from Irintan Floodplain

R/course					Upper									Middle	
Distance		5m			25m			45m			5m			25m	
Depth (cm)	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30
pH	5.44^{a} ±0.06	6.54^{b} ±0.03	6.44^{b} ±0.26	6.21^{a} ±0.02	6.67^{b} ±0.00	6.21^{a} ±0.15	6.41^{b} ±0.04	5.95^{a} ±0.00	6.57^{c} ±0.02	5.05^{a} ±0.03	6.01^{b} ±0.00	6.19^{b} ±0.00	5.64^{a} ±0.00	6.38^{b} ±0.05	6.43^{b} ±0.02
EC	135.67^{c} ±3.51	121.00^{b} ±9.00	41.67^{a} ±2.52	267.67^{b} ± 3.51	106.24^{a} ±2.09	101.00^{a} ±9.18	231.00^{b} ±7.00	61.00^{a} ±3.00	57.67^{a} ±2.52	463.67^{b} ±4.51	85.73^{a} ±2.52	89.12^{a} ±1.03	172.89^{c} ±3.15	59.00^{b} ±2.00	53.00^{a} ±0.05
OM	2.55^{c} ±0.08	1.10^{b} ±0.00	0.38^{a} ±0.02	3.08^{c} ±0.02	2.66^{b} ±0.05	1.23^{a} ±0.07	3.27^{c} ±0.02	1.41^{b} ±0.12	0.89^{a} ±0.05	3.55^{b} ±0.17	1.31^{a} ±0.00	1.12^{a} ±0.10	2.12^{a} ±0.06	0.29^{b} ±0.00	0.33^{b} ±0.00
TN	0.94^{c} ±0.04	0.34^{b} ±0.00	0.13^{a} ±0.00	1.11^{b} ±0.05	1.01^{b} ±0.00	0.48^{a} ±0.07	1.19^{b} ±0.00	0.39^{a} ±0.09	0.38^{a} ±0.02	1.31^{b} ±0.07	0.53^{a} ±0.03	0.44^{a} ±0.00	0.77^{b} ±0.00	0.13^{a} ±0.07	0.11^{a} ±0.00
Ca^{2+}	1.65^{b} ±0.00	1.85^{b} ±0.15	1.10^{a} ±0.03	4.94^{b} ±0.00	2.55^{a} ±0.75	2.65^{a} ±0.03	3.22^{c} ±0.02	1.70^{a} ±0.10	2.55^{b} ±0.00	0.65^{b} ±0.08	1.35^{a} ±0.35	4.18^{c} ±0.20	1.84^{b} ±0.00	0.40^{a} ±0.10	0.35^{a} ±0.05
Mg^{2+}	2.05^{b} ±0.09	0.20^{a} ±0.01	0.95^{a} ±0.15	0.50^{a} ±0.13	0.80^{a} ±0.00	1.05^{a} ±0.08	0.55^{c} ±0.20	0.35^{a,b} ±0.05	0.22^{a} ±0.00	0.75^{a} ±0.03	0.75^{a} ±0.25	0.85^{a} ±0.05	1.10^{c} ±0.06	0.25^{a} ±0.00	0.57^{a,b} ±0.02
Na^{+}	1.89^{c} ±0.00	1.82^{b} ±0.03	1.77^{a} ±0.20	2.13^{b} ±0.20	1.46^{a} ±0.01	1.42^{a} ±0.14	1.85^{b} ±0.03	1.63^{a} ±0.05	1.60^{a} ±0.00	2.60^{b} ±0.26	2.65^{a} ±0.05	2.28^{a} ±0.03	2.20^{a} ±0.01	1.88^{a} ±0.08	2.38^{a} ±0.41
K^{+}	9.47^{a} ±0.12	10.33^{b} ±0.18	11.98^{c} ±0.08	7.35^{a} ±0.15	7.73^{b} ±0.13	8.28^{c} ±0.08	3.08^{a} ±0.18	3.28^{a} ±1.03	3.75^{b} ±0.05	9.68^{a} ±0.13	10.10^{b} ±3.15	11.60^{c} ±0.90	12.25^{a} ±0.15	12.68^{b} ±4.63	13.43^{c} ±0.03
Al^{3+}	5.17^{b} ±0.00	5.17^{b} ±0.45	1.29^{a} ±0.32	8.28^{a} ±1.60	8.25^{a} ±0.20	19.14^{b} ±2.79	23.02^{b} ±0.09	7.76^{a} ±0.83	7.50^{a} ±1.19	11.38^{b} ±1.05	8.57^{b} ±0.97	10.86^{a} ±0.00	6.98^{b} ±1.55	16.26^{c} ±0.00	0.44^{a} ±0.05
H^{+}	5.43^{c} ±0.78	2.33^{b} ±0.00	0.78^{a} ±0.00	9.57^{a} ±0.45	9.57^{a} ±0.40	11.90^{b} ±0.45	8.79^{b} ±0.22	5.17^{a} ±0.05	12.67^{c} ±2.73	8.41^{a} ±0.22	9.31^{b} ±0.00	9.83^{b} ±0.14	13.97^{b} ±3.88	4.14^{a} ±1.19	0.34^{a} ±0.05
ECEC	26.66	21.70	17.87	32.77	30.36	44.44	41.51	19.89	28.29	33.47	32.73	39.60	38.34	36.61	17.51
BS (%)	56.49	65.44	88.42	45.25	41.30	30.15	21.48	34.99	28.70	40.87	45.37	47.75	45.36	41.55	95.55

EC= Electrical Conductivity, OM= Organic Matter, TN= Total Nitrogen, ECEC= Effective Cation Exchange Capacity, BS= Base Saturation

