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SEASONAL VARIATIONS IN PHYSICOCHEMISTRY OF WATER AND SEDIMENT OF A DEGRADED FRESHWATER WETLAND ECOSYSTEM: A CASE STUDY OF IPARE WETLAND IN ONDO STATE, NIGERIA

Asunbo, E. B. and Tanee, F.B.G.
Department of Plant Science and Biotechnology, University of Port Harcourt, Port Harcourt, Nigeria
Correspondence: bukola.asunbo@gmail.com
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ABSTRACT

This study was carried out to investigate the seasonal variations (dry and rainy seasons) in physicochemical characteristics of a degraded freshwater wetland in Ipare, Ondo State. The physicochemical parameters of water and sediment samples from three degraded stations and a control (non-degraded site) were analysed using standard analytical method. Results showed that sodium and chloride concentrations in water ranged from 1329 to 1583 mg/l and 7373.9 to 9345.5 mg/l (dry season), and 56.87 to 207.06 mg/l and 130.4 to 513.76 mg/l (rainy season), respectively. The sediment showed sodium and chloride concentrations that ranged from 738.08 to 742.33 mg/kg and 1749.69 to 1793.94 mg/kg (dry season), and 410.25 to 411.93 mg/kg and 702.82 to 848.09 mg/kg (rainy season), respectively. Values for the control for sodium were 29.59 mg/l and 58.62 mg/kg (dry season) and 7.11mg/l and 9.6 mg/kg (wet season), while chloride values were 61.2 mg/l and 126.56 mg/kg (dry season) and 15.81 mg/l and 17.52 mg/l (rainy season) for water and sediment, respectively. All other physicochemical parameters were altered due to the variation in season. Statistical analysis showed a significant difference ($p < 0.05$) between the degraded sites and the control. The study showed that season and anthropogenic activities have significant effects on the physicochemical characteristics of sediment and water in the freshwater wetland and, therefore, contribute to wetland degradation.
Keywords: Wetland; degradation; infiltration; sediments; Anthropogenic; Seasonal Variation.
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INTRODUCTION

The characteristics of wetland ecosystem are used in defining it (Fraser and Keddy, 2005; Ramsar, 2010). A more detailed description of wetland was given by Ramsar (2010) as an environment subject to permanent or periodic inundation or prolonged soil saturation sufficient for the establishment of hydrophytes and the development of hydric soils. Wetlands have been divided into different types based on several attributes. The most common division is based on ecological characteristics, using the vegetation cover as indicator of hydrological and geochemical status (EPA, 2002).The presence of partially decayed plant layer thicker than a few decimetres and salinity content of the water are also used when describing different types of wetlands (Mitsch and Gosselink, 2000). Based on these attributes, the four types of wetlands are bogs, marshes, swamps and fens (EPA, 2002).

Globally, wetlands are of great environmental and economic values (Ajibola *et al*., 2015). They offer great benefits including production of food (fish, reeds, rice, wild animals, etc), fuel, medicine, materials for craft work and building (Terer *et al.* 2004; Olalekan *et al*. 2014; Ajibola *et al*., 2015; Ayanlade and Proseke, 2016). According to Ebeku (2004), Nigeria has the largest wetland resources in Africa and third largest in the world. The country hosts fourteen major wetland sites, from which eleven are recognised internationally (Asibor, 2009). Out of these, two are located in the Niger Delta region in Apoi Creek Forests, Bayelsa State and Upper Orashi Forests, Rivers State (Nwakwoala, 2012). Nigeria has been reported to have one of the richest wetlands in the world in terms of biodiversity (Ebeku, 2004; Uluocha and Okeke, 2004).

