International Journal of Modern Research in Engineering and Technology (IJMRET)
www.ijmret.org Volume 3 Issue 4 ǁ April 2018.

Impact of Household Waste on the Water Quality of *Umuerim* River, Nekede, Owerri Nigeria.

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ABSTRACT: *The research was carried out to assess the quality of Umuerim River , Nekede which serves for domestic uses and fishery activities among the rural inhabitants in October 2016.The anthropogenic activities identified during reconnaissance visit include discharge of household wastes into its channel across Owerri; sand miningandAgricultural activities at it's bank that serve as non-point source. Water samples were collected from four sampling points (discharge point SP1, midstream SP2, downstream SP3 and upstream), in Nekede, using standard methods for sampling and analysis. Parameters analyzed include Lead, Zinc, Iron, Copper, Chromium, Nitrate, Sulphate, Phosphate, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), 5-day Biological Oxygen Demand (BOD_{5}), Turbidity, pH, Conductivity, and Temperature. Results showed that Conductivity (range= 5.50 µS/cm), Total Dissolved Solids (TDS) (range= 4.00 mg/L), Turbidity (range= 3.20 NTU) and Sulphates (SO_4) (range= 2.70 mg/L) recorded comparatively wide variations during the study period. Mean levels of pH (6.24 ± 0.09), DO (1.45 ± 0.08) mg/L, BOD (0.49 ± 0.09) mg/L, and Turbidity (4.93 ± 0.67) NTU were beyond the limits set by the Federal Ministry of Environment's recommended standards for surface water. It is therefore, recommended that constant monitoring by routine water quality checks should be conducted for safe public consumption of the water.*

Keywords: Umuerim River, water quality, Household wastes, Parameter

I. INTRODUCTION

Water is essential for livelihood as well as socio-economic development of any community and it is estimated that approximately one third of the world's population use groundwater for drinking[1].Many communities in Nigeria rely on surface and groundwater for both domestic and agricultural water supplies because of its abundance, stable quality and also because it is inexpensive to exploit. However, the urbanization process threatens the surface and groundwater quality because of the impact of domestic and industrial waste disposal. Water pollution is any chemical, physical or biological change in the quality of water that has a harmful effect on any living thing that drinks or uses or lives in it[2] Dissolved wastes and other materials that are dumped, spilled or stored on the surface of the land or in sewage disposal pits can be dissolved by precipitation, irrigation waters or liquid wastes and eventually seep through the soil in the unsaturated zone to pollute the groundwater [3]. Poor environmental management creates havoc on the water supply, hygiene and exacerbating public health [4]. [5]emphasized on the importance of surface and groundwater globally as a source for human consumption and changes in their quality with subsequent contamination can, undoubtedly, affect human health.

Heavy metals such as Fe, Cr, Ni, Cu and Zn are essential in living organisms because of their structural and functional roles in various physiological processes [6]. Essential heavy metals are required in trace quantities by organisms and if their concentration exceeds the threshold level they become toxic [7] especially at higher levels, [8],[9]. The World Health Organization (WHO) estimates that more than 20% of the world population (around 1.3 billion people) have no safe drinking water and that more than 40% of all populations lack adequate sanitation [10].

Household wastes are solid waste comprising of garbage and rubbish (such as bottles, cans, clothing, plastics, disposables, food packaging,cooked food scraps, newspapers and magazines, and yard trimmings) that originates from private homes or apartments [11.The presence of a number of various household wastes, point and non-point sources of pollution aroundthe Umuerim River pose a huge threat on the water quality of the river with numerous health implications. Municipal solid wastes are made up of household wastes, construction and demolition debris,garden wastes,electrical and electronic wastes and sanitation residue from the street. Residential and commercial complexes generate the garbage that forms part of the wastes that are classified as municipal/household wastes. With population increase in Owerri metropolis and Umuerim in particular and, the change in lifestyles and food habits, the amount of municipal wastes have been increasing rapidly. In the last few years, the consumer market has grown rapidly leading to products being packed in cans, aluminum foils, plastics, nylon and non-biodegradable items that could cause incalculable harm to the environment [12]; [13]. Proper handling of biodegradable wastes would lessen the burden of solid waste that each city has to tackle[14]

The use of the *Umuerim* River by the riparian population especially those using the water for domestic purposes necessitates the need to have the river assessed for its ability to carry the pollutants while maintaining water of suitable quality for its intended use. The human need for water is not only a function of quantity but also of the quality of the water[15][16]. Water can be polluted by substances that dissolve in it or by solid particles and insoluble liquid droplets that become suspended in it[17], and this poor quality water causes health hazard and death of human being, aquatic life and also disturbs the production of different crops[18]. In fact, the effects of water pollution are said to be the leading cause of death for humans across the globe, moreover, water pollution affects our oceans, lakes, rivers, and drinking water, making it a widespread and global concern [19]. Many studies have detected elevated levels of both organic and inorganic pollutants and heavy metals in surface and underground water and water in the vicinity of solid waste landfills.This includes those of [20],[21]; [22]; [23]. It has been observed from other studies that leachates from wastes at dumpsites are potential sources of contamination of both groundwater and surface water [24]. According to [25], industrial and municipal wastes have created multiple environmental hazards for mankind, irrigation, drinking and sustenance of aquatic life.

