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PHYSICOCHEMICAL PROFILE STUDY OF A PORTION OF THE ULASI RIVER FROM EZINIFITE TO OGWU-ANIOCHA, IN ANAMBRA STATE OF NIGERIA.

B. A. UZOUKWU, C. F. EZE and P. O. ORDU

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ABSTRACT

The physicochemical profile study carried out on Ulasi river course from Ezinifite to Ogwu-Aniocha in Anambra State of Nigeria shows that the water body has a fairly constant temperature that is in the 26 – 27 °C range. The mean pH values of the top level of the river is always higher than that of the bottom, and is outside the 6.5 – 8.5 range allowed by WHO for potable water. Apart from the river course from Ezinifite to Lilu statistical analysis has shown, however, that there is no significant difference between the mean pH values of the top and bottom level of the river. Results show that Fe content of the bottom level of the river is higher than that of the top level of the river. Apart from the river course at Ogwu Aniocha statistical analysis has shown, however, that there is no significant difference between the mean Fe values of the top and bottom level of the river. Hydrolysis of the high Fe content found in the sediment have been used to explain the slightly higher Fe content of the river bottom and also the slightly higher acidity of the bottom level of the river. The mean Fe concentration along the course of the river falls in the 0.6 – 2.5 mg/L for the top and 0.8 – 4.9 mg/L for the bottom levels of the river and are above the 0.2 mg/L guiding limit set by WHO for potable water. Low levels of inorganic PO_4^{3-} and NO_3^- nutrients were reported for the river. Sulphate, sulphite and nitrite ions were not detected and the metals: Cr, Pb, Cd, Mn, Ni, Cu, Co, Al, Ba, V, As, Hg and Mo were also not detected. The mean biochemical oxygen demand (BOD) recorded values lower than 1 mg/L O_2. Unacceptable levels of surfactants (0.50 mg/L) that are above the 0.2 mg/L EEC guiding limit set for potable water bodies were recorded. Unacceptable levels of hydrocarbon in the course of the river, falling within the 0.3 - 3.9 mg/L range were observed. Hydrocarbon pollution is more serious at Ulasi Ukpor/Okija to Ulasi Okija Junction water fronts and has been attributed to used engine oil waste disposed along the banks of the river.

The physicochemical studies on the sediments and soil showed that they can be characterized as ferrous with pH values that are close to 6.2-6.9 and < 5 respectively. Unacceptable levels of hydrocarbon were also detected in both sediment and soil samples and have been attributed to unguided disposal of used engine oil.

KEYWORDS: Physicochemical studies, Ulasi river, Anambra State

INTRODUCTION

Industrial waste disposal, effluent discharges, excessive fertilization and subsequent water runoff are some of the sources of pollution of water bodies that lead to algal bloom in water bodies and eutrophication (Lee et al 1978). These constitute environmental issues in many parts of Nigeria, particularly those areas witnessing tremendous growth in industrial activities. The result is that pollution of water bodies by organic and inorganic species, agricultural chemicals and allied materials, domestic and industrial wastes, solid debris and suspended particles are gradually taking centre stage in Nigeria. Apart from this, Nigeria as an oil producing country has an additional source of water pollution through oil spillage, pipe line leakage and crude oil transportation.

In this present study the water quality parameters of the top and bottom water profiles of the Ulasi river, the sediment and soil samples along the course of the river that flows through Ekwusigo, Nnewi and Ihiala Local Government areas were investigated. This is because this course of the river has received little or no study in the past. Apart from that these Local Government areas of Anambra State of Nigeria are experiencing gradual growth in industrial activities with its attendant pollution problems. The study is intended to identify if there is any form of impact of these activities on the Ulasi river in any way.

MATERIALS AND METHODS

The course of the Ulasi river studied stretches from Ezinifite, Lilu, Ukpor, Orsumoghu, Azia, Okija, Ozubulu, Ihiala down to Ogwu-Aniocha. All the towns are in Anambra state of Nigeria, covering a distance of about 40 km. These towns are either within or on the out-sketch of the Local Government areas of Ekwusigo, Nnewi and Ihiala that are experiencing one form of small scale or large scale industrial activities or the other.

Top water samples were collected from close to 30 cm below the water surface (Hunt and Wilson, 1986) of each of the Ulasi waterfronts within the months of June to August of 2002 and bottom water samples were collected from close to 30 cm to the floor of the river. Samples were preserved appropriately (Uzoukwu, 2000) where necessary. Data for temperature, dissolved oxygen, flow rate, turbidity and odour of all the samples were acquired in the field. Sediments from water fronts and soil samples along the banks of the river were also collected.