The wetland ecosystems in the country have suffered much degradation largely as a result of human activities and some other factors (UNEP, 2007; Chidi and Ominigbo, 2010; Nwakwoala, 2012). This includes the Ipare wetland in Ondo State. Geospatial map study on Nigeria wetlands revealed agricultural activities and urban development as major causes of wetland loss (Orimoogunje *et al*., 2009). The continuous degradation has resulted in loss of Nigeria's wetland resources, including flora and fauna (Uluocha and Okeke, 2004). Many flora and fauna in wetlands are generally very sensitive to changes in environmental chemistry (Madsen and Cedergreen, 2001). The alterations to the aquatic environment (sediment and water) will have direct impacts on the organisms being sheltered in the ecosystem. The report of NDDC (2004) showed that Ondo State had the richest wetland resources in the Niger Delta region. Regardless of the rich nature of this ecosystem, no wetland in Ondo State has been recognised internationally because the area has remained largely unreached by most ecological researchers. (Oyebande *et al*., 2003; Asibor, 2009; Nwakwoala, 2012). It is, therefore, important to investigate the wetland so as to gain indepth understanding on how seasonal changes, anthropogenic activities and other prevailing factors can affect the physicochemical properties of water and sediment in this unique ecosystem. This study was aimed to determine the seasonal variations in physicochemical characteristics of the degraded wetland sediment and water in Ipare, Ondo State.

MATERIALS AND METHODS

Description of Study Area

This research was carried out at a degraded wetland and the control was an unimpacted site, all located in Ipare, Aheri Kingdom District, Ilaje Local Government Area of Ondo State, Nigeria. The study area is located at Longitude 0040 40' 47.2E and Latitude 060 15' 50.6N for Station 1, while Stations 2 and 3 are located at 0040 40' 47.1E, 060 15'49.1N and 0040 40' 29.6E, 060 15'46.1N, respectively. The control site is located at Longitude 0040 41' 29.2E and Latitude 060 15' 57.3N (Fig. 1). The plants in the study area are predominantly raphia palm. Water organisms such as crabs, fishes and frogs were also present at the time of the study. One of the biggest markets and trading activities in the area was located near the study location, hosting daily transactions from neighbouring communities.