II. STUDY AREA

The *Umuerim* River originates from *Otamiri* River which is one of the major rivers in Imo state, Nigeria. The *Otamiri* River runs south from *Egbu* past *Owerri* and through *Nekede, Ihiagwa, Eziobodo, Olokwu Umuisi, Mgbirichi* and *Umuagwo* to *Ozuzu* in *Etche* in Rivers state from where it meets or flows to the Atlantic Ocean. The watershed covers about 10,000 km^2 with annual rainfall of about 2250-2750 mm. The watershed is mostly covered by depleted rain forest, having thick under brushes, creeping vines and deep green vegetation which is as a result of heavy decay of plant droppings and foliage. The mean temperature of about 25 degrees centigrade and relative humidity of about 75-85% is experienced within the region throughout the year. The study area is in the rainforest belt region having peak rainfall during the months of June, July and September and low rains in December and January[26].

The *Umuerim* watershed is dominated by sandy soil with little percentages of clay, loam and silt. The area is acidic with pH of between 4.67-5.6 for upper and lower layers and 5.0-5.6 at the crest and valley bottom and lower at mid slope [27]. The watershed also in addition has low organic carbon ranging between 0.676-3.764 meq/100g for upper soil layer, 5.34-4.27 meq/100g for lower soil layer and lower at the mid slope, low nitrogen concentration range of 0.008- 0.068% and 0.018-0.048% for upper and lower soil layers [27] The general slope of the *Umuerim* watershed is 0.016 [26]. The soil type belongs to ferralic. The soil profile is remarkably uniform throughout the area, deeply weathered and intensely leached [24].

The study area is within the subequatorial region which is characterized by two major seasons namely, the rainy season and the dry season [25]. It is under laid by the sedimentary sequence of the Benin formation (Miocene-Recent) and the underlying Ogwashi-Asaba formation (Oligocene). The Benin formation is made up of friable sands with minor intercalations of clay. The sand units are mostly coarse-grained. The formation starts as a thin edge at its contact with Ogwashi-Asaba formation in the north of the area and thickens southwards (seawards). The average thickness of the formation at the study area is 800 m. The terrain of the study area is characterized by two types of land forms; highly undulating ridges and nearly flat topography.

In terms of hydrogeology the study area is drained by two rivers, namely the Otamiri and Nworie(Fig.1.) The Otamiri River has maximum average flow of 10.7 m3/s in the rainy season (September-October) and a minimum average flow of about 3.4 m3/s in the dry season (November-February).

The total annual discharge of the Otamiri is about 1.7×108 m3 and 22% of this (3.74×l07 m3) comes from direct runoff from rainwater and constitutes the safe yield of the river [25]. The depth to groundwater varies from 15 m-35 m in parts of the Owerri urban area. The aquifers have reasonable thickness and are extensive [26]. In terms of geology and position it is located within southeastern Nigeria sedimentary basin. The study area consists of Owerri metropolis and environs and has boundaries with some local Government Areas such as Ohaji/Egbema,Owerri East/West,Mbaitoli,Ngor Okpala(Fig.2) among others. It is bounded by latitudes 5°15″-5° 35″N and longitude 6°55″-7°15″E.