Standard methods were used for the analysis of water (Greenberg et al 1992), sediment and soil (Allien et al 1974) samples. A Consort C531 pH and electrical conductivity meter was used for determining the pH and electrical conductivity of the samples. Fresh samples were used for determining the pH of sediments while a 1:1 volume suspension of the soil in water was used for determining the pH of the soil samples. Odour was determined following the method of olfactory sensation (Krasner et al, 1985). Alkalinity, total hardness and chloride ion contents of the samples were determined using appropriate titrimetric methods. Dissolved oxygen (DO) and Biochemical oxygen demand (BOD) were analysed electroanalytically using an OxyScan Light oxygen measuring meter. Sulphate and phosphate ions were analysed using the turbidometric and molybdenum blue methods respectively while nitrate ion was determined following the brucine method. Surfactant was determined using the methylene blue method (Uzoukwu, 2000). Known volumes of water samples were extracted with chloroform and the absorbance of organic extract measured at 450 nm and compared against crude oil standards. Determination of the metal content was carried out

B. A. UZOUKWU, Dept. of Pure and Industrial Chemistry, University of Port Harcourt, Choba, Port Harcourt, Nigeria. Tel: 023408037240817, e-mail: uzoukwupob331@yahoo.co.uk
C. F. EZE, Department of Pure and Industrial Chemistry, University of Port Harcourt, Choba, Port Harcourt, Nigeria.
P. O. ORDU, Department of Pure and Industrial Chemistry, University of Port Harcourt, Choba, Port Harcourt, Nigeria.

using a Buck Scientific 200A atomic absorption spectrophotometer (Bosnák et al, 1996).

RESULTS AND DISCUSSION

The course of Ulasi river from Ezinifite to Ozubulu had turbidity values close to 6 NTU, thus allowing the floor of the river to be visible from the river surface. Turbidity values close to 10 NTU and 15 NTU were however, recorded between the Okija and Ogwu-Aniocha course of the river. The river samples had little or no odour. The surface flow rate is within the 24 - 71 cm/sec range between Ezinifite and Ozubulu, with depths that vary within the range of 0.7 – 2.0 m (width ranged between 2 – 20 m), and as low as 15 cm/sec between Ihiala and Ogwu-Aniocha where the river is also deeper with depths that are within the 3 - 5 m range (width ranged between 20 – 40 m). Since the river is used mainly for domestic and transportation purposes the mean temperatures values listed on Table 1 for the top and bottom levels of the river which are fairly close to the 26 – 27 °C are comparable with the EEC guiding temperature of 25 °C allowed for potable water. It is also comparable with what was reported for the Ubu river (Uzoukwu at al, 2004) that has its course within the same geographical area. Results presented on Table 1 show that the mean pH values of the bottom level of the river is always outside the 6.5 – 8.5 range allowed by WHO for potable water. The mean pH (6.71±0.06) of the Ezinifite to LiLu (EL) course of the river is within WHO guiding limit however, the water tends to become more acidic with the mean pH value getting to values lower than 6.5 starting from OI (Ose Reuben in Ozubulu to Ose Akwa in Ihiala) down the course of the river to OA (Ose Ogwu-Aniocha) where mean pH value of 5.84±0.10 was recorded. Generally the mean pH values were found to be higher at the top level than at the bottom level of the river although statistical analysis at 90 % confidence level shows that it is only along the Ezinifite and Lilu course of the river that there is a significant difference between the two mean pH values. Table 1 shows that the level of Fe increases from 0.63 mg/L (Ezinifite) to 2.51 mg/L (Ogwu-Aniocha). Hydrolysis of the ferric species in the river body may have played a major role in contributing to the increase in acidity of the river with increase in Fe content of the water body. The values are however lower than the 5 mg/L maximum level required in aquatic ecosystems for the sustenance of aquatic life and for use in irrigation (Cain and Feachem, 1983). Table 2 also shows that the sediments which can be characterized as ferrous may have played a major role in the mineralization of the river.