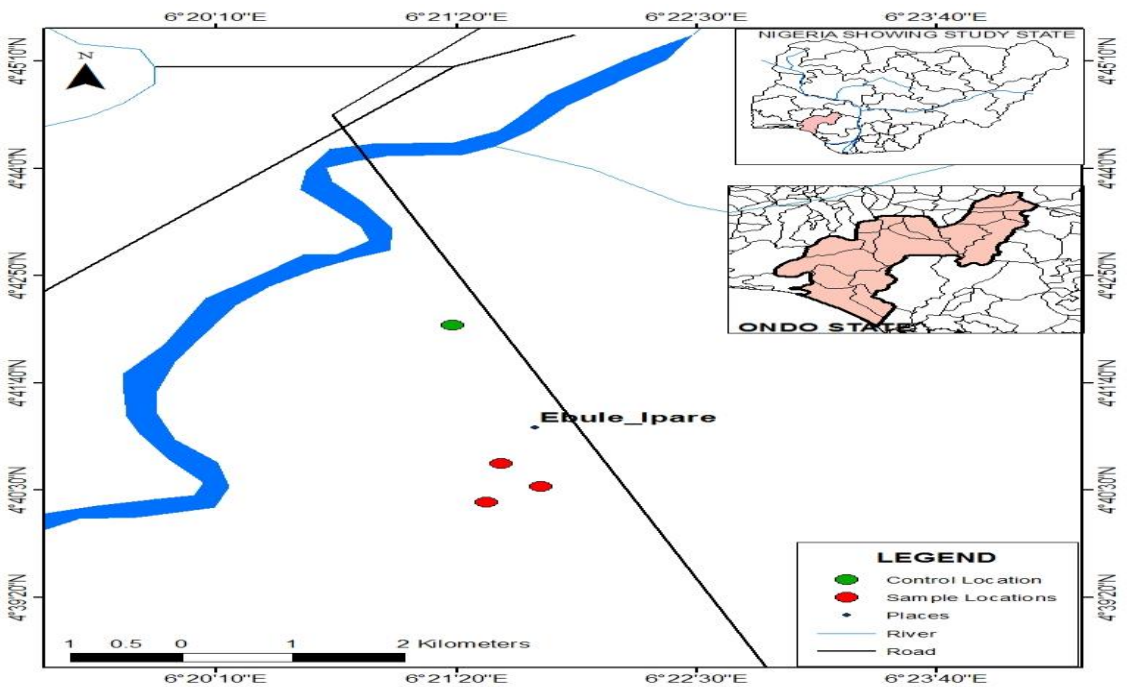

Fig. 1: Map of the study area showing sampling locations

Sample Collection and Handling

Samples were collected twice in the year 2018. The first sampling was done in February, 2018, representing the dry season while the second sampling was done in July for the rainy season. At each degraded station and the control, three sample points measuring 5 m x 5 m were strategically mapped out for sampling. Water samples were collected in already prepared clear 0.75 litre-sample containers while sediments were collected into plastic sampling bags using soil auger at a depth of 0 – 15 cm. All samples were taken in triplicates, properly labeled, analysed for *in situ* parameters (pH and electrical conductivity) using EXTECH (EC600) portable water equipment. The samples were later preserved for subsequent laboratory examination at the Institute of Pollution Studies (IPS), Rivers State University, Port Harcourt, Nigeria.

Physicochemical Analysis of Water and Sediment

Standard laboratory procedures were used to analyse the samples. The portable Palintest photometer D7500 was used to determine the concentration of magnesium, copper, zinc, iron and manganese in the water while portable Palintest photometer (Soil Test 10) was used to determine the pH, conductivity, chloride, sodium, phosphate, sulphate, calcium, magnesium, potassium, sodium, ammonia, nitrate, cadmium, manganese, iron, lead, copper and zinc concentration in the sediment. The Argentometric and UV spectrophotometer method was used to determine the concentration of chloride and nitrate in the water, respectively (Davies, 2013). EDTA titrimetric method was used for calcium concentration determination. Stannous chloride method 4500 PD was used for phosphate; Liquid-liquid extraction method was used for total hydrocarbon and UV spectrophotometer method was used for sulphate concentration determination in the water (Davies, 2013). Oxidation method was used for determination of total organic carbon and spectrophotometer method was used for total hydrocarbon content in the sediment.

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) test and means were compared using the least significance difference (LSD).

RESULTS

Tables 1 and 2 show results of water and sediment physicochemical analysis, respectively. The results of pH for both water and sediment showed a significant difference between the dry and rainy seasons. There was also significant difference between stations and the control ($p<0.05$) within and across the seasons, with the control having a higher pH value than the degraded stations. No significant difference was observed between stations. The water and sediment conductivity, salinity, chloride and sodium for degraded stations 1 to 3 were higher during the dry season than during the rainy season (Tables 1 and 2). The nitrate concentration for the control and station 1 was lower in the dry season when compared to the rainy season while stations 2 and 3 recorded a higher nitrate concentration during the rainy season. The nitrate concentration for the sediment showed a slight decrease at all the stations and the control for the dry season compared to the rainy season (Table 2).

The result showed that ammonium concentration in the water was higher at all the stations in the dry season compared to the rainy season. On the other hand, sediment in wet season showed a higher concentration of ammonium than during the dry season. The concentration of the phosphate was generally low in the water at all the sampled stations with the rainy season showing reduced values at stations 1 and 2 (Table 2). Sulphate concentration in water and sediment showed significant difference between the stations and across the seasons ($p<0.05$). Results also showed that there were significant differences in the concentrations of magnesium, calcium and potassium when compared to the control between the two seasons.