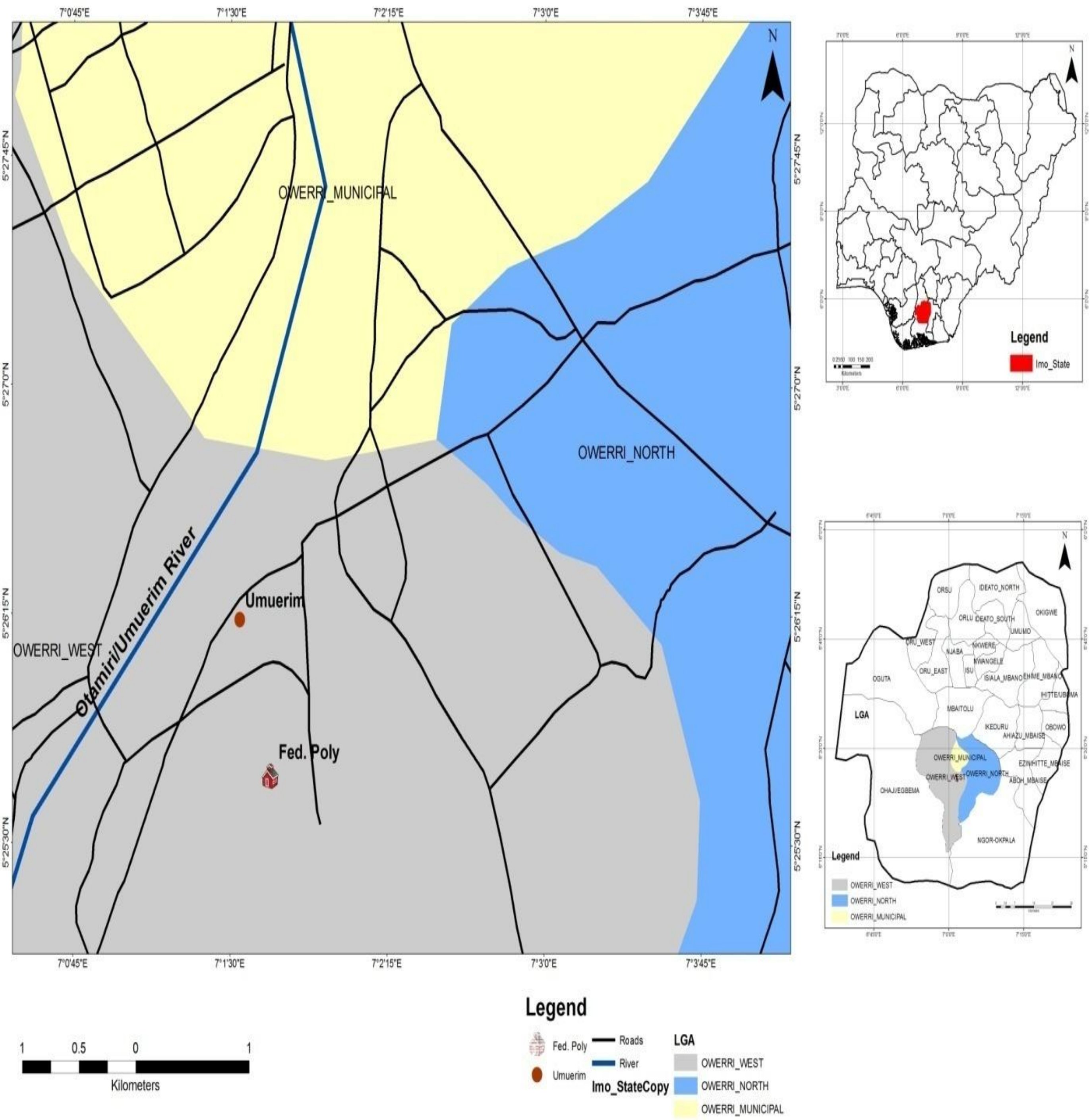


Fig. 1.Map showing Owerri municipal andUmuerim River

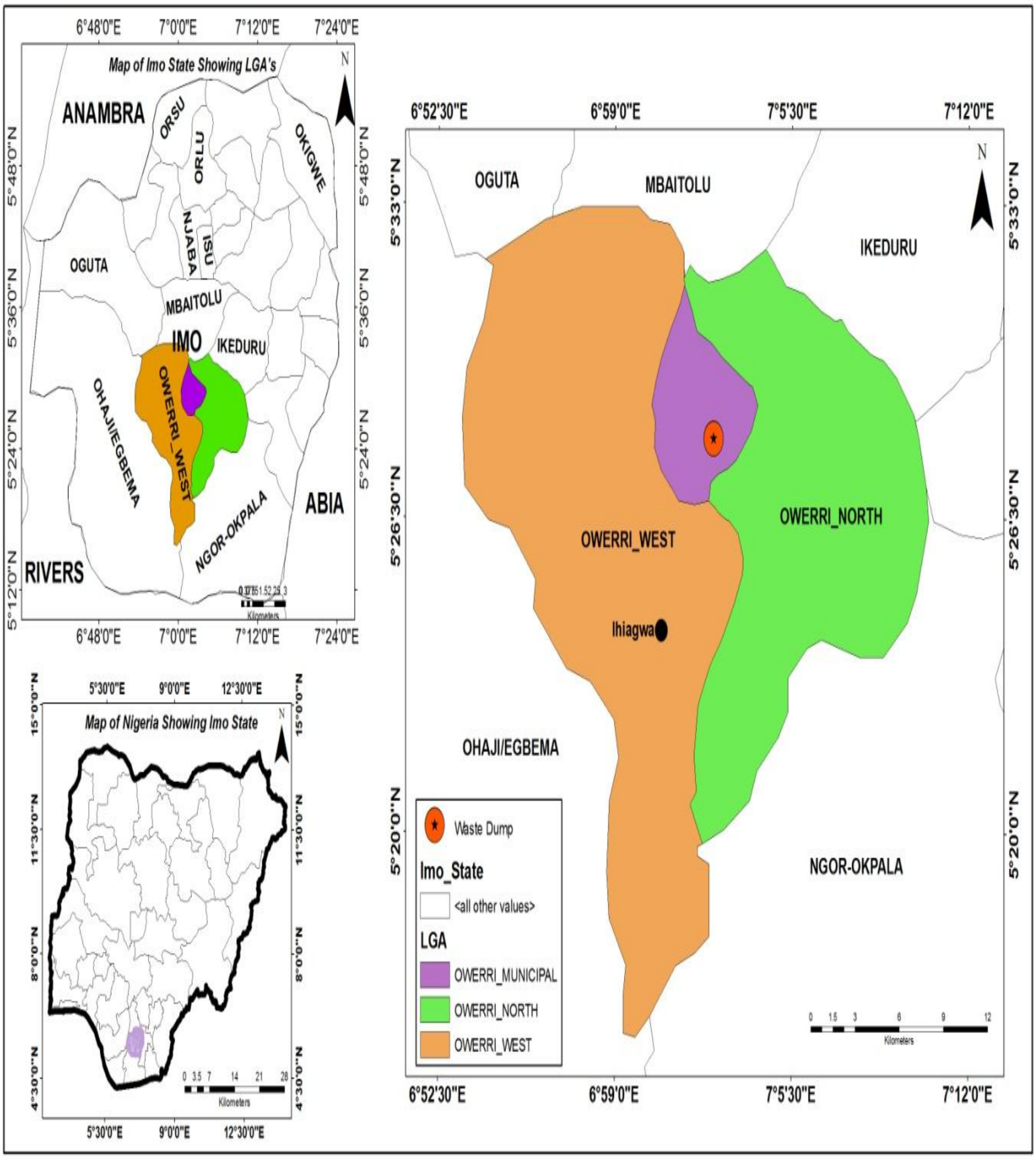


Fig.2.Showing Owerri Municipal L.G.A and neighboring L.G.As

III. MATERIALS AND METHODS

This study was preceded by reconnaissance visit which revealed lot of anthropogenic activities taking place in the area; such asdischarge ofdomestic wastes from householdsand washing of automobiles, block industry on the banks, The methodology involved collection of water samples with plastic containers at different stations; upstream, discharge point,midstream and further downstream, which was conducted during the month of October, 2016.The upstream and downstream served as control stations.

Sampling and Choice of Sampling Locations/Transportation

Four sampling points(upstream, discharge point, midstream, and downstream), designated as discharge point (SP1), midstream (SP2), downstream (SP3), and upstream point were established for comparative basis in the middle reaches of the River between Uzomiri and *Umuerim* communities, covering the area traversing the Federal Polytechnic site(Fig.1). Water samples were collected from four sampling pointsat different proximities (between 150 and 840 meters) to the River. Samples for biochemical oxygen demand (BOD) were collected in 250mL brown bottles. Water samples for trace metal were collected in plastic containers and fixed with conc. HNO_3 in the ratio of 2:500. Water samples for the other physicochemical parameters (sulphate, nitrate, phosphate, and total suspended solids) were collected with 500mL sterile plastic containers. Water samples were transported to the laboratory for analysis as soon as possible in an iced-cooler to maintain their integrity and ensure quality assurance and contro[[28].

Plate 1.Showing sampling at the one of the stations

Plate 2.Showing sampling near the bank of Umuerim River(Discharge point).

Plate 3.Showing a contaminated section of the river.

Plate 4.Showing the upstream section of the river

3.4 *In-situ* measurements

Surface water temperature, conductivity, pH, Dissolved Oxygen (DO), turbidity and Total Dissolved Solids (TDS) were determined electrometrically with the HANNAH HI 9828 VI 4 PH/OR/EC/DO meter. The meter was pre-calibrated with the standard HI 9828-25 calibration solution. The desired physicochemical parameter was read off the LCD of the meter.