Table 1: Physicochemical Characteristics of soil from Irintan Floodplain contd

R/course							Lower							Control	
Distance		45m			5m			25m			45m				
Depth (cm)	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30
pH	5.87^{a} ±0.06	6.54^{b} ±0.00	6.83^{c} ±0.01	6.24^{a} ±0.01	6.25^{a} ±0.05	6.25^{a} ±0.00	6.04^{a} ±0.01	6.62^{c} ±0.00	6.57^{b} ±0.02	5.82^{b} ±0.02	5.65^{a} ±0.00	6.29^{c} ±0.00	6.14^{a} ±0.01	6.93^{b} ±0.00	7.33^{c} ±0.01
EC	77.00^{c} ±6.00	61.00^{b} ±2.15	45.00^{a} ±3.00	205.00^{c} ±4.00	71.00^{a} ±2.00	87.67^{b} ±0.57	171.67^{c} ±0.58	75.15^{b} ±1.53	48.00^{a} ±0.00	126.07^{c} ±2.51	74.24^{b} ±0.58	55.35^{a} ±0.25	131.20^{c} ±0.50	37.00^{b} ±1.00	18.67^{a} ±0.85
OM	0.39^{b} ±0.00	0.13^{a} ±0.09	3.11^{c} ±0.02	2.98^{c} ±0.08	1.03^{b} ±0.02	0.14^{a} ±0.09	0.43^{a} ±0.12	0.97^{b} ±0.03	0.35^{a} ±0.04	3.33^{b} ±0.07	1.00^{a} ±0.01	0.91^{a} ±0.08	2.04^{c} ±0.07	1.31^{b} ±0.01	0.15^{a} ±0.00
TN	0.10^{b} ±0.02	0.03^{a} ±0.00	1.19^{c} ±0.01	1.08^{c} ±0.00	0.36^{b} ±0.00	0.05^{a} ±0.02	0.19^{b} ±0.02	0.38^{c} ±0.00	0.12^{a} 0.00	1.22^{c} ±0.07	0.44^{b} ±0.00	0.31^{a} ±0.00	0.67^{b} ±0.06	0.59^{b} ±0.18	0.06^{a} ±0.00
Ca^{2+}	1.85^{c} ±0.00	0.55^{b} ±0.02	0.23^{a} ±0.06	2.54^{b} ±0.30	1.15^{a} ±0.00	1.25^{a} ±0.00	3.35^{b} ±0.07	2.24^{a} ±0.02	2.10^{a} ±0.19	2.94^{b} ±0.00	2.25^{a} ±0.10	3.30^{b} ±0.03	2.59^{b} ±0.10	2.04^{a} ±0.05	2.15^{a} ±0.00

Scientia Africana, Vol. 22 (No. 1), April, 2023. Pp 297-310 https://dx.doi.org/10.4314/sa.v22i1.25
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Mg^{2+}	0.50^{a} ±0.00	0.50^{a} ±0.03	0.45^{a} ±0.01	0.51^{a} ±0.10	1.50^{c} ±0.08	$0.60^{a,b}$ ±0.00	0.25^{a} ±0.03	0.95^{b} ±0.00	0.95^{b} ±0.01	0.75^{a} ±0.35	1.75^{b} ±0.05	0.50^{a} ±0.10	0.25^{a} ±0.05	0.15^{a} ±0.00	0.95^{b} ±0.00
Na^{+}	2.09^{c} ±0.03	1.69^{b} ±0.28	1.55^{a} ±0.00	2.64^{a} ±0.48	2.51^{b} ±0.03	2.42^{b} ±0.12	2.47^{c} ±0.09	2.22^{b} ±0.00	2.01^{a} ±0.00	2.28^{c} ±0.00	2.13^{b} ±0.03	1.91^{a} ±0.05	1.96^{b} ±0.10	1.70^{a} ±0.03	1.75^{a} ±0.01
K^{+}	4.80^{a} ±0.10	4.78^{a} ±0.04	6.00^{a} ±1.26	8.78^{a} ±0.20	10.06^{b} ±0.13	10.98^{c} ±0.08	6.63^{a} ±0.00	7.03^{b} ±0.13	7.73^{c} ±0.83	2.40^{a} ±0.00	3.95^{b} ±0.10	4.23^{b} ±0.00	1.20^{c} ±0.00	1.10^{b} ±0.00	0.85^{a} ±0.05
Al^{3+}	10.61^{b} ±0.00	9.83^{b} ±1.44	6.98^{a} ±0.78	11.38^{b} ±1.95	12.42^{b} ±0.00	6.98^{a} ±0.00	6.98^{a} ±0.00	7.50^{c} ±0.00	5.43^{a} ±0.03	7.50^{b} ±0.00	10.09^{c} ±0.78	4.40^{a} ±1.19	8.83^{a} ±0.05	9.25^{a} ±1.62	6.28^{a} ±0.90
H^{+}	5.69^{a} ±0.08	4.66^{a} ±1.55	9.31^{b} ±1.25	8.79^{b} ±1.95	6.98^{b} ±0.78	2.85^{a} ±0.45	6.73^{b} ±0.15	1.03^{a} ±0.08	7.50^{b} ±0.40	8.02^{a} ±1.19	13.71^{c} ±0.11	9.57^{b} ±0.00	22.50^{c} ±0.78	2.83^{a} ±0.86	10.34^{b} ±0.09
ECEC	25.54	22.01	24.52	34.64	34.62	25.08	26.41	20.97	25.72	23.89	33.88	23.91	37.55	15.84	24.32
BS (%)	36.18	34.17	33.56	41.77	43.96	60.81	48.09	59.32	49.73	35.04	29.75	41.57	15.98	31.50	23.44

EC= Electrical Conductivity, OM= Organic Matter, TN= Total Nitrogen, ECEC= Effective Cation Exchange Capacity, BS= Base Saturation

