Effects of Land-Uses on the Quality of Imabolo Stream in Ankpa Urban Area of Kogi State, Nigeria

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Abstract

This study examined the effects of land-use on the quality of Imabolo stream in Ankpa urban area of Kogi State, Nigeria. The objective is to examine how the diverse land-use types along the stream environment affect pollutant load of the stream which is used extensively for domestic purposes by the residents. To achieve the aim of the study, water samples were collected from seven locations along the stream reach corresponding to the identified land-uses in the study area in March and June, 2014. Eighteen physico-chemicals and two microbiological parameters were analyzed using standard procedures. Descriptive statistics were used to analyze the data obtained. The results were also compared with WHO and NSDWQ standard for drinking water quality for characterization. The analysis revealed six water samples had elevated values of parameters above the recommended limits for human consumption. Descriptive statistics revealed consistent variations in the concentrations of parameters in water samples among land-use zones, while student t-test showed significant difference ($p<0.05$) in the quality of water samples between dry and rainy seasons. Water samples from commercial, educational, industrial and residential land-uses returned the highest levels of pollutants concentration. This is probably due to high intensity of human activities within these land-use types. The study advocated apposite recommendations to remediate and improve the quality of the stream water in these areas in order to reduce the risk to which the growing urban population is exposed to.

Keywords: *Stream Water quality, Land-uses, Urban, Pollutant Concentrations, Seasonal Variation, Remediation*

1. Introduction

Land-use type simply refers to the specific use to which a given piece of land is used for, and the relationship between land use type and environmental pollution is frequently discussed in literature (Dylan et al., 2005). Changes in land-use occur as a result of economic development, population growth, technology, removal of vegetation and rapidly growing demand for natural resources (Alemayehu, 2015; Houghton, 1994). Pollution from urban land-use activities affect surface water quality by adding sediment, nutrients, toxics, organic materials, and pathogens to surface and ground waters (Marquita et al., 2007). Water quality is a major determinant of the integrity of water resources and its decline post great risk to users and place pressure on peoples' water needs globally (Raji and Ibrahim, 2011). Water is polluted through direct or indirect introduction of chemicals and other substances to water sources, and this renders it unfit for its intended purpose (Hussain et al., 2008). Impaired water is of great health challenge and it accounts for over 1.7 million deaths world-wide every year (Ashbolt, 2004). Water-related diseases such as cholera, diarrhoea, bilharzias and so on affect the poor local people who lack potable water and as such resorted to using contaminated stream and underground water for drinking and domestic purposes (Galadima et al., 2011).

In many developing countries including Nigeria, there are extensive variations in land-use types along stream channels. These land-use changes result from various activities such as agriculture, residential, industrial and urbanization (Allan et al., 1997). The nature of land-use within any river basin significantly impacts rivers and streams in terms of the level of pollutant load concentrations and changes in water quality (Sliva and Williams, 2001; Ngoye and Machiwa, 2004). These alterations in water quality cause problems of their own such as eutrophication, stream bank erosion and changes to plant communities. Furthermore, nutrient enrichment seriously degrades aquatic ecosystems and impairs the use of water for drinking, industry, agriculture, and recreation (Ouyang et al., 2006).

Currently, Imabolo stream is largely the source of water for domestic, drinking, irrigation and other uses for the inhabitants of Ankpa urban and the people within its catchment. The catchment has long been subjected to land-use change from forest to croplands and residential areas. Discharges of untreated sewage effluents from settlements and industries, excessive nutrient loads in return flows from agriculture, as well as modification of stream flow regimes and changing land-use/land-cover patterns lead to large-scale changes to aquatic ecosystem (Obeta, and Ocheje, 2013). Despite the significance of the stream to the Anpka urban residents, there is currently, dearth of information on the effects of land-uses on the quality of the Imabolo stream and on its spatiotemporal variations patterns. The purpose of this study, therefore, is to characterize the Imabolo stream water quality among the different land-use types transversed by the stream within Ankpa urban area. The pattern of contaminant concentrations within the land-use types were identified and discussed in detail. Accurate and reliable information on the effects of land-use types on Imabolo stream will, in our view, aid policy formulation and implementation with regards to the management of the stream water quality in the study area.