It was also observed that cadmium, lead and total hydrocarbon content between the seasons for water and sediment in the degraded stations showed no significant difference compared to the control. Both the control and stations 1 to 3 had a low concentration of copper in the two seasons. Comparing the concentration of copper at all the stations with control and across the seasons, only stations showed a significant difference during the rainy and dry seasons. For sediment, station 1 had the highest concentration of copper during the rainy season while station 2 showed the highest concentration during the dry season. Table 1 showed the result of zinc analysis. Both the control and the stations had the same concentration (0.01mg/l) of zinc in the dry and rainy seasons. For the sediment, the result showed that the values for the two seasons in the control and stations 1 to 3 were within the same range, showing no significant difference at $p<0.05$. When the iron concentrations in water for all the stations were compared with the control between seasons, stations 1 to 3 did not show significant difference during the dry season but there was difference in the rainy season at $p<0.05$. In the sediment, all the stations showed significant difference for both seasons at $p<0.05$. Manganese concentration was similar for the two seasons with a value of 0.01 mg/l across all the water stations, as shown in Table 1. For sediment, the stations and the control for dry and rainy seasons showed significant difference between the seasons at $p<0.05$. The total organic carbon content (TOC) for the control in the two seasons was higher when compared to the other stations (1 to 3). The results showed that the values for the rainy season for all the stations, including the control, were higher when compared to those of the dry season.

Table 1: Physicochemical Analysis of water from Degraded Freshwater Wetland stations of Ipare, Ondo State, Nigeria