Table 2: Physicochemical Characteristics of soil from Omi-Eye Floodplain

R/course				Upper									Middle		
Distance		5m			25m			45m			5m			25m	
Depth (cm)	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30
pH	6.41^{a} ±0.08	7.08^{b} ±0.24	7.12^{b} ±0.02	7.04^{c} ±0.04	6.63^{a} ±0.15	6.82^{b} ±0.02	6.35^{a} ±0.14	6.73^{b} ±0.24	$6.55^{a,b}$ ±0.05	6.67^{a} ±0.13	6.91^{b} ±0.08	$6.79^{a,b}$ ±0.03	6.48^{a} ±0.02	6.80^{b} ±0.16	6.80^{b} ±0.03
EC	219.00^{b} ±5.00	36.67^{a} ±0.58	37.00^{a} ±2.00	34.00^{a} ±4.00	213.00^{b} ±7.00	34.00^{a} ±3.00	131.00^{b} ±5.00	58.00^{a} ±1.00	64.67^{a} ±4.50	159.67^{c} ±0.58	141.3^{b} ±0.00	43.00^{a} ±3.00	277.00^{b} ±10.00	37.00^{a} ±5.00	46.67^{a} ±2.50
OM	3.10^{c} ±0.09	1.49^{b} ±0.13	0.97^{a} ±0.09	0.96^{b} ±0.07	2.70^{c} ±0.00	0.60^{a} ±0.10	1.87^{c} ±0.05	1.87^{c} ±0.05	0.99^{a} ±0.08	3.09^{c} ±0.04	2.69^{b} ±0.00	1.84^{a} ±0.00	1.95^{b} ±0.03	1.60^{a} ±0.06	1.63^{a} ±0.00
TN	1.26^{b} ±0.08	0.41^{a} ±0.00	0.44^{a} ±0.05	0.41^{b} ±0.07	1.00^{c} ±0.00	0.27^{a} ±0.02	0.64^{c} ±0.03	0.50^{b} ±0.00	0.38^{a} ±0.00	1.08^{b} ±0.07	1.00^{b} ±0.10	0.72^{a} ±0.02	0.73^{c} ±0.00	0.66^{b} ±0.03	0.61^{a} ±0.02
Ca^{2+}	2.65^{b} ±0.25	0.80^{a} ±0.00	0.65^{a} ±0.00	0.85^{a} ±0.15	2.15^{b} ±0.05	2.25^{b} ±0.25	1.48^{a} ±0.08	2.90^{b} ±0.00	1.75^{a} ±0.35	2.90^{b} ±0.11	2.55^{b} ±0.05	1.30^{a} ±0.18	4.20^{b} ±0.10	1.65^{a} ±0.15	1.70^{a} ±0.10
Mg^{2+}	0.89^{a} ±0.03	0.60^{a} ±0.07	0.30^{a} ±0.05	0.35^{a} ±0.15	0.75^{b} ±0.05	0.20^{a} ±0.00	0.85^{c} ±0.05	0.15^{a} ±0.00	0.35^{b} ±0.00	0.54^{b} ±0.15	0.60^{b} ±0.00	0.25^{a} ±0.03	0.45^{b} ±0.00	1.40^{c} ±0.20	0.15^{a} ±0.05
Na^{+}	1. 92^{b} ±0.00	1. 25^{a} ±0.04	1. 20^{a} ±0.09	1. 82^{b} ±0.02	1. 78^{b} ±0.06	1. 61^{a} ±0.25	1. 73^{b} ±0.17	1. 50^{a} ±0.04	1. 38^{a} ±0.09	1. 94^{b} ±0.01	1. 67^{a} ±0.16	1. 57^{a} ±0.07	2. 48^{b} ±0.04	1. 69^{a} ±0.26	1. 48^{a} ±0.11
K^{+}	18.10^{a} ±0.10	19.45^{b} ±0.00	19.75^{c} ±0.00	15.08^{a} ±0.18	16.50^{b} ±0.20	17.78^{c} ±0.13	4.43^{a} ±0.03	4.95^{b} ±0.25	6.16^{c} ±0.05	17.75^{a} ±0.15	18.18^{b} ±0.08	18.43^{c} ±0.13	14.20^{a} ±0.20	14.75^{a} ±0.05	15.40^{b} ±0.54
Al^{3+}	9.31^{a} ±0.00	9.31^{a} ±0.78	9.31^{a} ±0.22	7.50^{a} ±0.05	8.28^{a} ±0.00	12.15^{b} ±0.10	15.26^{b} ±0.45	8.28^{c} ±0.00	5.95^{a} ±0.17	8.31^{a} ±0.24	7.76^{a} ±0.00	9.31^{a} ±0.70	1.29^{b} ±0.40	1.94^{c} ±0.10	1.94^{c} ±0.10
H^{+}	9.05^{a} ±0.14	12.93^{b} ±1.45	9.31^{a} ±2.05	13.45^{b} ±0.80	9.57^{a} ±1.19	13.45^{b} ±0.03	19.65^{c} ±0.40	8.02^{a} ±0.19	11.64^{b} ±0.00	9.31^{a} ±0.77	9.83^{a} ±1.09	23.28^{b} ±2.33	1.03^{c} ±0.25	0.54^{a} ±0.00	0.80^{b} ±0.00
ECEC	41.92	44.34	40.52	39.05	39.03	47.44	43.40	25.80	27.23	40.75	40.59	54.14	23.65	21.97	20.28
BS (%)	56.20	49.84	54.05	46.35	54.27	46.04	19.56	36.82	35.40	56.76	56.66	39.80	90.19	88.71	92.36

EC= Electrical Conductivity, OM= Organic Matter, TN= Total Nitrogen, ECEC= Effective Cation Exchange Capacity, BS= Base Saturation

Table 2: Physicochemical Characteristics of soil from Omi-Eye Floodplain contd

R/course							Lower							Control	
Distance		45m			5m			25m			45m				
Depth (cm)	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30
pH	6.79^{a} ±0.16	6.81^{a} ±0.09	6.91^{a} ±0.07	6.01^{a} ±0.00	6.38^{b} ±0.05	6.72^{c} ±0.00	6.49^{a} ±0.05	6.55^{a} ±0.11	6.68^{b} ±0.00	6.39^{a} ±0.01	6.80^{b} ±0.09	6.45^{a} ±0.04	6.08^{a} ±0.00	7.46^{c} ±0.04	6.83^{b} ±0.02
EC	131.67^{b} ±0.55	49.00^{a} ±5.00	44.00^{a} ±1.00	163.00^{b} ±5.40	108.00^{a} ±7.00	62.67^{a} ±0.16	153.67^{c} ±0.95	114.00^{b} ±1.00	48.00^{a} ±0.00	194.00^{c} ±4.00	47.00^{a} ±2.00	55.67^{b} ±0.58	139.67^{c} ±0.58	25.00^{a} ±0.00	32.67^{b} ±1.53
OM	1.17^{c} ±0.10	0.97^{b} ±0.07	0.36^{a} ±0.00	3.66^{b} ±0.20	3.69^{b} ±0.00	1.43^{a} ±0.06	3.51^{b} ±0.00	3.56^{b} ±0.00	1.50^{a} ±0.05	2.34^{c} ±0.02	1.32^{b} ±0.04	0.40^{a} ±0.01	2.44^{c} ±0.09	1.67^{b} ±0.03	1.33^{a} ±0.21
TN	0.44^{b} ±0.00	0.42^{b} ±0.03	0.18^{a} ±0.04	1.28^{b} ±0.10	1.33^{b} ±0.04	0.46^{a} ±0.02	1.28^{b} ±0.02	1.32^{b} ±0.13	0.63^{a} ±0.00	0.91^{c} ±0.04	0.58^{b} ±0.00	0.17^{a} ±0.00	0.97^{b} ±0.02	0.62^{a} ±0.00	0.56^{a} ±0.14
Ca^{2+}	1.55^{a} ±0.05	1.35^{a} ±0.00	1.60^{a} ±0.20	1.80^{b} ±0.30	1.85^{b} ±0.09	1.00^{a} ±0.12	3.70^{b} ±0.00	4.05^{c} ±0.25	1.50^{a} ±0.03	3.25^{c} ±0.35	0.85^{a} ±0.10	2.05^{b} ±0.00	3.39^{b} ±0.00	1.45^{a} ±0.19	1. 82^{a} ±0.12