2. Materials and Methods

2.1 The Study Area

Imabolo stream is the only surface water in Ankpa urban and has its source at Ogaji. It flows from north to south through metropolis and has a catchment area of about 635 Km^2 and distance of about 14.8 Km (Figure 1). Ankpa Urban area lies appropriately between Latitudes 7^0 16' N and 7^0 4' N and Longitudes 7^o 22' E and 7^0 51' E. The area has warm Tropical Savannah Climate with clearly marked wet and dry seasons (Ali, 2010). Rainfall is well distributed and is of double maxima (Iloeje, 1972). The amount of rainfall ranges between 1,000mm to 1,750mm. Temperature is moderately high throughout the year, averaging 25^0C. The maximum temperature of the area lies between 29.7^0C – 35.6^0C while the minimum temperature ranges between 23.3^0C and 25.2^0C (Ali, 2010). The geology of the area is the false bedded sandstone of the Ajali and Mamu Formations which falls within the Anambra Basin. These formations consist of thick friable poorly sorted sandstone, well drained soils, red or reddish brown in colour and sandy surface horizons which occur on the crest of inter-fluves and on upper and middle slopes. The vegetation is that of the Guinea Savannah type and is characterized by scattered trees, most of which are deciduous.

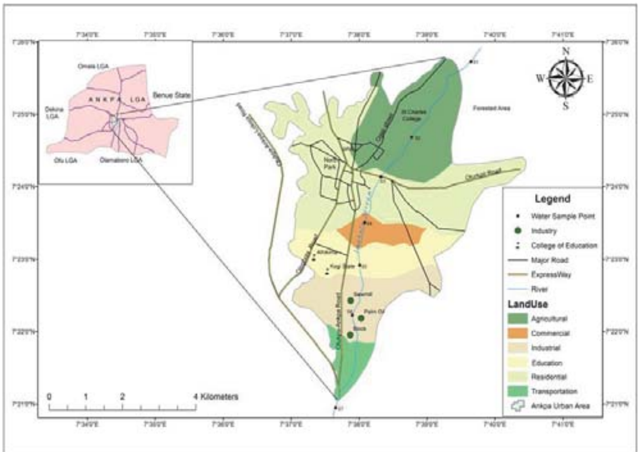

Figure 1: Ankpa Urban Area showing Land-uses, Imabolo Stream and Water Sample Points

Source: GIS Unit, Department of Geography, University of Nigeria Nsukka

Table 1: Water Sample Locations and Coordinates

SITES	LOCATION	LAND-USE TYPES	DATE	TIME	GPS COORDINATES	
					NORTHING	EASTING
S1	OGAJI	Forested	March, 2014 June, 2014	11:30am11:30am	007°25'2.90"	007°39'5.80"
S2	OLUBOJO AND ST. CHARLES COLLEGE AREA	Agricultural	March, 2014 June, 2014	11:30am11:30am	07º 24'18.7"	007º 38'27.8"
S3	CENTRAL RESIDENTIAL AREA	Residential	March, 2014 June, 2014	11:30am11:30am	07º 24'.08.9"	007º 38'20.0"
S4	SABONGARI	Commercial	March, 2014 June, 2014	11:30am11:30am	07º 23'57.0"	007º 38'14.7"
S5	KOGI STATE COLLEGE OF EDUCATION AREA	Educational	March, 2014 June, 2014	11:30am11:30am	007°23'2.01"	007°38'0.64"
S6	OJELANYI	Industrial	March, 2014 June, 2014	11:30am11:30am	07º 22' 20.6"	007º 37'59.0"
S7	OJOKODO	Transportation	March, 2014 June, 2014	11:30am11:30am	07º 24'18.7"	007º 38'27.8"

Source: Fieldwork, 2013-2014

2.2 Sample Points Selection

Stratified random sampling in which the stream was divided according to land-use zones was undertaken. This involved the identification of land-use types along the stream watercourse which formed areas of sample point collection. Sampling positions were purposively selected within stratified zones thus ensuring that chances of missing the specific contribution of land-use types are extremely small. The sampling stations represent a wide range of water quality conditions in the study area. Seven sample sites 1, 2, 3, 4, 5, 6 and 7 were selected on the impacted zone of the Imabolo stream. Each water sampled site was designated to represent one of the land-use categories identified in our study area. This is because water quality of stream is generally linked to the land use practices in an area due to input (Williams *et al.,* 2001). Sites 1(Forested) was selected as reference point and is situated at the upstream at Ogaji (S1) before it enters the urbanized areas of the metropolis. Site 2 receives discharge from agricultural runoff, Site 3 receives inflow from residential areas, Site 4 receives waste from commercial activities, Site 5 receives input from educational land-use, Site 6 receives effluent discharged from Industrial activities into the lower section of the stream and Site 7 receives effluent from Transportation land-use.