Nitration ions were determined by cadmium reduction method as adapted from [28] was employed in the determination of nitrate levels of the water samples. A cadmium based reagent pillow was added into 25mL of the water sample in a cuvette and shaken for one minute and allowed to stand for another five minutes for complete reaction to occur. The absorbance and concentration in mg/L was read at 500nm wavelength using HACH DR 2010 UV-visible spectrophotometer.The Sulphate ions was determined by barium chloride (Turbidometric) method [22] was adopted. The barium chloride based powdered reagent pillow was added into 25mL of water sample. The mixture was properly mixed and allowed to stand for five minutes for reaction to occur. The absorbance and concentration in mg/L was read at 450nm wavelength using HACH DR 2010 UV-visible spectrophotometer.

The Phosphate ions was determined by ascorbic acid method, according to [28] was adopted for the determination of phosphate level of the river water. Ascorbic acid based reagent powdered pillow was added into 25mL of the water sample in a cuvette. The sample was allowed to stand for two minutes for reaction to occur. The absorbance and concentration in mg/L was read at 890nm wavelength using HACH DR 2010 UV-visible spectrophotometer.For determination of Total Suspended Solids (TSS} an aliquot of the sample was filtered through a weighed glass-fibre filter paper, and the filter paper was oven-dried at 105^0C for three hours according to ASTM D 1888-78 method. The weight of the filter paper was measure with a Meter H78AR balance. The difference in weight was taken as the TSS in mg/L.The heavy metals (PH, Cd, Zn, Fe, Cu, Cr) contents of the river water was determined with the use of a Varian Spectra AA 600 Atomic Adsorption Spectrophotometer, as adopted from [28].The flame atomization method was used. Five milliliters of concentrated HNO_3 and a few boiling chips of Hengar granules were mixed with 250mL of the sample in a 400mL conical flask. The mixture was then boiled slowly and the content evaporated on a hot plate to the lowest volume possible (about 10–30ml) before precipitation occurred. Concentrated HNO_3 was added during the heating process. This was done to attain necessary complete digestion indicated by the observation of a light clear solution. During digestion, precaution was followed not to allow the sample dry completely. Ten milliliters of water was used to rinse the flask and added to the volumetric flask, which was further allowed to cool, diluted to 50ml mark and mixed thoroughly. From the mixture, the concentrations in mg/L of the trace elements in the cooled sample were determined by means of an atomic absorption spectrophotometer. The specific metal standards in the linear range of the metals were used to calibrate the equipment. The concentrated or digested samples were then aspirated and their actual concentrations obtained by referring to the calibration graph and necessary calculations made.