Mg^{2+}	0.60^{b} ±0.10	0.20^{a} ±0.00	0.25^{a} ±0.07	0.75^{c} ±0.23	$0.56^{a,b}$ ±0.05	0.70^{a} ±0.00	0.10^{a} ±0.00	0.20^{b} ±0.10	0.53^{b} ±0.44	0.10^{a} ±0.00	0.85^{a} ±0.37	0.25^{a} ±0.05	0.15^{a} ±0.00	0.60^{a} ±0.03	1.25^{b} ±0.14
Na^{+}	1.64^{c} ±0.01	$1. 49^{b}$ ±0.00	$1. 43^{a}$ ±0.08	$1. 99^{c}$ ±0.03	$1. 45^{b}$ ±0.10	$1. 32^{a}$ ±0.05	$1. 35^{a}$ ±0.07	$1. 82^{c}$ ±0.04	$1. 47^{b}$ ±0.03	1.45^{a} ±0.01	1.64^{b} ±0.04	1.39^{a} ±0.10	2.02^{b} ±0.02	1.71^{a} ±0.04	1.77^{a} ±0.05
K^{+}	3.40^{a} ±0.20	4.93^{b} ±0.08	5.78^{c} ±0.13	21.95^{c} ±0.15	17.55^{a} ±0.05	19.70^{b} ±0.10	18.30^{b} ±0.40	17.03^{c} ±0.18	14.55^{a} ±0.05	5.80^{a} ±0.10	6.38^{b} ±0.23	6.88^{c} ±0.75	5.40^{c} ±0.10	5.15^{b} ±0.05	4.40^{a} ±0.12
Al^{3+}	17.59^{c} ±0.30	14.49^{b} ±0.12	7.50^{a} ±0.20	10.09^{a} ±1.52	12.16^{b} ±0.20	8.54^{a} ±0.16	13.97^{a} ±0.68	12.16^{a} ±0.20	16.30^{b} ±0.13	9.05^{b} ±0.54	8.41^{a} ±0.35	8.28^{b} ±1.45	9.05^{a} ±0.39	8.02^{a} ±1.62	8.27^{a} ±0.90
H^{+}	29.75^{b} ±0.41	24.21^{b} ±5.39	6.21^{a} ±0.00	28.71^{c} ±0.87	20.43^{b} ±1.26	13.97^{a} ±2.13	19.91^{b} ±0.09	17.33^{b} ±0.16	9.31^{a} ±0.03	8.79^{b} ±0.29	9.14^{a} ±0.11	9.31^{b} ±0.78	15.00^{b} ±0.48	10.86^{a} ±0.10	16.55^{b} ±2.63
ECEC	54.53	56.67	22.83	65.32	54.00	44.01	57.33	52.59	43.66	28.44	27.27	28.16	35.01	27.79	34.06
BS (%)	13.19	31.71	39.95	40.55	39.65	48.85	40.90	43.92	34.47	37.27	35.64	37.53	31.31	32.06	27.13

EC= Electrical Conductivity, OM= Organic Matter, TN= Total Nitrogen, ECEC= Effective Cation Exchange Capacity, BS= Base Saturation

Table 3: Physicochemical Characteristics of soil from Egbigbu Floodplain

R/course	Upper									Middle					
Distance	5m			25m			45m			5m			25m		
Depth (cm)	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30
pH	6.68^{a} ±0.06	6.62^{a} ±0.02	6.77^{a} ±0.17	5.82^{a} ±0.32	6.00^{a} ±0.58	6.14^{a} ±0.15	6.12^{b} ±0.03	6.14^{b} ±0.00	5.41^{a} ±0.03	6.02^{b} ±0.10	5.41^{a} ±0.17	5.79^{b} ±0.13	6.19^{a} ±0.02	6.26^{a} ±0.08	6.42^{a} ±0.04
EC	211.00^{c} ±1.00	94.00^{a} ±2.00	143.00^{b} ±0.00	270.00^{c} ±3.00	170.67^{a} ±9.51	191.6^{b} ±4.51	495.33^{b} ±29.14	148.67^{a} ±5.51	571.00^{c} ±3.00	291.67^{c} ±6.51	144.00^{b} ±0.00	84.00^{a} ±4.00	215.67^{b} ±29.50	88.00^{a} ±4.00	102.00^{a} ±2.00
OM	1.37^{a} ±0.09	2.72^{c} ±0.03	2.47^{b} ±0.08	2.69^{b} ±0.08	$2.02^{a,b}$ ±0.00	1.57^{a} ±0.01	3.77^{c} ±0.10	3.62^{b} ±0.03	3.48^{a} ±0.21	2.57^{b} ±0.05	1.12^{a} ±0.07	1.97^{a} ±0.42	1.80^{c} ±0.09	0.47^{a} ±0.00	1.22^{b} ±0.17
TN	0.47^{a} ±0.04	1.00^{b} ±0.02	0.97^{b} ±0.15	1.01^{c} ±0.03	0.80^{b} ±0.00	0.64^{a} ±0.07	1.47^{b} ±0.04	1.28^{a} ±0.09	1.26^{a} ±0.00	1.00^{c} ±0.02	0.45^{a} ±0.06	0.60^{b} ±0.11	0.80^{c} ±0.10	0.17^{a} ±0.03	0.49^{b} ±0.16
Ca^{2+}	2.34^{a} ±0.15	2.50^{a} ±0.00	4.64^{b} ±0.05	2.40^{a} ±0.30	2.50^{a} ±0.20	2.50^{a} ±0.00	3.69^{b} ±0.30	2.89^{a} ±0.10	2.90^{a} ±0.20	2.80^{b} ±0.00	2.25^{a} ±0.05	3.04^{b} ±0.35	1.00^{b} ±0.00	0.60^{a} ±0.00	0.55^{a} ±0.05
Mg^{2+}	0.70^{b} ±0.10	1.00^{b} ±0.30	0.15^{a} ±0.11	0.25^{a} ±0.18	0.25^{a} ±0.05	0.30^{a} ±0.20	0.15^{a} ±0.05	0.95^{b} ±0.00	0.15^{a} ±0.00	0.45^{b} ±0.05	0.15^{a} ±0.00	0.55^{b} ±0.15	1.20^{b} ±0.30	0.30^{a} ±0.10	0.20^{a} ±0.10
Na^{+}	1.74^{b} ±0.00	1.33^{a} ±0.03	2.00^{c} ±0.07	$1.75^{a,b}$ ±0.28	1.68^{a} ±0.00	2.06^{c} ±0.04	2.63^{a} ±0.04	2.94^{b} ±0.11	3.62^{c} ±0.42	1.94^{c} ±0.02	1.79^{b} ±0.00	1.55^{a} ±0.07	1.50^{b} ±0.02	1.36^{a} ±0.05	1.39^{a} ±0.00
K^{+}	7.68^{a} ±0.18	8.85^{b} ±0.05	9.50^{c} ±0.20	7.25^{a} ±0.05	8.58^{b} ±0.28	9.43^{c} ±0.20	9.53^{a} ±0.79	11.95^{c} ±0.15	10.55^{b} ±0.65	7.85^{a} ±0.05	8.30^{a} ±0.20	8.80^{b} ±0.10	7.05^{b} ±0.15	6.55^{a} ±0.00	6.55^{a} ±0.05
Al^{3+}	4.65^{a} ±0.78	4.66^{a} ±0.00	4.14^{a} ±0.45	2.85^{a} ±0.30	2.85^{a} ±1.19	5.43^{b} ±0.72	6.21^{b} ±0.54	1.55^{a} ±0.16	8.54^{b} ±1.55	8.28^{b} ±0.48	2.85^{a} ±0.10	7.50^{b} ±0.90	7.50^{b} ±0.20	2.85^{a} ±0.20	7.76^{b} ±1.04
H^{+}	2.85^{b} ±0.70	5.17^{c} ±0.00	1.81^{a} ±0.10	0.78^{a} ±0.00	1.81^{b} ±1.32	8.27^{c} ±0.71	2.33^{a} ±0.07	1.29^{a} ±0.46	13.71^{b} ±1.69	6.21^{b} ±0.14	2.59^{a} ±0.00	13.19^{c} ±0.30	1.81^{a} ±0.39	3.10^{a} ±0.06	8.27^{b} ±1.25
ECEC	19.96	23.51	22.24	16.31	17.67	27.99	24.54	21.57	37.47	27.53	17.93	343.63	20.06	14.76	24.72
BS (%)	62.42	58.19	73.25	71.43	73.63	51.05	65.20	86.83	45.96	47.37	69.66	40.25	53.59	59.69	35.15