2.3 Water Sample Collection

Stream water samples were collected aseptically at each location into two litres sterilized polyethylene bottles and filled to the brim; one for physico-chemical analyses and the other for microbiological analyses according to recommended standard procedure for water quality analysis (APHA, 1995). Water samples were collected from seven different points along the length of the stream in March and July, 2014. This was to ensure that samples were collected at the peaks of the dry and rainy seasons, and also to cover for variations between the two seasons for the physico-chemical and microbial water qualities for the locations. The direct sampling technique was employed at sites where water samples could be collected close to the stream bank and the dip sampling technique where direct access was limited (US EPA, 1994). Bottles were labelled before sampling and gloves were worn when handling the bottles. All samples were taken immediately to the laboratory for analysis. The water quality parameters analyzed are shown in Table 2

2.4 Sample Preservation/Quality Assurance

This was carried out following standard procedure for water quality analysis (APHA, 2002). Plastic bottle containers of 2 litres volume for collection of samples were labelled and thoroughly rinsed with distilled water. Upon reaching the sampling site, each container was rinsed with water from the stream three times before actual samples were collected to prevent any probable contaminant from the containers used for the samples. Water samples collected were carefully bottled to avoid contaminant that may affect the reading of laboratory analysis. Also, the samples were preserved in Ice block in a cooler and sent immediately to the laboratory for analysis. The aim was to slow down the rate of any biochemical reaction.

2.5 Choice of Water Quality Parameters

The water quality parameters used for this study are shown in Table 2. These parameters were selected based on their relevance to human health and occurrence statistics in water quality studies.

Table 2: Selected Water Quality Parameters, their Standard Limits and Method of Analysis

Parameters	WHO (2011)	NSDWQ (2007)	Method of Water Analysis
Temp. (°C)	25	-	HANNA Model HI 9812
Ph	6.5-8.5	6.5-8.5	HANNA Model HI 9813-0
EC (mS/m)	400	1000	EC/TDS Meter
TDS (mg/l)	500	500	HANNA Model HI 9813-6
Turbidity (NTU)	5.0	5.0	HANNA ModelLP 2000
DO (mg/l)	6.0	6.0	HANNA Model HI 9813-5
BOD (mg/l)	10	-	Dilution Winkler Method
COD (mg/l)	10 – 20	-	Reflux Oxidation Titrimetric Method
PO_4^{2-} (mg/l)	0.3	0.5	Ascorbic Acid Colorimetric Method
NH_3^-N(mg/l)	<1.5	1.0	Phenol-Hypochlorite Method
NO_3^-N(mg/l)	10	50	Phenoldisulphonic Acid Colorimetric Method
SO_4(mg/l)	250	100	Spectrophotometer Method
Fe^{2+} (mg/l)	0.3	0.3	Flame Atomic Absorption Spectrophotometer Method
Ca^{2+} (mg/l)	75-200	-	EDTA Titration Method
Pb^{2+} (mg/l)	0.01	0.01	Atomic Absorption Spectrophotometric Method
Cd (mg/l)	0.003	0.003	Atomic Absorption Spectrophotometric Method
Alkalinity (mg/l)	80-120	-	Titrating a known volume of water sample with 0.01M NaOH solution
Total Hardness (mg/l)	500	150	EDTA Titrimetric Method
Total Coliform (cfu/100ml)	10	10	Incubator Based Standard Method
E. Coli (cfu/100ml)	0	0	Incubator Based Standard Method

Sources: WHO (2011); NSDWQ (2007)

2.6 Data analysis

Simple descriptive statistics such as minimum, maximum and mean were used to interpret the raw data on the physicochemical and microbiological parameters generated in the cause of this investigation with the aid of Statistical Package for Social Sciences (SPSS) Version 20 and Microsoft Excel 2010 software. The WHO (2011) and Nigerian Standard for Drinking Water Quality (NSDWQ) Guidelines on Drinking water were used as the benchmark for the interpretation of water quality in this study. Water Quality Index (WQI) software was used analyze the quality rating among the various land-use types. This was achieved by using selected parameters (pH, Temperature, DO, BOD, Turbidity, Phosphate, Nitrate and E. coli) at each sampled station. The selection of the parameters was based on their established importance and standards. The analysis will elucidate stations of best water source and stations that can be used after appropriate treatment.