IV. Statistical Analysis

The descriptive statistics was used to obtain means, standard errors, range etc of the data set of parameters measured. The test of variance equality in means of concentrations of the physicochemical parameters was conducted with the One-way Analysis of Variance (ANOVA) at the 95% confidence limit.

V. RESULTS

The results of the concentrations of measured parameters of the study area and variations of the statistics are shown in this subsection.

The variations in physicochemical variables measured in Umuerim River, Nekede, Owerri during the study period are shown in table 1. Conductivity (range= 5.50 µS/cm), Total Dissolved Solids (TDS) (range= 4.00 mg/L), Turbidity (range= 3.20 NTU) and Sulphate ions (SO_4) (range= 2.70 mg/L) recorded comparatively wide variations during the study period. Temperature, pH and Conductivity varied from 27.50-27.82 (27.63 ± 0.07) ^{0}C, 5.98-6.37 (6.2425 ± 0.09) and 22.50-28.00 (25.88 ± 1.20) µS/cm respectively (Table 4.1). Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and Sulphate varied from 1.28-1.60 (1.45 ± 0.08), 0.30-0.73 (0.49 ± 0.01) and 8.50-11.20 (10.38 ± 0.63) mg/L respectively.

Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Turbidity varied from 2.80-4.10 (3.70 ± 0.30) mg/L, 10.00-14.00 (12.75 ± 0.95) mg/L and 3.20-6.40 (4.93 ± 0.67) NTU respectively.

Table 1:Water quality parameters of the Umuerim River in Nekede

Parameters	SP1	SP2	SP3	Upstream	FME
Temperature (^{0}C)	27.58	27.82	27.62	27.50	28-30
pH	5.98	6.25	6.37	6.37	6.5-8.5
Conductivity (µS/cm)	28.00	26.00	27.00	22.50	100
TSS (mg/L)	4.00	3.90	4.10	2.80	<10.0
TDS (mg/L)	14.00	13.00	14.00	10.00	500
DO (mg/L)	1.57	1.33	1.28	1.60	4.5-6.5
BOD_5 (mg/L)	0.53	0.73	0.41	0.30	0
Turbidity (NTU)	4.80	6.40	5.30	3.20	1.0
NO_3^- (mg/L)	0.30	0.40	0.20	0.20	10.0

PO_4^{2-} (mg/L)	1.00	1.20	1.20	0.80	≯5
SO_4^{2-} (mg/L)	11.20	10.80	11.0	8.50	-
Pb (mg/L)	0.002	0.004	0.002	BDL	0.05
Zn mg/L	0.12	0.14	0.15	0.10	5.0
Fe mg/L	0.64	0.72	0.80	0.55	1.0
Cu mg/L	0.04	0.10	0.04	0.04	0.1
Cr mg/L	0.005	0.003	0.004	BDL	0.05

Table 2: Descriptive statistics of water quality parameters of the *Umuerim* River in Nekede, Owerri.

Parameters	**Minimum**	**Maximum**	**Range**	**Mean**	**SE**	**FME**
Temperature (^{0}C)	27.50	27.82	0.30	27.63	0.07	28-30
pH	5.98	6.37	0.39	6.24	0.09	6.5-8.5
Conductivity (µS/cm)	22.50	28.00	5.50	25.88	1.20	100
TSS (mg/L)	2.80	4.10	1.30	3.70	0.30	<10.0
TDS (mg/L)	10.00	14.00	4.00	12.75	0.95	500
DO (mg/L)	1.28	1.60	0.32	1.45	0.08	4.5-6.5

BOD (mg/L)	0.30	0.73	0.43	0.49	0.09	0
Turbidity (NTU)	3.20	6.40	3.20	4.93	0.67	1.0
NO^{-}_{3} (mg/L)	0.20	0.40	0.20	0.28	0.05	10.0
PO^{2-}_{4}(mg/L)	0.80	1.20	0.40	1.05	0.10	≯5
SO^{2-}_{4} (mg/L)	8.50	11.20	2.70	10.38	0.63	500
Pb (mg/L)	0.00	0.00	0.00	0.00	0.00	0.05
Zn (mg/L)	0.10	0.15	0.05	0.13	0.01	5.0
Fe (mg/L)	0.55	0.80	0.25	0.68	0.05	1.0
Cu (mg/L)	0.04	0.10	0.06	0.06	0.02	0.1
Cr (mg/L)	0.00	0.01	0.01	0.00	0.00	0.05