SAMPLE	CONTROL		STATION 1		STATION 2		STATION 3	
PARAMETER	DRY	RAINY	DRY	RAINY	DRY	RAINY	DRY	RAINY
pH	6.15 ± 0.03^{a,c}	6.78 ± 0.01^{a,d}	7.40 ± 0.03^{b,d}	7.15± 0.01^{b,c}	7.59± 0.06^{b,d}	6.99 ± 0.02^{b,c}	7.36 ± 0.06^{b,d}	7.26 ± 0.01^{b,c}
Temperature	25.90±0.12^{a,c}	25.10 ± 0.06^{a,c}	26.30± 0.06^{b,c}	25.90± 0.12^{b,c}	26.30± 0.06^{b,c}	25.70± 0.06^{b,c}	26.10± 0.06^{b,c}	25.70 ± 0.06^{b,c}
Salinity, %0	49.50±0.12^{a,c}	0.05 ± 0.01^{a,d}	179.00± 2.31^{b,d}	0.35 ± 0.01^{b,d}	196.00± 1.15^{b,d}	0.26 ± 0.01^{b,d}	116.80± .64^{b,d}	0.42 ± 0.01^{b,d}
TDS, mg/l	69.10±0.06^{a,c}	17.80 ± 0.06^{a,d}	506.00± 0.06^{b,d}	0.80± 1.15^{b,c}	385.01± 0.06^{b,d}	3.50 ± 1.73^{b,c}	3.50 ± 1.73^{b,c}	5.30 ± 2.89^{b,c}
Chloride, mg/l	61.20±0.64^{a,c}	15.81 ± 0.03^{a,d}	9345.50±5.83^{b,d}	203.53±0.01^{b,c}	7373.90±6.35^{b,d}	130.40±0.64^{b,c}	8217.50±1.21^{b,d}	513.76± 0.64^{b,c}
Conductivity, μS/cm	171.0±1.15^{a,c}	99.80 ± 0.06^{a,d}	21162.00±5.77^{b,d}	726.00± 0.56^{b,c}	21309.0±5.77^{b,d}	550.00± 2.89^{b,c}	23820.00±5.77^{b,d}	1835.0±5.77^{b,c}
Hardness, mg/l	42.24±0.01^{a,c}	40.32± 0.06^{a,d}	5128.00±6.35^{b,d}	99.47± 0.07^{b,c}	5760.00±5.77^{b,d}	96.96± 0.02^{b,c}	4440.00± 1.15^{b,d}	288.51± 0.64^{b,c}
Ammonium mg/l	0.25 ± 0.01^{a,cc}	0.11 ± 0.01^{a,d}	0.07 ± 0.01^{b,d}	0.01 ± 0.00^{b,c}	0.13± 0.01^{b,d}	0.01 ± 0.00^{b,c}	0.47 ± 0.01^{b,d}	0.01 ± 0.00^{b,c}
Nitrate, mg/l	0.23 ± 0.01^{a,c}	0.14 ± 0.01^{a,d}	0.95 ± 0.01^{b,d}	0.48 ± 0.01^{b,c}	0.05 ± 0.01^{b,d}	0.38 ± 0.01^{b,c}	0.13 ± 0.01^{b,d}	1.39 ± 0.01^{b,c}
Magnesium, mg/l	20.00±0.03^{a,c}	4.40 ± 0.01^{a,d}	1250.00 ± 2.89^{b,d}	15.11 ± 0.01^{b,c}	1375.00 ± 2.89^{b,d}	14.63 ± 0.06^{b,c}	1000.00 ± 1.15^{b,d}	43.59 ± 0.01^{b,c}
Calcium, mg/l	21.22±0.06^{a,c}	13.33 ± 0.06^{a,d}	3570.00 ± 2.89^{b,d}	38.74 ± 0.06^{b,c}	4010.00±2.89^{b,d}	37.50 ± 0.03^{b,c}	2985.00 ± 6.93^{b,d}	91.02 ± 0.01^{b,c}
Potassium, mg/l	6.80 ± 0.05^{a,c}	1.21 ± 0.05^{a,d}	12.00 ± 0.05^{b,d}	22.70± 0.05^{b,c}	9.50 ± 0.05^{b,d}	16.91± 0.10^{b,c}	10.20 ± 0.05^{b,d}	21.54 ± 0.11^{b,c}
Sodium, mg/l	29.58±0.58^{a,c}	7.11 ± 0.01^{a,d}	1562.00± 6.35^{b,d}	98.11± 0.06^{b,c}	1583.00±0.20^{b,d}	56.87± 0.06^{b,c}	1329.00 ± 5.77^{b,d}	207.06± 0.58^{b,c}
Phosphate, mg/l	0.02 ± 0.01^{a,c}	0.02 ± 0.01^{a,d}	0.14 ± 0.01^{b,d}	0.01 ± 0.00^{a,d}	0.14 ± 0.01^{b,d}	0.01 ± 0.00^{a,d}	0.02 ± 0.01^{a,c}	0.02 ± 0.01^{a,d}
Sulphate, mg/l	7.27 ± 0.01^{a,c}	9.68 ± 0.06^{a,d}	2096.59±0.64^{b,d}	16.76± 0.01^{a,d}	2954.03±0.58^{b,d}	13.58± 0.05^{a,d}	1132.68 ± 0.64^{b,d}	18.75 ± 0.06^{a,d}
THC, mg/l	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}
Cadmium, mg/l	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}
Lead, mg/l	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}
Copper, mg/l	0.01 ± 0.00^{a,c}	0.02 ± 0.01^{a,d}	0.02 ± 0.01^{a,c}	0.02 ± 0.01^{a,d}	0.02 ± 0.01^{a,c}	0.04 ± 0.01^{b,c}	0.02 ± 0.01^{a,c}	0.02 ± 0.01^{a,d}
Zinc, mg/l	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}
Iron, mg/l	2.72 ± 0.06^{a,c}	1.71 ± 0.01^{a,d}	1.76 ± 0.06^{a,d}	1.08 ± 0.01^{b,c}	1.90 ± 0.03^{a,d}	1.22 ± 0.01^{b,c}	1.83 ± 0.01^{a,d}	1.10 ± 0.01^{b,c}

THC= Total hydrocarbon content

Values are means ± Standard Error of Mean (SEM). Values with different superscripts are significantly different at $p < 0.05$. Superscripts (a,b) compare stations 1, 2 and 3 against the control across the season for both seasons while superscripts (c,d) compare each sample to the other within the seasons.