3. Results and Discussion

3.1 Distribution of Pollutants Build-up among the various Land-use Types

The results of the contributions of land-uses types in the study area to the quality of the stream water are summarized in Table 3, and discussed briefly below. Level of stream water pollution was interpreted by examining the total number of the mean values of the tested water quality indicators that exceeded the 2011 WHO and 2007 Nigerian Standard for Drinking Water Quality (NSDWQ) at each land-use type.

Table 3: Levels of Pollutants Distribution in Water Samples among the Land-use Types.

Parameters	LANDUSES													
	Forested		Agricultural		Residential		Commercial		Educational		Industrial		Transportation	
	D/S	RS	D/S	RS	D/S	RS	D/S	RS	D/S	RS	D/S	RS	D/S	RS
Temp.(°C)	22.10	24.5	23.10	23.2	24.30	25.0	24.10	25.3 *	25.0	25.0	25.0	25.0	23.2	26.8*
Ph	7.50	7.69	7.89	7.44	7.50	7.89	7.53	7.19	7.22	7.66	7.44	7.66	7.23	7.88
EC (mS/m)	10.3	51.0	158.0	360.0	191.3	549.0*	170.0	540.0*	299.0	610.10 *	153.8	610.10 *	174.2	342.30
TDS (mg/l)	18.6	168.90	48.80	292.50	94.40	465.20	114.70	284.60	102.40	286.40	179.50	286.40	92.00	340.20
Turbidity (NTU)	1.06	5.20	3.0	56.0*	3.40	253.0*	5.10*	180.0*	4.91	50.64*	4.95	50.64*	5.20*	25.60*
DO(mg/l)	80.00*	94.50*	104.0*	98.40*	23.00*	79.0*	86.00*	99.50*	75.00*	97.0*	130.0*	97.0*	131.0*	110.0*
BOD(mg/l)	8.49	7.49	16.70*	20.64*	2.39	4.12	11.84*	19.42*	7.80	7.49	7.64	7.49	14.30*	18.40*
COD(mg/l)	5.6	6.7	8.4	20.8*	6.0	25.9*	10.20	48.3*	12.30	54.3*	10.5	54.3*	6.95	10.50
PO_4^{2-} (mg/l)	0.20	1.5*	0.24	2.1*	1.66*	2.8*	1.88*	3.4*	3.44*	5.7*	3.33*	5.7*	0.30	1.8*
NH_3-N(mg/l)	0.10	0.12	0.30	0.51	1.46*	5.82*	1.38*	5.65*	2.58*	7.65*	2.91*	7.65*	0.45	1.51
NO_3-N(mg/l)	0.02	0.44	0.04	1.60	0.03	2.50	0.95	0.15	0.05	1.50	0.94	1.50	1.60	2.40
SO_4(mg/l)	10.2	17.56	33.5	50.8	91.50	107.3*	144.8*	210.3*	201.6*	251*	200.1*	251*	185.40*	150.4*
Fe (mg/l)	0.02	0.03	0.04	0.6	0.20	0.50*	0.2	0.50*	0.3	0.3	0.20	0.3	0.03	0.06
Ca (mg/l)	5.6	3.1	17.3	11.4	12.6	7.6	8.4	5.6	11.4	7.5	13.6	7.5	12.9	8.2
Pb (mg/l)	ND	ND	0.001	0.003	0.002	0.04*	0.002	0.03*	0.012	0.023*	0.010	0.023*	ND	0.01
Cd (mg/l)	ND	ND	0.001	0.01*	0.002	0.003	0.001	0.003	0.003	0.03*	0.002	0.03*	0.001	0.002
Alkalinity(mg/l)	2.19	3.49	1.56	2.91	2.46	2.15	2.72	5.44	2.10	2.46	1.84	2.46	3.16	3.55
Total Hardness (mg/l)	18.1	24.3	25.1	72.1	35.6	70.5	52.4	88.2	74.6	110.8	69.8	110.8	58.7	100.1
Total coliform (cfu/100ml)	4	6.0	8.5	9.5	12.3*	14.4*	14.3*	18.2*	11.6*	28.5*	15.3*	28.5*	10	23.3*
E. coli (cfu/100ml)	0	0	0.3*	0.8*	0.6*	1.6*	1.7*	2.3*	1.3*	3.1*	1.8*	3.1*	1.2*	2.4*
Number of Parameters that Exceeded WHO and NSDWQ Limits in D/R and S/R	1	2	3	7	5	11	8	13	7	12	7	11	6	8
Total number of Parameters that Exceeded WHO and NSDWQ Limits in both seasons	3		10		16		21		19		18		14	