For instance, it is obvious that OA with the highest concentration of Fe (11,630 mg/kg) in its sediment also had the highest Fe concentration in the water body, and one of the

Table 1 Physicochemical properties of the top and bottom (in parenthesis) levels of the course of the Ulasi river studied

	EL	UOA	OK	OI	OA
Temperature (°C)	26.9±0.1 (26.9±0.1)	27.1±0.1 (27.0±0.1)	27.9±0.1 (27.7±0.2)	26.2±0.1 (26.2±0.1)	27.0±0.1 (26.8±0.1)
pH	6.71±0.06 6.38±0.07	6.42±0.11 (6.36±0.13)	6.36±0.16 (6.18±0.11)	5.79±0.07 (5.74±0.12)	5.84±0.10 (5.83±0.10)
Electrical conductivity EC (μS/cm)	18.68±0.50 (17.97±0.64)	18.55±0.20 (17.49±0.26)	17.41±1.78 (17.13±0.68)	22.30±1.04 (20.23±0.47)	24.86±0.50 (22.06±0.60)
Dissolved Oxygen (mg/L O_2)	5.94±1.00 (5.88±0.76)	4.85±0.45 (4.90±0.26)	4.85±0.07 (4.82±0.18)	4.70±1.04 (4.21±0.53)	4.12±0.25 (4.02±0.20)
Biochemical Oxygen Demand (mg/L O_2)	0.85±0.84 (0.78±0.65)	0.31±0.38 (0.27±0.34)	0.22±0.02 (0.31±0.06)	0.10±0.04 (0.11±0.07	0.98±0.21 (1.02±0.16)
Alkalinity (mg/L $CaCO_3$)	30.8±4.6 (30.0±4.9	26.0±0.7 (26.3±1.8)	23.3±0.4 (25.3±0.4)	25.8±4.6 (24.8±2.5)	22.0±1.5 (24.0±1.5)
Total Hardness (mg/L $CaCO_3$)	6.3±1.8 (6.8±0.4)	7.5±3.5 (8.3±3.2)	8.5±2.8 (7.8±2.5)	12.0±0.1 (11.0±4.2)	20.5±0.5 (14.5±0.4)
Surfactants (mg/L)	0.49±0.16	0.46±0.17	0.45±0.12	0.58±0.18	0.17±0.10
Total Hydrocarbon Content THC (mg/L)	0.96±0.13	0.49±0.04	3.90±5.57	0.37±0.31	0.44±0.17
Chloride (mg/L)	9.2±1.0 (10.0±0.5)	8.9±1.5 (9.3±0.5)	8.6±0.5 (8.4±1.8)	10.0±2.5 (9.2±1.9)	8.9±1.2 (8.5±0.9)
Nitrate (mg/L)	3.1±0.1 (2.9±0.1)	3.5±0.4 (3.6±0.5)	2.7±0.1 (3.4±0.3)	1.8±0.4 (2.1±0.7)	2.2±0.2 (2.0±0.2)
Phosphate (mg/L)	0.32±0.01 (0.66±0.16)	0.18±0.06 (0.19±0.02)	0.16±0.02 (0.17±0.01)	0.18±0.04 (0.22±0.02)	0.23±0.02 (0.24±0.03)
Fe (mg/L)	0.63±0.18 (0.78±0.46)	0.72±0.37 (0.87±0.21)	0.68±0.04 (0.87±0.13)	1.26±0.28 (1.23±0.50)	2.51±0.08 (4.93±0.15)
Zn (mg/L)	0.44±0.32 (0.29±0.15)	0.57±0.20 (0.56±0.74)	0.48±0.08 (0.92±0.22)	0.04±0.03 (0.04±0.01)	0.45±0.05 (0.30±0.04)
Na (mg/L)	1.59±0.23 (1.61±0.08)	1.56±0.18 (1.83±0.70)	1.67±0.47 (2.04±0.02)	1.31±0.03 (1.31±0.16)	1.65±0.04 (1.69±0.02)
K (mg/L)	0.87±0.16 (0.71±0.10)	0.73±0.15 (0.86±0.43)	0.83±0.22 (0.81±0.06)	0.85±0.05 (0.85±0.16)	1.14±0.22 (1.74±0.30)
Ca (mg/L)	0.45±0.04 (0.31±0.02)	0.64±0.33 (0.35±0.04)	0.29±0.01 (0.33±0.01)	0.29±0.01 (0.28±0.03)	0.61±0.05 (0.26±0.02)