Table 2: Physicochemical Analysis of Sediment from Degraded Freshwater Wetland stations of Ipare Ondo, State, Nigeria

SAMPLE	CONTROL		STATION 1		STATION 2		STATION 3	
PARAMETER	DRY	RAINY	DRY	RAINY	DRY	RAINY	DRY	RAINY
pH	5.28± 0.04^{a,c}	6.83± 0.03^{a,d}	5.14± 0.02^{b,c}	5.40± 0.12^{b,c}	5.80± 0.04^{b,c}	5.27±0.07^{b,d}	5.15±0.02^{b,c}	5.40± 0.06^{b,d}
Conductivity, µs/Cm	327.00±50.54^{a,c}	0.00± 0.00^{a,d}	7743.33±289.50^{b,d}	8206.67±32.83^{b,c}	7607.00±183.85^{b,d}	6476.6±17.64^{b,c}	7312.33±308.59^{b,d}	2529.33±298.24^{b,c}
Chloride, mg/Kg	126.56±30.39^{a,c}	17.52±1.17^{a,d}	1749.69±50.62^{b,d}	848.09±18.55^{b,c}	1793.94±30.94^{b,d}	758.50±29.81^{b,c}	1779.83± 20.28^{b,d}	702.82± 41.69^{b,c}
Sodium, mg/Kg	58.62 ± 6.75^{a,c}	9.60± 1.27^{a,d}	738.08± 4.80^{b,d}	411.93±1.72^{b,c}	742.33± 4.29^{b,d}	410.37±2.21^{b,c}	740.02± 6.67^{b,d}	410.25± 1.61^{b,c}
Phosphate, mg/Kg	43.67 ± 3.51^{a,c}	46.33±3.51^{a,d}	56.00± 2.00^{b,d}	51.67± 5.67^{b,c}	55.33± 0.11^{b,d}	53.67±4.04^{b,c}	57.67±0.19^{b,d}	64.33± 6.35^{b,c}
Sulphate, mg/Kg	184.00±1.73^{a,c}	172.33±19.66^{a,d}	480.00± 5.00^{b,d}	404.11±60.48^{b,c}	351.16±0.54^{b,d}	330.67±14.36^{b,c}	581.06± 0.85^{b,d}	530.30±22.81^{b,c}
Calcium, mg/Kg	45.89 ± 0.57^{a,c}	48.60 ± 0.40^{a,c}	132.91± 1.57^{b,d}	131.69±0.78^{b,c}	136.89±46.32^{b,d}	132.94±1.76^{b,c}	130.86± 9.40^{b,d}	138.81±2.62^{b,c}
Magnesium, mg/Kg	73.67 ± 1.86^{a,c}	80.67 ±4.06^{a,d}	449.00±21.00^{b,d}	406.00±11.15^{b,c}	437.67±26.91^{b,d}	381.67±39.06^{b,c}	454.33±15.34^{b,d}	422.33±20.63^{b,c}
Potassium, mg/Kg	24.06 ± 2.43^{a,c}	20.48 ± 0.83^{a,d}	19.06 ± 1.11^{a,d}	19.62± 0.70^{b,d}	21.00 ±0.61^{a,d}	21.95± 1.09^{b,d}	20.35± 1.67^{a,d}	21.88±0.49^{b,d}
Ammonium, mg/kg	3.43 ± 0.24^{a,c}	3.65 ± 0.04^{a,d}	0.18 ± 0.01^{b,d}	0.84 ± 0.06^{b,c}	0.19 ± 0.06^{b,d}	1.17 ± 0.14^{b,c}	0.38± 0.10^{b,d}	1.16± 0.24^{b,c}
Nitrate, mg/Kg	14.43 ± 0.27^{a,c}	11.5 ± 0.16^{a,d}	4.97 ± 0.19^{b,d}	4.13 ± 0.31^{b,c}	5.16 ± 0.01^{b,d}	3.80 ± 0.08^{b,c}	5.06± 0.03^{b,d}	3.53± 0.20^{b,c}
TOC, %	9.03 ± 0.10^{a,c}	11.17 ± 0.28^{a,d}	2.80 ± 0.24^{b,d}	3.07 ± 0.14^{b,c}	2.91 ± 1.33^{b,d}	3.62 ± 0.07^{b,c}	2.76± 3.18^{b,d}	4.14± 0.19^{b,c}
Manganese, mg/Kg	0.27 ± 0.03^{a,c}	0.23 ± 0.03^{a,d}	0.03 ± 0.00^{b,d}	0.02 ± 0.00^{b,c}	0.07 ± 0.04^{b,d}	0.11 ± 0.01^{b,c}	0.11± 0.05^{b,d}	0.20± 0.04^{b,c}
Iron, mg/Kg	10.33 ± 0.23^{a,c}	8.90 ± 0.66^{a,d}	11.13 ± 0.44^{b,d}	11.53 ± 0.58^{b,c}	11.13 ± 0.13^{b,d}	13.27 ± 0.52^{b,c}	8.67± 0.07^{a,d}	9.93± 0.38^{a,c}
Lead, mg/Kg	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.02 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.02 ± 0.00^{a,c}	0.01 ± 0.00 ^{a,d}	0.04±0.01^{b,d}	0.01± 0.00^{a,d}
THC, g/Kg	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,c}	0.02 ± 0.00^{a,c}	0.02 ± 0.01^{a,d}	0.01 ± 0.00^{a,c}	0.01 ± 0.00^{a,d}	0.04±0.01^{b,d}	0.01± 0.00^{a,d}
Cadmium, mg/Kg	0.22 ± 0.13^{a,c}	0.26 ± 0.15^{a,d}	0.14 ± 0.08^{b,d}	0.18 ± 0.10^{b,c}	0.24 ± 0.14^{b,c}	0.15 ± 0.09^{b,c}	0.03± 0.02^{b,c}	0.14±0.08^{bc}
Copper, mg/Kg	0.29 ± 0.05^{a,c}	1.10 ± 0.25^{a,d}	1.10 ± 0.06^{a,d}	2.73 ± 0.07^{b,c}	2.42 ± 0.16^{b,d}	2.60 ± 0.10^{b,c}	1.20± 0.36^{a,d}	0.83±0.03^{b,c}
Zinc, mg/Kg	0.05 ± 0.01^{a,c}	0.07 ± 0.01^{a,d}	0.03 ± 0.01^{a,c}	0.03 ± 0.01^{a,d}	0.04 ± 0.02^{a,c}	0.06 ± 0.01^{a,d}	0.07± 0.02^{a,c}	0.06±0.00^{a,d}