EC= Electrical Conductivity, OM= Organic Matter, TN= Total Nitrogen, ECEC= Effective Cation Exchange Capacity, BS= Base Saturation

Table 3: Physicochemical Characteristics of soil from Egbigbu Floodplain contd

R/course							Lower							Control	
Distance		45m			5m			25m			45m				
Depth (cm)	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30
pH	5.98^{a} ±0.04	6.34^{a} ±0.26	6.28^{a} ±0.20	6.22^{c} ±0.06	5.02^{a} ±0.02	6.01^{b} ±0.05	5.14^{a} ±0.02	6.07^{b} ±0.55	$5.76^{a,b}$ ±0.16	6.06^{b} ±0.05	6.52^{b} ±0.41	5.48^{a} ±0.05	6.81^{a} ±0.56	6.88^{a} ±0.06	6.94^{a} ±0.42
EC	146.67^{c} ± 5.51	66.00^{b} ±1.00	56.00^{a} ±2.00	221.67^{c} ±0.58	49.67^{a} ±1.53	202.00^{b} ±4.00	525.67^{c} ±22.50	65.00^{a} ±7.00	182.67^{b} ±0.58	58.00^{a} ±2.00	169.00^{b} ± 5.00	408.67^{c} ±2.52	48.67^{a} ±1.53	39.67^{a}±0.75	83.00^{b} ±19.98
OM	1.93^{c} ±0.30	0.77^{b} ±0.08	0.34^{a} ±0.02	2.77^{b} ±0.08	2.17^{a} ±0.55	2.25^{a} ±0.13	3.13^{b} ±0.04	3.26^{b} ±0.11	2.02^{a} ±0.00	1.13^{a} ±0.09	2.29^{b} ±0.04	3.69^{c} ±0.09	2.04^{c} ±0.06	1.31^{b} ±0.01	0.15^{a} ±0.00
TN	0.76^{b} ±0.00	0.41^{a} ±0.07	0.11^{b} ±0.03	1.03^{b} ±0.02	0.89^{b} ±0.08	9.69^{a} ±0.13	1.20^{b} ±0.03	1.19^{b} ±0.01	0.78^{a} ±0.00	0.47^{a} ±0.02	0.97^{b} ±0.10	1.36^{c} ±0.07	0.44^{b} ±0.05	0.44^{b} ±0.02	0.19^{a} ±0.04
Ca^{2+}	0.70^{a} ±0.50	0.60^{a} ±0.30	0.60^{a} ±0.40	2.80^{a} ±0.30	$3.00^{a,b}$ ±0.10	3.90^{c} ±0.80	1.60^{a} ±0.20	3.55^{c} ±0.00	2.15^{b} ±0.25	1.10^{a} ±0.40	1.30^{a} ±0.05	4.00^{b} ±0.25	0.85^{a} ±0.05	2.24^{b} ±0.35	1.85^{b} ±0.20
Mg^{2+}	0.45^{b} ±0.05	0.75^{c} ±0.00	0.10^{a} ±0.00	0.40^{a} ±0.30	1.25^{b} ±0.05	0.25^{a} ±0.05	1.15^{c} ±0.00	0.25^{b} ±0.05	0.10^{a} ±0.00	0.25^{a} ±0.00	0.55^{b} ±0.05	0.15^{a} ±0.00	0.60^{b} ±0.20	0.10^{a} ±0.00	0.50^{b} ±0.05
Na^{+}	1.33^{c} ±0.10	$1.27^{a,b}$ ±0.00	1.20^{a} ±0.03	2.11^{b} ±0.02	2.03^{a} ±0.00	1.99^{a} ±0.67	1.84^{c} ±0.03	1.75^{b} ±0.05	1.67^{a} ±0.18	1.36^{a} ±0.02	1.81^{b} ±0.04	2.02^{c} ±0.13	1.76^{c} ±0.03	$1.65^{a,b}$ ± 0.00	1.57^{a} ±0.13
K^{+}	4.25^{b} ±0.15	3.80^{a} ±0.10	3.93^{a} ±0.03	9.35^{c} ±0.15	8.80^{b} ±0.10	8.15^{a} ±0.05	7.10^{a} ±0.60	7.45^{a} ±0.05	7.25^{a} ±0.00	2.85^{c} ±0.05	2.55^{b} ±0.00	2.15^{a} ±0.15	4.20^{c} ±0.05	3.93^{b} ±0.23	3.68^{a} ±0.39

Scientia Africana, Vol. 22 (No. 1), April, 2023. Pp 297-310 https://dx.doi.org/10.4314/sa.v22i1.25
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Al^{3+}	3.88^{b} ±0.70	2.33^{a} ±1.22	4.40^{b} ±0.45	7.24^{a} ±1.69	17.84^{b} ±4.34	6.98^{a} ±0.87	0.91^{a} ±0.28	1.29^{a} ±0.11	2.33^{b} ±0.00	0.47^{a} ±0.26	1.55^{b} ±0.00	2.07^{b} ±0.12	7.76^{a} ±1.55	11.38^{c} ±1.09	8.79^{b} ±0.35
H^{+}	3.10^{b} ±0.52	0.78^{a} ±0.57	3.10^{b} ±0.74	10.85^{b} ±1.16	10.86^{b} ±5.29	6.98^{a} ±0.00	0.65^{a} ±0.22	1.03^{a} ±0.11	3.62^{b} ±0.07	0.80^{b} ±0.43	3.10^{b} ±0.71	1.03^{a} ±0.44	12.93^{a} ±1.09	12.67^{a} ±0.88	16.55^{b} ±1.09
ECEC	13.71	9.53	13.33	32.75	43.78	28.25	13.25	15.32	17.12	6.83	10.86	11.42	28.10	31.97	32.94
BS (%)	49.09	67.37	43.74	44.76	34.44	50.58	88.23	84.86	65.24	81.41	57.18	72.85	26.37	24.77	23.07

EC= Electrical Conductivity, OM= Organic Matter, TN= Total Nitrogen, ECEC= Effective Cation Exchange Capacity, BS= Base Saturation

The increased pH with depth is in agreement with similar work reported by Olawale *et al*. (2017) who reported a range of 6.39-7.12 for Owena floodplain but higher than the ones obtained by Afu *et al*. (2019) who reported a range of 5.5-5.75 for Calabar floodplain, Cross River State and Osakwe (2014) who reported a range of 4.8-6.1 for Isoko Region, Delta State all in Nigeria. The soil pH was equally found to decrease as the distance increased from the river bank into the farm. This observation could be attributed to humic acid (the major acid of soil organic matter) which may be deposited by the flood on the top soil after recession thus making it more acidic than layers beneath (Olayinka *et al.*, 2017).