D/S: Dry Season; R/S: Rainy Season; ND Not Detected; * *Parameters that Exceeded the WHO and NSDWQ Limits*

Source: Field work, 2013 – 2014

Table 4: Descriptive Statistics of Pollutants Concentration levels in water Samples.

Descriptive Statistics	Water Quality Parameters																			
	Temp. (°C)		Ph		EC (mS/m)		TDS (mg/l)		Turbidity (NTU)		DO (mg/l)		BOD (mg/l)		COD (mg/l)		PO_4^{2-} (mg/l)		NH_3-N(mg/l)	
	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS
Max	25.7	26.8	7.89	7.89	299	650	5.2	465.2	5.2	20.8	130	110	16.7	20.64	12.3	60.7	3.44	5.7	2.91	8.12
Min	22.1	23.2	7.22	7.19	10.3	51	1.06	168.9	1.06	5.2	23	79	2.39	4.12	5.6	6.7	0.2	1.5	0.1	0.12
Range	3.6	3.6	0.67	0.7	288.7	599	4.14	296.3	4.14	15.6	107	31	14.39	16.52	6.7	54.0	3.24	4.2	2.81	8.0
Mean	23.9	25	7.5	7.6	164.1	443.2	3.9	303.1	3.9	12	89.9	95.3	9.9	12.6	8.6	32.5	1.6	3.2	1.3	4.2
Variance	1.6	1.2	0.05	0.06	7172.3	43684.9	2.4	7793.5	2.4	37.5	1384.5	92.04	22.88	45.5	6.39	475.03	1.99	2.69	1.24	11.58
Std. Dev.	1.3	1.08	0.22	0.24	84.68	209	1.5	88.3	1.54	7.3	37.2	9.6	4.78	6.7	2.52	21.8	1.41	1.6	1.1	3.4

Descriptive Statistics	Water Quality Parameters																			
	NO_3-N (mg/l)		SO_4 (mg/l)		Fe^{2+} (mg/l)		Ca^{2+} (mg/l)		Pb^{2+} (mg/l)		Cd (mg/l)		Alkalinity (mg/l)		Total Hardness (mg/l)		Total Coliform Count(cfu/100ml)		E. Coli (cfu/100ml)	
	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS
Max	1.6	2.5	201.6	286	0.3	1.3	17.3	11.4	0.012	0.05	0.003	0.03	3.16	5.44	74.6	120.6	15.3	28.5	1.8	3.1
Min	0.02	0.15	10.2	17.56	0.02	0.04	5.6	3.1	0	0	0	0	1.56	2.15	18.1	24.3	4	6	0	0
Range	1.58	2.35	191.4	268.44	0.28	1.26	11.7	8.3	0.0012	0.05	0.003	0.03	1.56	3.29	56.5	96.3	11.3	22.5	1.8	3.1
Mean	0.5	1.6	118.9	158.3	0.1	0.5	11.7	7.1	0.004	0.02	0.001	0.009	2.3	3.4	47.8	83.8	10.94	18	0.98	1.41
Variance	0.41	0.97	5825.9	10383.9	0.01	0.19	14.2	14.2	0.0001	0.0004	0.0000	0.0001	0.292	1.186	481.4	1037.1	14.5	72.2	0.49	1.26
Std. Dev.	0.6	1.0	76.32	102.0	0.11	0.42	3.77	2.6	0.00049	0.02	0.0009	0.01	0.54	1.1	21.9	32.2	3.8	8.5	0.7	1.1