The mean and standard deviations are from three replicate results from three waterfronts along a course.
EL= Ulasi Ezinifite to LiLu/Ukpor waterfronts, UOA = Ulasi Ukpor/Orsumughu to Ukpor/Azia waterfronts, OK = Ulasi Ukpor/Okija to Okija Junction waterfronts, OI = Ulasi Ozubulu to Ihiala waterfronts, OA = Ulasi Ogwu-Aniocha waterfront

Table 2 Some physicochemical properties of sediments from water fronts of the Ulasi river Studied

	pH	EC	PO_4^{3-}	NO_3	THC	Fe	Zn	Mn	Cd	Al	Ni	Ca	K	Mg
EL	6.27 ±0.16	96 ±17	6 ±5	174 ±23	39 ±8	7,300 ±60	51 ±9	44 ±5	2.9 ±0.6	4,310 ±1,220	4 ±4	14 ±4	88 ±18	70 ±13
UOA	6.89 ±0.08	720 ±97	13 ±1	310 ±66	346 ±343	9,220 ±15	63 ±18	116 ±24	3.7 ±0.6	6,724 ±731	3 ±2	19 ±11	129 ±42	174 ±117
OK	6.69 ±0.07	380 ±194	8 ±7	224 ±20	465 ±404	5,390 ±1,650	58 ±14	24 ±15	3.3 ±0.1	4,828 ±975	4 ±4	11 ±1	74 ±7	59 ±11
OI	6.76 ±0.04	715 ±177	9 ±5	206 ±29	160 ±26	6,540 ±5,870	39 ±4	63 ±58	0.1 ±0.1	7183 ±20	5 ±2	16 ±6	135 ±7	134 ±1
OA	6.64 ±0.05	1,150 ±180	25 ±6	389 ±79	279 ±138	11,630 ±160	63 ±5	567 ±30	2.6 ±0.1	11,126 ±100	12 ±2	122 ±15	811 ±10	828 ±6

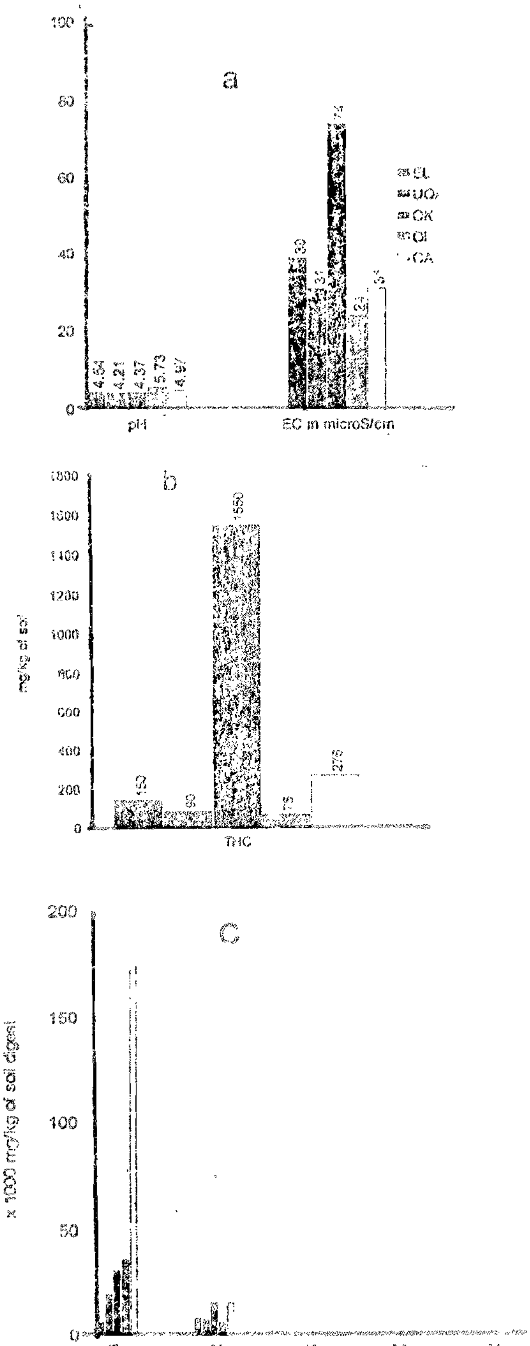

Fig 1 Mean levels of some physicochemical properties of soil from the banks of the Ulasi river

lowest pH values recorded. Table 1 also shows that the river has fairly low mean alkalinity values, an indication of the existence of low buffering capacity in the Ulasi ecosystem. This has been corroborated by low mean Ca concentration that are less than 0.7 mg/L (Table 1) and Mg concentration that has values that fall within the 0.10 – 0.70 mg/L range. It also shows that the mean alkalinity follows the decreasing trend that starts from EL (30.8 mg/L $CaCO_3$) to OA (22.0 mg/L $CaCO_3$), a pattern that has been observed with the mean pH values.