The highest soil pH (7.12 ± 0.02) was recorded at Omi-Eye floodplain while the least (5.05 ± 0.03) was recorded at Irintan floodplain. The overall mean at Irintan floodplain was 6.19 ± 0.29, at Omi-Eye floodplain it was 6.67 ± 0.14 and at Egbigbu floodplain it was 6.03 ± 0.02 implying that the soils in the study area were moderately acidic. The pH is important in soil processes responsible for stability of metals in soil and their transportation (Mathews–Amune and Kakulu (2013). As acidity decreases, metals tend to form insoluble metallic phosphates and carbonates, thus making them unavailable for plant uptake. However, at high acidity (pH 2-6), metals tend to be available in their ionic species or in soluble organometallic forms and are more available for plant uptake (Egbenda *et al.*, 2015; Zhong *et al*., 2020; Suleymanov *et al*., 2022). The values obtained in this study fall within this range mostly suggesting that the soil may release heavy metals for plant uptake which may eventually have adverse effect on man through food chain.

The range of electrical conductivity (µS/cm) was 41.67-463.67 at Irintan floodplain, 34.00-227.00 at Omi-Eye floodplain and 49.67-571 at Egbigbu floodplain. The mean electrical conductivity (EC) was 116.43 ± 77.62 for Irintan floodplain, it was 98.28 ± 54.79 for Omi-Eye floodplain while it was 198.96 ± 81.35 for Egbigbu floodplain. The value of EC obtained for control each at Irintan, Omi-Eye and Egbigbu floodplains was 62.29, 65.78 and 57.11 µS/cm respectively suggesting that the EC at each site was greater than its corresponding control. The values obtained in this study were higher than those reported by Egbenda *et al.* (2015) who reported a range of 10-20 µS/cm for agricultural soils of Sierra Rutile environ of Sierra Leone, Akpoveta *et al*. (2014) who reported 140.8 µS/cm for Onitsha flooded soil, Anambra State, and 112.8 µS/cm for Asaba floodplain in Delta State, Nigeria.

The high EC values indicate significant presence of trace metals ions or ionizable materials in the soil (Egbenda *et al.*, 2015; Osakwe and Okolie, 2015), electrical conductivity less than 1000 µS/cm is graded as normal for plant growth, 1000-2000 µS/cm as critical for germination, 2000-3000 µS/cm critical for growth of salt sensitive crop and > 3000 µS/cm is graded as injurious to crops (Horneck *et al*., 2011). Thus, the range of EC values obtained at the sites is good for plant growth.

The range of organic matter content at Irintan (Ogbese) was 0.14-3.54 %, at Omi-Eye (Erio), it was 0.36-3.68 %, while at Egbigbu (Ayetoro), it was 0.34-3.77 %. The overall mean at Irintan (Ogbese) was 0.89 %, at Omi-Eye (Erio), it was 1.87 % and at Egbigbu (Ayetoro) it was 2.13 % while the control was 1.15 %, 1.81 % and 0.83 % respectively. This implies that the farm site soils are richer in organic matter than the control site soils (Tables 1, 2 and 3). The values obtained in this study were higher than those reported by Idugbue *et al*. (2014) but were in the range of those reported by Abata *et al*. (2016) who reported a range of 0.08-0.18% for Ala River in Akure and Osakwe (2014) who reported a range of 0.10-0.22% for Isoko Region in Delta State. The values obtained in this report are however lower than those reported by Tukura *et al.* (2009); Osenwota (2009) and Mofor *et al.* (2017). The organic matter content in soil is the organic fraction derived from living organisms, decomposed plant and animal residues. The level of organic matter in soils influence a number of soil chemical and physical properties. The soil organic matter, pH and clay contents are known to influence the dynamics and behaviour of both inorganic and organic pollutants in the soil (DPR, 2002; Gale *et al.*, 2004; Aiyesanmi *et al.*, 2008). The presence of organic matter in the soil is also known to promote crop growth (Afu *et al.*, 2019). Organic matter, of which organic carbon is the basis, contains humus, which is responsible for the storage and release of plant nutrients. It is vital to plant life in the maintenance of soil fertility.

The range of total nitrogen (%) content for Irintan was 0.03-1.13, it was 0.17-1.33 at Omi-Eye while at Egbigbu it was 0.11-1.47. The overall site average was 0.44 at Irintan, 0.71 at Omi-Eye and 0.83 at Egbigbu. The control value for Irintan, Omi-Eye and Egbigbu was 0.44 %, 0.71 % and 0.36 % respectively. The total nitrogen values obtained in this study are higher than those reported by Osakwe (2014)who reported 0.012-0.071 % and Afu *et al.* (2019) who reported 0.03-0.29 % but they are within the range reported by Mofor *et al.* (2017) who reported a range of 0.09-0.49 for some agricultural soils of Awing, North west Cameroon. The higher values obtained could be attributed to deposition by the flood as well as nitrogen introduced to the soil by natural processes such as lightning and decayed plant tissues (Eddy *et al.*, 2006). Nitrogen is essential to plants for formation of living tissues as it is a necessary component of proteins such as DNA and RNA as well as vitamins, hormones and enzymes (Rim-Rukeh *et al*., 2007).

The range of Ca^{2+}(cmol/kg) content for Irintan was 0.23-4.94 while it was 0.65-4.05 and 0.55–4.64 for Omi-Eye and Egbigbu respectively. The overall mean for Irintan floodplain, Omi-Eye floodplain and Egbigbu floodplain was 2.11 ± 0.62, 2.01 ± 0.48 and 2.29 ± 0.35 respectively. Equally, the control value for Irintan, Omi-Eye and Egbigbu was 2.26, 2.22 and 1.65 cmol/kg respectively. Thus, except for Egbigbu, the control values for Irintan and Omi-Eye were higher than the corresponding farm values. This higher value of Ca^{2+}at Egbigbu could be as a result of the nature of the soil used for the control which may be richer in Ca^{2+} than that of the farm site. The values of Ca^{2+} concentration along soil profile and across farm did not show any particular pattern. The lack of trend in Ca^{2+} may be as a result of irregular nature of soil constituents. The values obtained in this report are in the same range with those reported for similar works done by Osakwe (2014) who recorded a range of 0.98-2.96 cmol/kg and Afu *et al*. (2019) with a range of 1.2-4.0 cmol/kg but lower than the one reported by Mofor *et al*. (2017) with 3.84-8.66 cmol/kg.