Std. Dev. = Standard Deviation; - = No guideline value; DS = Dry Season; RS = Rainy Season

Source: Field work, 2013-2014

3.2 Pollutants Concentration levels in the Forested Land-use Zone

In the forested land-use area, DO and PO_4^{2-} were identified to returned values above the WHO and NSDWQ limits for drinking water quality (Table 3 and Figure 2). DO returned value of 80mg/l (dry season), while PO_4^{2-} returned values of

94.50mg/l (dry season) and1.5mg/l (rainy season). However, the high concentration of DO is not harmful but an indication that the oxygen content of the stream at this location has little organic matter entering into the stream from the surroundings (Etim and Adie, 2012).

The presence of phosphate at this spot might be due to the remains of plants and animals at the bottom of the stream bed (See Plate 1). The minimum concentration of most parameters at this location showed that this area has fewer disturbances from anthropogenic activities and seasonal changes. This result agrees with the findings of Fatoki *et al.* (2003) who stated that forested areas along stream channels encounters minimum impurities from the surroundings.

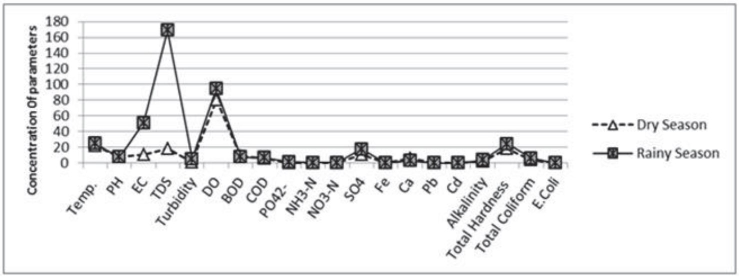

Figure 2: Concentration of Pollutants at the Forested Land-use Area

Plate 1: Decayed plants' remains in the Stream in the forested land-use area.

3.3 Pollutants Concentration levels in Agricultural Land-use Zone

Water samples in this zone showed higher concentration for turbidity, DO, BOD, COD, PO_4^{2-}, Cd *and E. coli* (see Table 3 and Figure 26). The returned values for the parameters were 104(mg/l), 16.7(mg/l) and 0.3(cfu/100ml) for DO, BOD and *E. coli* in dry season while in rainy season, the concentration for turbidity, DO, BOD, COD, PO_4^{2-}, Cd and *E. coli* were 56.0(mg/l), 98.4(mg/l), 20.64(mg/l), 20.8(mg/l), 2.1(mg/l), 0.01(mg/l) and 0.8(cfu/100ml) respectively. The relatively high levels of these contaminants recorded at this sample point is an indication of increase in the addition of both organic and inorganic substance from the environment, as well as organic contaminant entering the systems from the municipal sewage (Ogunfowokan *et al.,* 2005). This may also be attributed to runoff from agricultural land (See Plate 2 and 3) with high content of phosphate fertilizers and grazing taking place around the stream and utilization as nutrients by algae and other aquatic plants that are discharged into the stream at this point (Venkatesharaju, 2010). This observation agrees with the works of Morrison *et al.* (2001) who reported that the contribution of BOD, COD, PO_4^{2-}, Cd and *E. Coli* from agricultural land uses to receiving water bodies in Nigeria appears to be significant.

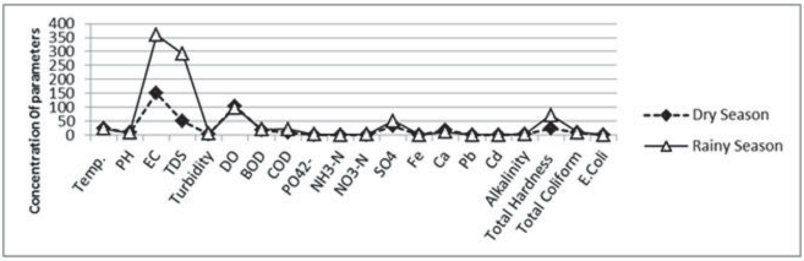

Figure 3: Concentration of Pollutants at the Agricultural Land-use Area.