SE= standard error of mean, DO= Dissolved Oxygen, BOD= Biological Oxygen Demanded, TSS= Total Suspended Solids, TDS= Total Dissolved Solids, FME= Federal Ministry of Environment, 2001

Spatial Variations in Water Quality Parameters

Longitudinal spatial variations were observed in the physicochemical parameters measured in the study as shown in the figures below:

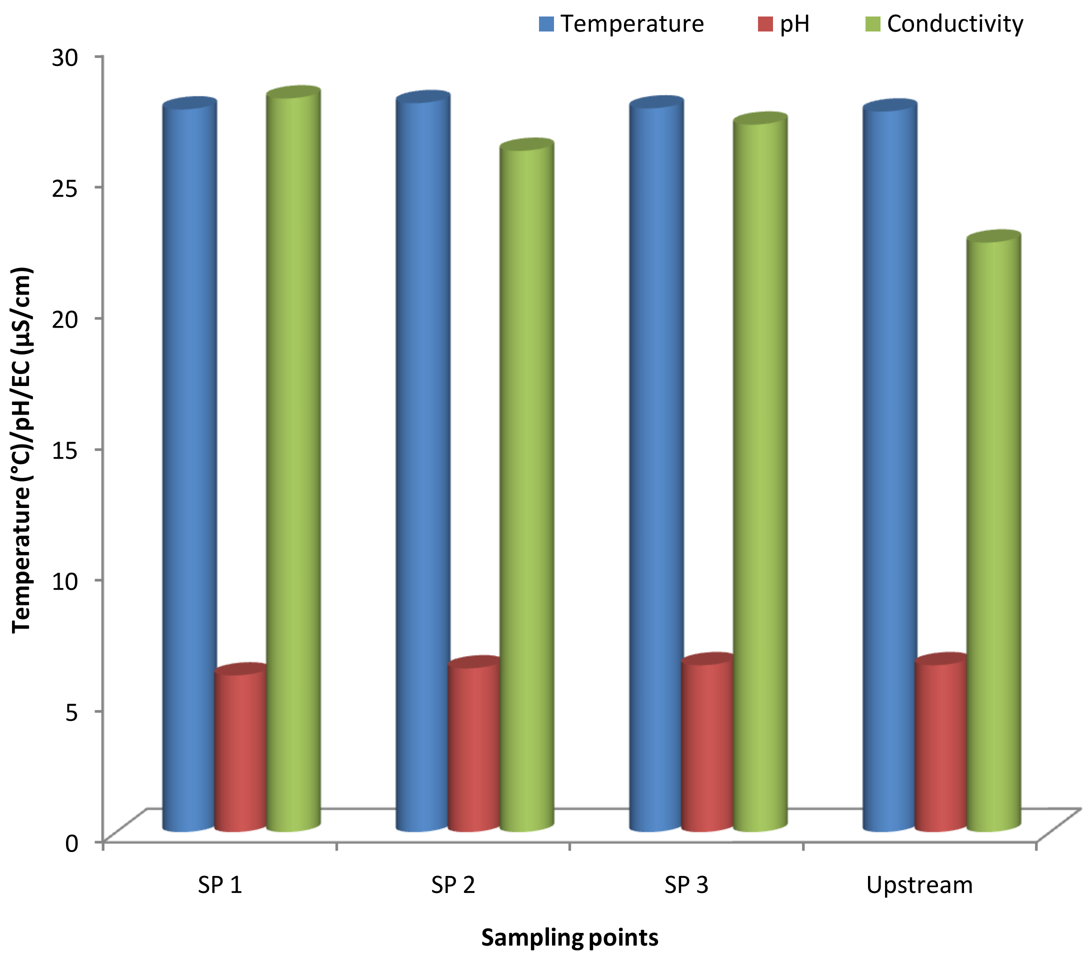
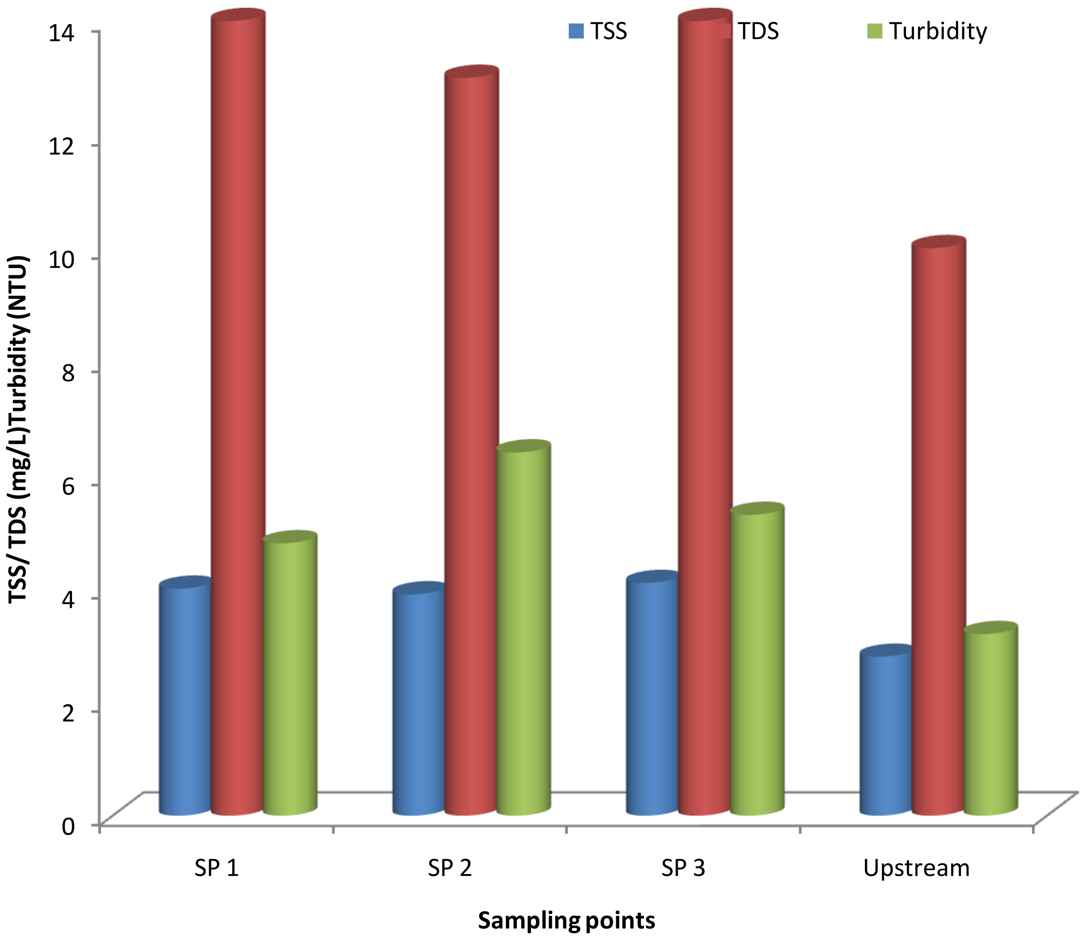