The range of Mg^{2+} (cmol/kg) content for each of Irintan floodplain, Omi-Eye floodplain and Egbigbu floodplain was 0.20-2.05, 0.15-1.53 and 0.55-4.64 while the overall average was 0.74 ± 0.06, 0.53 ± 0.16 and 2.29 ± 0.35 respectively. The control mean value for Irintan was 0.45, for Omi-Eye it was 0.67 and while for Egbigbu, it was 0.40. The exchangeable Mg^{2+} levels in this study are consistent with those reported by Afu *et al*. (2019) with a range of 0.8-3.0 cmol/kg and Mofor *et al*. (2017) with a range of (1.18-2.08

Scientia Africana, Vol. 22 (No. 1), April, 2023. Pp 297-310 https://dx.doi.org/10.4314/sa.v22i1.25
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cmol/kg) as well as Osakwe (2014) with 0.80-3.04 cmol/kg. Optimum Mg^{2+} level in the soil ranges from 100 to 250 cmol/kg (Osakwe, 2014). The low concentration of both Ca^{2+} and Mg^{2+} could be attributed to the fact that both elements often bond to the soil macro colloids, thereby reducing their availability in the soil. It could also be as a result of their higher ionic charge which makes them to be bond more to the exchangeable sites than ions of lower ionic charge (Osakwe 2014). Calcium deficiencies are rare to occur when the soil pH is adequate (Snober *et al.*, 2011). Exchangeable calcium and magnesium are secondary nutrients which are required in relatively smaller but appreciable quantities (Osakwe, 2014). Magnesium is a constituent of chlorophyll and chromosome (Mamun *et al.*, 2011).

The range of Na^+ (cmol/kg) was 1.42-2.69 for Irintan floodplain, it was 1.20-2.48 for Omi-Eye floodplain and 1.20-3.62 for Egbigbu floodplain. The overall average for Irintan floodplain, Omi-Eye floodplain, and Egbigbu floodplain, was 2.04 ± 0.18, 1.61 ± 0.19 and 1.86 ± 0.13 while the control was 0.57, 1.83 and 1.66 (cmol/kg) respectively.

The range of K^+ for Irintan floodplain also was 2.40-13.43, for Omi-Eye floodplain it was 3.40-19.75 and for Egbigbu floodplain it was 2.15–11.95 while overall mean was 7.86 ± 0.75, 13.46 ± 0.31 and 7.26 ± 0.24 respectively. The control for Irintan was 1.05, for Omi-Eye it was 4.98 and for Egbigbu it was 3.94. The values obtained for both Na^+ and K^+ in this study are higher than the ones reported by Osakwe (2014) who reported (0.06-0.23 cmol/kg) and Afu *et al*. (2019) who reported (0.06-0.09) but within the range reported by Mofor *et al*. (2017) who reported 0.21-3.17 cmol/kg. The exchangeable sodium percentage (ESP) which is a measure of the relative contribution of Na^+ to the overall cation exchange capacity is very important indicator of soil dispersion (Osakwe 2014). Exchangeable Na^+ greater than 2.5 % of the CEC may cause adverse physical and chemical conditions to develop in the soil that may hinder plant growth. High level of exchangeable Na^+ affects soil permeability and may be toxic to sensitive plants (McCauley *et al.*, 2005). The mean CEC for Irintan was 28.72 cmol/kg while at Omi-Eye and Egbigbu it was 4.24 and 8.82 cmol/kg respectively. The mean exchangeable sodium is 2.04, 1.61 and 1.86 cmol/kg for Irintan Omi-Eye and Egbigbu respectively. Thus, the exchangeable sodium percentage (ESP) for Irintan was 7.10 while it was 4.24 and 8.82 for Omi-Eye and Egbigbu respectively. The ESP at each of the three sites was greater than 2.5 % and therefore the growth of the plants on the floodplains may be hindered. The levels of K^+ in this study were higher than the ones reported by Osakwe (2014) but consistent with values reported by Mofor *et al*. (2017). Plants utilize potassium for photosynthesis, plant metabolism, and regulation of enzyme activities and for increase of sugar, starch and oil contents in plant storage organs (Egharevba *et al*., 2003) in the soil, potassium exists in three forms unavailable, slowly available and available forms (Ijaz *et al*., 2006; Osakwe 2014).

The range of Al^{3+} for Irintan, Omi-Eye and Egbigbu was 0.44-23.02, 0.41-17.59 and 0.47-17.85 while the overall mean was 8.67±2.08, 7.21±3.72 and 4.78±0.64 respectively. Equally, the control value was 8.12, 8.45 and 9.31 for Irintan, Omi-Eye and Egbigbu respectively.

The H^+ acidity range was 0.34-13.97 at Irintan 0.80-28.71 at Omi-Eye and 0.65-10.86 at Egbigbu. The overall mean at Irintan, Omi-Eye and Egbigbu was 7.30 ± 1.03, 13.14 ± 2.07, 4.42 ± 1.95 while the control was 11.89, 14.14 and 14.05 respectively. The values obtained for Al^{3+} and H^+ acidities in this study are higher than the ones reported by Osakwe (2014) who reported a range of 0.10-0.80 cmol/kg for H^+ and 0.60-3.40 cmol/kg for $Al^{3+}$and Afu *et al*. (2019) who recorded a range of 0.28-1.32 for H^+ and 0.07-0.09 cmol/kg for Al^{3+}. This observation could be attributed to low pH which favors increased binding of the ions to the soil macro colloids (Osakwe, 2014).

Generally, the physicochemical properties down the depth (Figs. 2-4) and as the distance increased away from the river bank into the farm (as observed on Tables 1-3) showed trends for some properties while no particular trend was noticed for others. For instance, the electrical conductivity values at Irintan and Omi-Eye floodplains reduced both down the soil profile and as the distance increased from the river bank. However, at Egbigbu floodplain, the electrical conductivity values were observed to be high at 0-10 cm and 20-30 cm but low at 10-20 cm along the soil profile (Fig. 4) but it was observed to increase as the distance increased away from the river bank (Table 3). The values that decreased down the soil profile could be attributed to deposition after the flood which may raise the values on top soil than the layers beneath. The same reason could be adduced for decrease in values at distances away from the river bank as distances closer to the river bank may retain more of the flood deposition due to the topography of the sites (Olawale *et al.*, 2017).