Plate 2: Farmland around Imabolo Stream

Plate 3: Banana Plantation by the Stream

3.4 Pollutants Concentration levels within the Residential Land-use Area

The pollutants that were found to influence the quality of water in the stream at the residential land-use area includes DO (23mg/l), PO_4^{2-} (1.66 mg/l), NH_3^-N(1.46 mg/l), total coliforms (12.3cfu/100ml) and *E. coli* (0.6cfu/100ml) in dry season while in rainy season, DO (79mg/l), EC (549mS/m), turbidity (253NTU), COD (25.9mg/l), PO_4^{2-} (2.8mg/l), NH_3^-N (5.82mg/l), SO_4 (107.3mg/l), Fe (0.5mg/l), Pb (0.04mg/l), total coliforms (14.4cfu/100ml) and *E. coli* (1.6cfu/100ml) returned high values (Table 3 and Figure 4). The concentration of these contaminants in the stream at this point can be traced to waste disposal from domestic source and human excreta around the stream channel (Plates 4 & 5). Also, most of the drainages channels from different parts of the urban area are emptied into the stream at this point carrying all sorts of wastes such as lead based batteries from the communities.

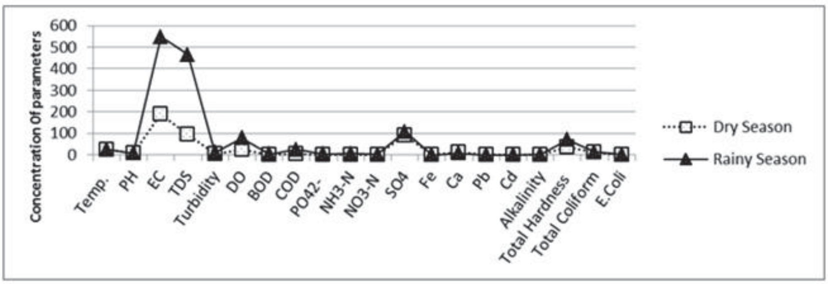

Figure 4: Concentration of Pollutants at the Residential Land-use Area.

Plate 4: Domestic Waste from Residential Land-use Area. **Plate 5:** Urban Waste Area are Emptied into the Stream from Drainage Channels.

3.5 Pollutants Concentration levels at the Commercial Land-use Zone

Analysis of water samples from the stream at the commercial land-use area revealed high values for turbidity (5.10NTU), DO (86 mg/l), BOD (11.84 mg/l), COD, PO_4^{2-} (1.88 mg/l), NH_3-N(1.38 mg/l), SO_4 (144.8 mg/l), total coliforms (14.3 cfu/100ml), and *E. coli* (1.7 cfu/100ml) above the recommended limits for drinking water quality in dry season (see Table 2 and Figure 5). However, in rainy season the returned values were high for temperature (25.3°C), EC (540mS/m), turbidity (180NTU), DO (99.5mg/l), BOD (19.42mg/l), COD (48.3mg/l), PO_4^{2-} (3.4mg/l), NH_3-N (5.65mg/l), SO_4 (210.3mg/l), Fe (0.5mg/l), Pb (0.03mg/l), total coliforms (18.2cfu/100ml), and E. coli (2.3cfu/100ml). The concentration of these pollutants at this location may be as a result of large and varied types of wastes generated from the Central Business District (CBD) which is the commercial hub of the urban area. Some of these parameters emanated from the decay of carcass of meat sold in the market. It was also observed that wastes from this area are channelled into drainages and are washed into the stream through the drainages.