CEC= Cation exchange capacity, TOC= Total organic content, THC= Total hydrocarbon content
Values are means ± Standard Error of Mean (SEM). Values with different superscripts are statistically significant at $p < 0.05$. Superscript (a,b) compare stations 1, 2 and 3 against the control across the season for both seasons while superscript (c,d) compare each sample to the other within the seasons

DISCUSSION

The result of pH showed that there was a significant change between the dry season and rainy season observations in both water and sediment. The pH value in water for the control varied from 5.28- 6.83 and 5.14 - 5.80 for all the stations for the two seasons. For sediments, the control value ranged from 6.15- 6.78 and 6.99 - 7.59 for the stations. The value for water observed in this study was below the standard of 6.5 - 9.0 given by U.S. EPA (2008) water quality criteria, with the exception of the control during the rainy season. The values obtained in this study were within the values reported by Agorua *et al.* (2021). Variations in the pH values observed at Ipare might be attributed to seasonal variations and the presence of agricultural or domestic effluents (Matta *et al.,* 2017). The reduction in the concentration of sodium, chloride, salinity and conductivity in the dry season in the degraded stations (1 to 3) in water and sediment might be due to disposal of sewage from various anthropogenic activities in and around the area. Infiltration of saline water into the stations was also suspected. The fact that salinity values in the control station were all within permissible limits given for a freshwater wetland (UNEP, 1996; WHO, 2011)) justified the effects of external sources as major reasons for high salt contents at the impacted sites. The drastic reduction recorded in the rainy season could be due to dilution resulting from rain inflow as reported by Bornman and Adams (2010) and Sushanth and Rajashekhar (2012). During the dry season, evaporation also contributes to the increased salt concentration of the water body, as reported by the Clean Water Team (2004). A strong correlation between salinity and electric conductivity has been reported by Onyema and Nwankwo (2009).