Fig 3:Spatial variations in water temperature, pH and electrical conductivity of the Umuerim River in Nekede



. Fig.4 Spatial variations in total suspended and dissolved solids and turbidity of the Umuerim River in Nekede

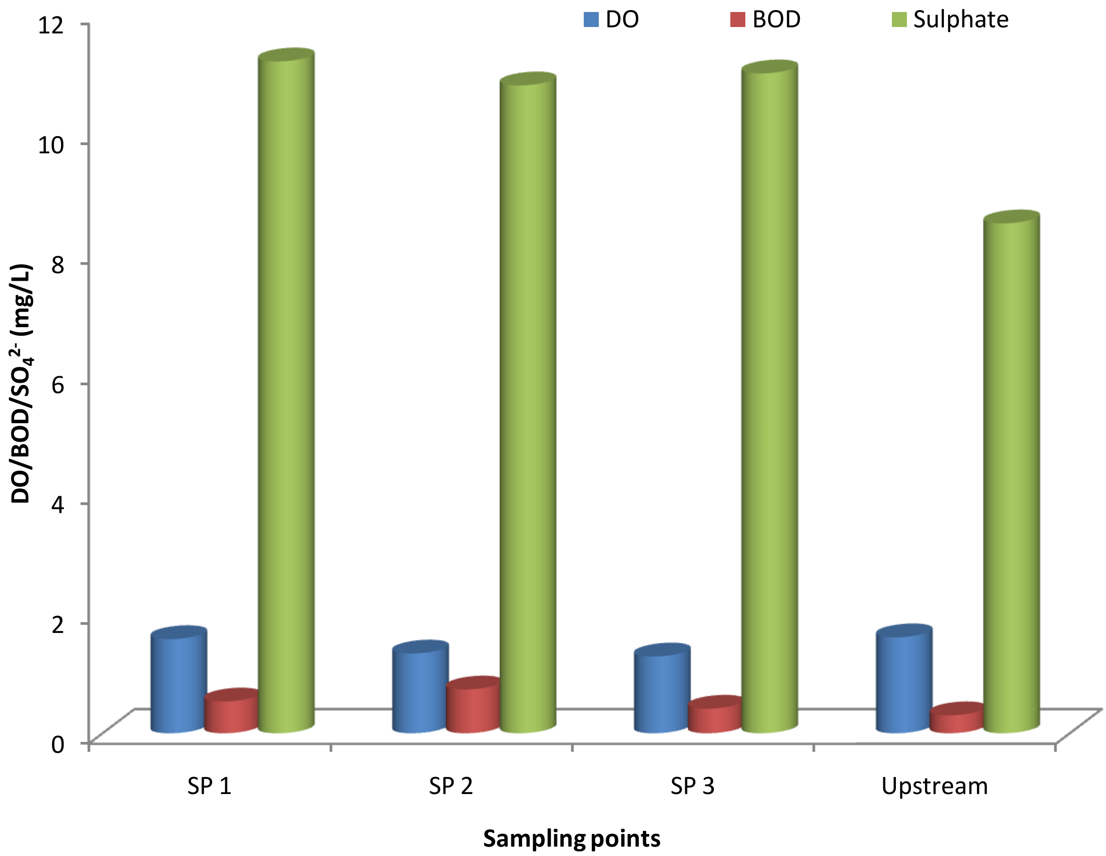


Fig. 5. Spatial variations in dissolved oxygen, biological oxygen demand and sulphate ion concentrations of the Umuerim River in Nekede

Umuerim River is facing severe degradation from anthropogenic activities in the catchment area. These activities include in block industry, stream sand mining, washing of automobiles, household wastes and agricultural waste input. The wide variations recorded in levels of conductivity, TDS, turbidity and sulphate ions of the other indicates that the rate of their input was higher than those parameters that had narrow variations.