The average electrical conductivities recorded values that are less than 30 µS/cm indicating that the course of the Ulasi river is a fresh water body. This is supported by the low levels of nitrate, chloride, phosphate, total hardness and metal ions recorded. Table 1 also shows that the mean electrical conductivity of the top level of the river is slightly higher than that of the bottom level of the river. Sulphate, sulphite and nitrite ions were not detected and metal ions of Cr, Pb, Cd, Mn, Ni, Cu, Co, Al, Ba, V, As, Hg and Mo were also not detected. The mean dissolved oxygen (DO) of the river surface is highest (5.94 mg/L O_2) at the upstream course (EL) and falls gradually to values lower than 5 mg/L O_2 towards the lower courses of the river (OA). Also it is observed that the DO level is higher in the top level of the river than in the bottom level of the river. These values are comparable with reports (Uzoukwu at al, 2004) presented in literature for water bodies in the region and satisfies the minimum DO level of 5 mg/L O_2 suggested (Alabaster and Lloyd, 1980) for the sustenance of aquatic life and for domestic purposes. Mean biochemical oxygen demand (BOD) determinations recorded values that are lower than 1 mg/L O_2 an indication of the low level of biochemical activities along the courses of the Ulasi river from Ezinifite to Ogwu Aniocha, due to a low level of organic feed. This compares well with values lower than 0.8 mg/L O_2 recorded for Ubu river (Uzoukwu et al, 2004). The low levels of inorganic PO_4^{3-} and NO_3^- nutrients in the river indicate that the two species don't play any major role in the level of biochemical activities in the course of the Ulasi ecosystem (Gladyshev et al, 1993) studied. The mean NO_3^- (2 – 4 mg/L) levels are however, remarkably higher than values < 0.6 mg/L reported by Orisakwe et al (2001) for the course of the Niger river found in the same geographical area, and we have attributed this to a relatively higher level of use of nitrogen based fertilizers by farmers along the banks of the Ulasi river or as a result of a bigger fold of dilution factor of the larger Niger river.

The EL to OI course of the river has unacceptable levels of surfactants that are close to 0.50 mg/L since they are above the 0.2 mg/L EEC guiding limit set for potable water bodies. We have made a similar observation in other reports (Uzoukwu et al 2004). This is an indication of the high level of surfactant usage by the local populace for washing and cleaning purposes along the EL to OI course of the river, and the fact that the waste water resulting from this exercise is dispersed into the river without any form of treatment. The mean surfactant level in the OA course of the river is slightly lower than 0.2 mg/L and, hence is within the EEC acceptable limit. The greater dilution factor of the large volume of water encountered in this course of the river may have helped in reducing the surfactant concentration to within this acceptable limit, because it does not preclude the usage and free dispersal without treatment of surfactant waste water into this course of the river by the local populace.

The data for THC presented on Table 1 show that the river has unacceptable levels of hydrocarbon content in all the courses of the river, with mean THC values that fall within the 0.3 - 3.9 mg/L range. These concentrations are above the 0.1 mg/l guiding level set by EEC for potability. Hydrocarbon pollution is more serious at the OK course of the river which consists of Ulasi Ukpor/Okija to Ulasi Okija Junction water fronts. It is not clear at the moment the sources of the hydrocarbon content of the other reported courses of the river but that of OK is due the used engine oil waste that is frequently disposed by auto-mechanics along the banks of the OK course of the river, and is being carried down the river by flood water runoffs. The other possibility is the oil spillages from canoes used for conveying white sand or palm and agricultural produce along the course of the river. This may have been the common source of hydrocarbon content of EL to OA course of the river. The implication of this hydrocarbon content of the Ulasi river is that treatment of the water by chlorination will not be a suitable method because (Morris, 1995) chlorination of such water bodies may result in carcinogens and cancer of the gastrointestinal tracks if taken as drinking water. Detoxification of the organic content of the river where necessary can be achieved by ozonation or through electro-oxidation (Wabuer et al, 1985).