The concentrations of nitrate and ammonium in Ipare wetland water during the study were within the permissible limit of 5 mg/l and 0.53 mg/l for nitrate and ammonium, respectively (UNEP, 1996; WHO, 2011). Nitrogen is an essential nutrient that floras require for growth and productivity (Santamaria, 2002; Zhu *et al*., 2008). Typically, the sources of nitrogen to the sediments at the stations under study could be from the atmosphere, through nitrogen fixation and nitrification processes, or from decaying organic matter. Expectedly, the nitrogen levels were generally low during the dry season due, perhaps, to absence of leguminous plants that could fix nitrogen. When rain begins to fall, more nitrogen may be available through decay as confirmed by the increased levels of nitrogen and ammonium during the rainy season. This nitrogen boost could also result in reduction in salinity concentration of the wetland water. Muhammad *et al.* (2012) observed that reduction in salinity concentration and increase in dissolved oxygen as a result of increased rainfall could improve the activities of nitrifying bacteria. Phosphorus is another essential soil nutrient that is abundant in nature. Nevertheless, the values obtained for stations 1 to 3 did not show sufficient abundance at the degraded wetlands.

The high concentration of sulphate observed in the waters could be due to discharge of wastes from anthropogenic sources. Sulphide toxicity has been observed to be one of the causes of root decay in aquatic plants (Van Der Welle *et al*., 2007). The reduction in sulphate concentration recorded across the seasons for stations 1 to 3 could have resulted from rainwater discharge into the wetland and reduction in the evaporation rate during the wet season. This corroborates the findings of Garg *et al*. (2009). Results of this study also showed that there were significant differences in the concentrations of magnesium, calcium and potassium when compared to the control within and across the two seasons. The concentrations of magnesium and calcium during the dry season might be due to the inflow of hardness from a non-point source and from some anthropogenic activities going on in the area. This observation is in line with the findings of Cheremisinoff (2019) who reported that soft freshwater can become hard if there is an infiltration or inflow of calcium and magnesium-rich water. The cadmium, lead and total hydrocarbon content of the study area were all within the acceptable limit of 3 µg/l for cadmium and lead, and 10 µg/l for total hydrocarbon (FMENV, 1991; FEPA, 2003; WHO, 2011; EGASPIN, 2018).

Zinc and copper are micronutrient elements required by flora for proper growth and functioning. Serious consequences may arise when the concentration is beyond 2000 µg/l for copper and less than or equal to 5 mg/l for zinc (McNeely *et al*., 1979; WHO, 2011) in a wetland water. It was observed that the concentration of these micronutrient elements were very low in all the stations including the control. The concentrations of iron at the study stations were higher than 0.3 mg/l provided as the permissible limit by WHO (2011) while manganese was within the limit.

Total organic matter is a parameter that is used to determine soil fertility. Soil organics mostly come from decayed or decaying organic matters such as leaves, plant and animal remains. The high TOC observed in this study typical of fertile soils for both dry and rainy seasons. Nevertheless, poor vegetation growth and yield were predominant during the dry season, which could be due to high salinity content. In the wet season, the value of TOC generally increased, indicating more decay of organic materials as a result of rainfall (Mulholland *et al*., 1997; Osland *et al*., 2018).

CONCLUSION

The sediment and water physicochemical characteristics of the degraded sample locations showed significant differences when compared to the control, with the exception of heavy metals in which the results were relatively comparable over the two seasons. Although the concentration of metals remained fairly comparable throughout the study period, seasonal variations had a significant impact on physicochemical properties of water and sediment. Anthropogenic activities have also been shown to contribute to the degradation of the wetland.

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