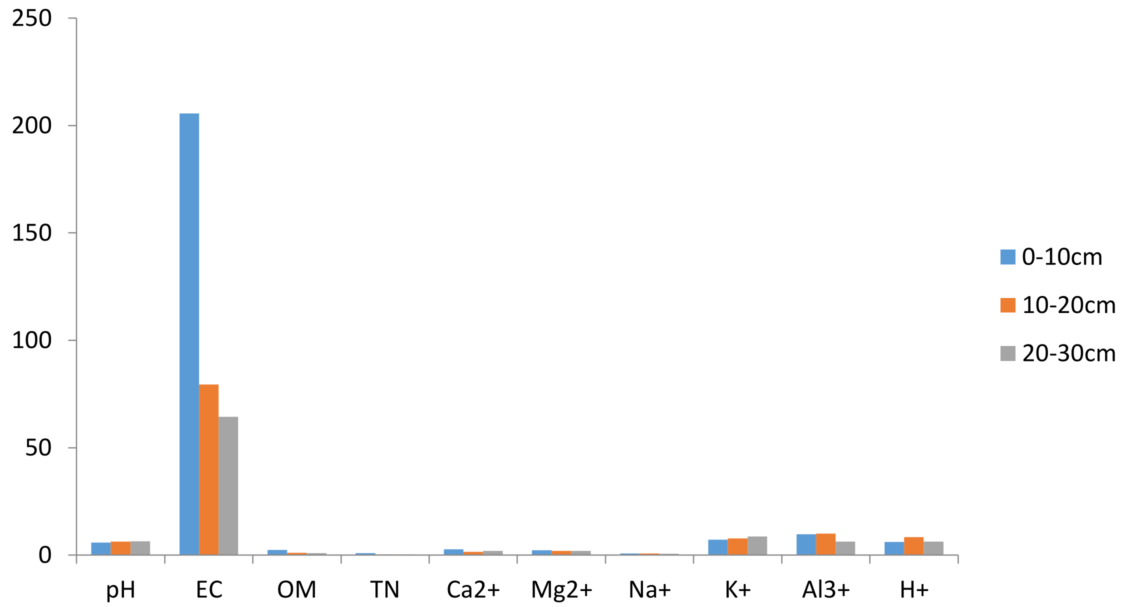

Fig: 2: Irintan Floodplain Physicochemical Properties by Depth

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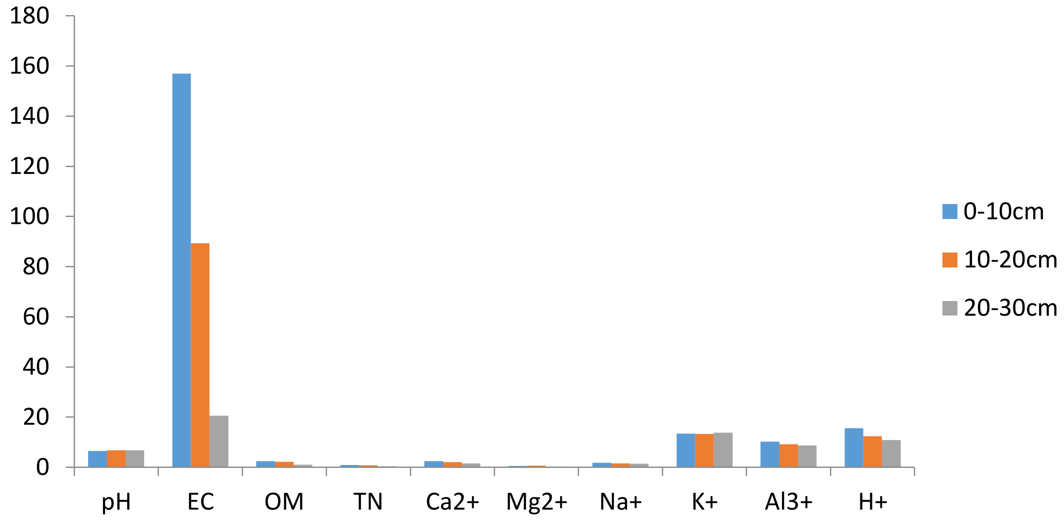

Fig. 3: Omi-Eye Floodplain Physicochemical Properties by Depth

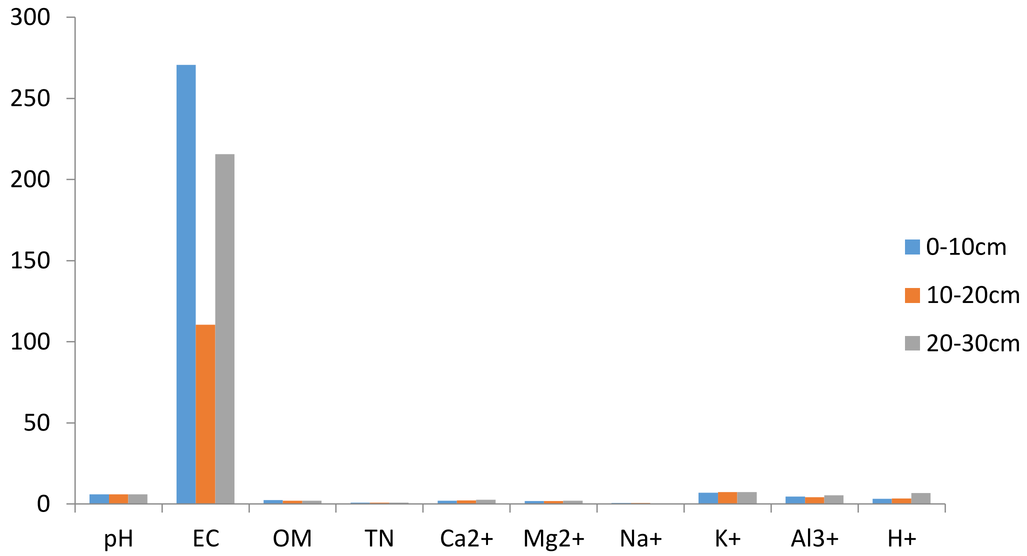

Fig. 4: Egbigbu Floodplain Physicochemical Properties by Depth

CONCLUSION

The results of the physicochemical properties of the floodplains under study were similar in many respects. The pH showed the floodplains were mostly slightly acidic to slightly alkaline which is optimum for crop production. The electrical conductivity, organic matter and nitrogen were also moderate. However, the exchangeable sodium percentage at each of the sites was found to be high and this may affect the crops. The variation of the physicochemical properties down the soil profile and away from the river bank into the farm indicated irregular trends in the floodplains. In general, the floodplains are slightly acidic with low organic matter content typical of West African sub-region with moderate cation exchange capacity. It is recommended that the floodplains under study be treated to reduce the exchangeable sodium percentage for better crop production. Some of the soils that are acidic should also be limed in order to prevent the possibility of pollutants like heavy metals from getting mobile and thereby entering into the food chain.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgements

The authors deeply appreciate the farmers who allowed their farms to be used for this study and the staff of Department of Chemistry, Federal University of Technology, Akure for their useful pieces of advice and technical assistance during the laboratory work.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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