Apart from the unacceptable levels of surfactant and hydrocarbon concentrations the mean Fe concentration along the course of the river which falls in the 0.6 – 2.5 mg/L for the top and 0.8 – 4.9 mg/L for the bottom levels of the river are above the 0.2 mg/L guiding limit set by WHO for potable water. In all cases the results presented show that the bottom level of the river has the higher mean amount of Fe than the top level of the river. It is hereby being suggested that hydrolysis of the high Fe content found in the sediment (Table 2) may have added to the slightly higher concentration of Fe in the river bottom due their closer proximity, and also to the slightly higher acidity of the bottom level of the river than the top level. Generally the mean Fe values were found to be higher at the bottom level than at the top level of the river although statistical analysis at 90 % confidence level shows that it is only along the Ogwu Aniocha course of the river that there is a significant difference between the two mean pH values. Table 1 also shows that the Na content is higher at the bottom level than at the top level of the river while that of Ca followed the opposite trend with the top level having the higher mean Ca concentration. Earlier reports by Orisakwe et al (1999) and Uzoukwu et al (2004) on fresh water bodies have shown that mean iron concentration > 0.3 mg/L is wide spread in many fresh water bodies found in the area. All other metal ion contents are within guiding limits set by WHO for potability.

Brown sediments were collected from all the water fronts studied (Table 2). This is due to the high Fe content of the sediments and as such the sediments can be characterized as being ferrous. The brown colour of the sediment may have explained the apparently brown colour of the river when observed from the banks without a corresponding high level of turbidity of the river The mean pH values fall within the 6.2-6.9 range. They contained detectable amounts of many metals that were listed on Table 1 as undetected in the water bodies of river. Precipitation of the mineralised water runoffs that flow into the river may have been the process that gave rise to detectable quantities of these metals in the sediments. Table 2 also shows that the level of these metals is always highest in the sediments collected along the OA course of the river. It is important to state that toxic metals such as Pb, Hg, and As were undetected in the sediments of the course of the river studied.

Some physicochemical properties of the soil samples collected from the banks along the course of the river are presented on Fig 1 and it shows that the soil is fairly acidic with pH values that are lower than 5. The wide spread of soil acidity in the area has been reported in another study (Uzoukwu and Onomake, 2004). Fig 1a also shows that the electrical conductivity of a 1:1 suspension of the soil is lower that 80 µS/cm, an indication that the soil is totally non-saline. That explains why Cl^- (40 – 150 mg/kg of soil), SO_4^{2-} (8 – 20 mg/kg of soil), NO_3^- (35 – 50 mg/kg of soil) and PO_4^{3-} (1 – 3 mg/kg of soil) could be extracted from the soil samples. Apart from the courses of EL, UOA, OI where THC were found to be below 150 mg/kg of soil and OA with THC value of 276 mg/kg, its is obvious from Fig 1b that unacceptable levels of hydrocarbon had occurred along the banks of OK where THC value as high as 1,557 mg/kg of soil was recorded. The source of the hydrocarbon has been traced to the unguided disposal of waste engine oil along the OK bank of the river by auto-mechanics. The source of hydrocarbon in other banks of the river, particularly from OI to OA may be due to unguided palm oil spillages from the small scale palm oil producing industries sited along the banks of the river. These values are higher than the 20 mg/kg allowed by FEPA Nigeria for effluent disposal on land. The result of the remarkably high THC in soils along the OK course of the river is that sediments from the OK course of the river (Table 1) recorded the highest THC content of 465 ± 404 mg/kg of sediment. Fig 1c shows that the metal abundance follows the trend Fe > Al > Mg > K > Na. Subsequently the soil can be characterised as ferrous and the intensity increases gradually from the course at EL (6,990 mg Fe/kg of soil) as one proceeds down to OA where the Fe content as high as 174,660 mg/kg of soil digest was recorded.

CONCLUSION

The physicochemical studies have shown that the mean pH of the bottom level of the Ulasi along the course studied is more acidic than the top level of the water. Mineralization of the river may have resulted in the iron content of the bottom level of the river being always higher than its content at the top level of the river. The sediments are neutral while the soil along the banks of the river are fairly acidic but both can be characterized as ferrous. The Fe content of the course of the river is unacceptably high for potability. The hydrocarbon content of the river, sediment and soil are unacceptably high at some parts of the river and this has been attributed to unguided disposal of used engine oil along the banks of the river. Thus baseline pollution data for this area have been determined for future comparative studies.

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