The results also showed a trend of high concentrations of DO in Upstream and low concentration at SP3, which gradually increased in SP1. This observed spatial variation also reflects input of oxygen demanding pollutants mainly at SP3 and a gradual river recovery capacity downstream.

The concentration of DO in *Umuerim* River was below the recommended limits in fresh water (4.5-6.5 mg/L) by Federal Ministry of Environment. Low concentrations of DO in the *Umuerim* River could be associated with direct discharges of untreated Anthropogenic effluents and municipal sewage in the Owerri Municipal where the river had earlier passed through. Municipal sewage and Anthropogenic effluents contain organic substances, which are biodegradable, require a large amount of oxygen for oxidation process by micro-organisms and causes depletion of DO. In aquatic systems, excessive organic and inorganic input (from industrial and urban waste) may reduce the availability of DO. Recommended concentration of DO is 4.0 mg/L for fishes [29]. However, most species are distressed when it falls between 2.0 - 4.0 mg/L. Low level of DO (less than 2.0 mg/L) can cause fish mortality [29]. Municipal sewage and Anthropogenic effluents decrease DO level and increase BOD level in stream water (Singh *et al*., 2005).

The highest level of BOD recorded in SP2 may be due to the discharge of higher volumes of oxygen-demanding wastes into the stream [30]. However, the level of BOD in *Umuerim* River was above the recommended limit 0.0 mg/L in freshwater by [31].

Similarly, high concentrations of TDS which were recorded in SP1and SP3 were below the permissible limit of 500 mg/L by FME. High values of TDS could have resulted from effluents containing higher concentrations of soluble salts related with natural and anthropogenic sources.

The high concentrations of TSS which was recorded in SP3, was within the permissible limit of <10.0 mg/L recommended by [31].

The mean level of turbidity recorded in this work was above the permissible limit of 1.0NTU by [31].

The highest concentration of NO^-_3 ions which was recorded in SP2, could be associated with agricultural activities in the catchment area. Elevated concentration of NO_3^- ions comes from agricultural fields after surface runoff. [32] and [35] also reported similar reason of high level of NO_3^- ions in stream water, which was below the permissible level (10 mg/L) recommended by [31].

In contrast, highest level of PO_4^{2-} ions was observed in SP2 and the lowest in Upstream. These were below the permissible limit of 5mg/L recommended by [31].The level of SO_4^{2-} ions was also below the permissible limit of 500 mg/L recommended by [31]. Municipal sewage was identified as the possible source of PO_4^{2-} ions. The elevated concentration of PO_4^{2-} ions could be due to human impacts on streams and may be associated with direct discharge of raw sewage [30] from the earlier parts of the river in Owerri municipality. Higher level of PO_4^{2-} ions may also occur as a consequence of the use of detergents [34]. Higher concentrations of PO_4^{2-} and NO_3^- ions may cause eutrophication in streams and lakes [33].

Cr concentration in *Umuerim* River was below the permissible limit (0.05mg/L) recommended by [31]. Large volumes of effluents are produced during tanning process, which contain high concentration of chromium and soluble salts such as NaCl [36]. These contributions could come from abattoirs sited along the course of the river in the Owerri Municipal. Indiscriminate use of Cr salts in tanneries is one of the main sources of its increased level in drains and streams. Cr is mainly found in industrial wastes from the chrome tanning process. About 70% of the total amount is taken up by the hides and about 30% remains unabsorbed, which goes into the effluent and sludge. Continuous discharges of Cr, even in low concentrations, have been reported to have toxic effects on aquatic life and can disrupt the food chain in aquatic ecosystems [34]. High pH allows Cr to convert into complex substances and become part of suspended particulate matter, which settles down as effluents travel the distance from the source. Higher concentration of Cr in sediment is toxic to aquatic organisms in general and particularly to bottom dwelling organisms.Maximum concentration of Zn which was recorded in SP3 was however, below the permissible limit of 5.00mg/L recommended by[31]. Maximum concentration of Fe which was recorded in SP3 was below the permissible limit 1.0mg/L recommended by [31]. Maximum concentration of Cu which was recorded in SP1was below the permissible limit of 0.1 mg/L recommended by [31].

CONCLUSION AND RECOMMENDATION

The results showed that the discharge of household wastes had negative influence on the analyzed parameters. The water quality was slightly acidic and DO was low to sustain aquatic life. Constant monitoring and profound lifestyle changes are necessary to arrest the trend.

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