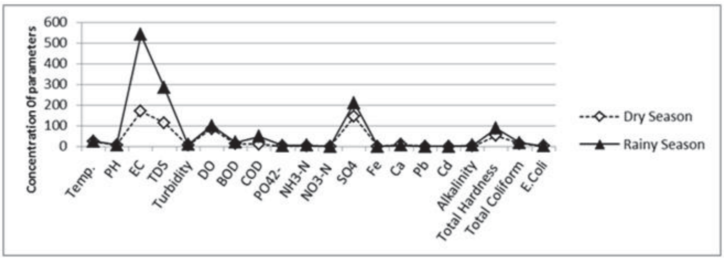

Figure 5: Concentration of Pollutants at the Commercial Land-use Area

3.6 Pollutants Concentration levels at the Educational Land-use Zone

Pollutants influencing water quality of the stream within the educational land-use are shown in Table 3 and Figure 6. Those with higher concentrations include DO (75mg/l), PO_4^{2-} (3.44mg/l), NH_3-N (2.58mg/l), SO_4 (201.6mg/l), Total coliforms (11.6cfu/100ml) and *E. coli*(1.3cfu/100ml) in dry season. The observed pollutants in rainy season were EC (610.10mS/m), Turbidity (50.64NTU), DO (97mg/l), COD (54.3mg/l), PO_4^{2-} (5.7mg/l), NH_3-N (7.65mg/l), SO_4 (251mg/l), Pb (0.023mg/l), Cd (0.03mg/l), Total coliforms (28.5cfu/100ml), *E. coli* (3.1cfu/100ml). The sources of these pollutants are likely from the various human activities in this area that generated one form of waste or another.

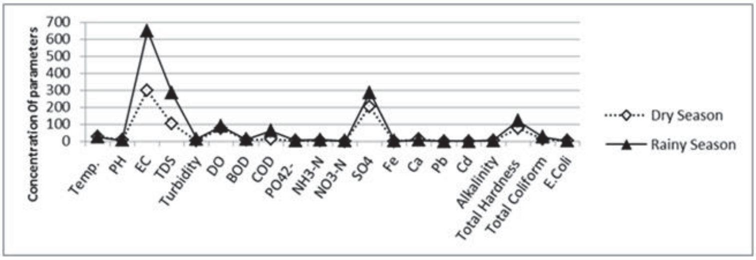

Figure 6: Concentration of Pollutants at the Educational Land-use Area

3.7 Pollutants Concentration levels at the Industrial Land-use Zone

The analysis of water sample from this station of the stream revealed pollutants (EC, Turbidity, DO, COD, PO_4^{2-}, NH_3-N, SO_4, Pb, Cd, total coliforms, *E. coli*) with high concentration (Table 3 and Figure 7). The returned values in dry season were 130mg/l for DO, 3.33mg/l for PO_4^{2-}, 2.91mg/l for NH_3-N, 200.1mg/l for SO_4, 15.3cfu/100ml for total coliforms and 1.8cfu/100ml. Those with elevated values in rainy season include EC (610.10mS/m), Turbidity (50.64NTU), DO (97mg/l), COD (54.3mg/l), PO_4^{2-} (5.7mg/l), NH_3-N (7.65mg/l), SO_4 (251mg/l), Pb (0.023mg/l), Cd (0.03mg/l), total coliforms(28.5cfu/100ml), *E. coli* (3.1cfu/100ml). The presence of these pollutants in stream may be due to the discharge of the wastes from the saw-mill, block industries and palm oil industries within this zone. Some of these pollutants may have originated from some of the farm land adjacent to the stream channel. These pollutants find their way into the stream especially after heavy downpour.

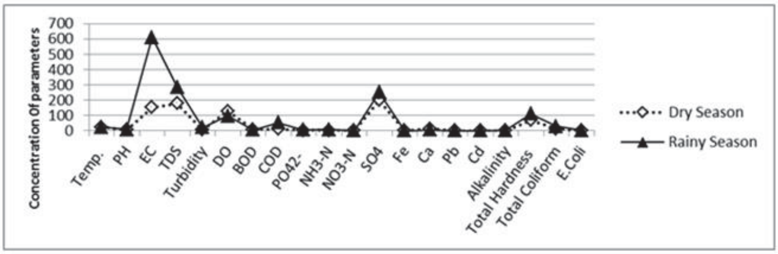

Figure 7: Concentration of Pollutants at the Industrial Land-use Area

Plate 6: Block Industries located around Imabolo Stream

3.8 Pollutants Concentration levels at the Transportation Land-use Zone

In this section, pollutants namely, turbidity, DO, BOD, SO_4, PO_4^{2-}, NH_3-N, SO_4, and *E. coli* with high levels of concentrations impact the quality of water at this sample station (Table 3 and Figure 8). The pollutants with elevated concentrations in dry season were turbidity (5.2NTU), DO (131mg/l), BOD (14.30mg/l), SO_4 (185.4mg/l), and *E. coli* (1.2cfu/100ml) while in rainy season they include turbidity (25.6NTU), DO (110mg/l), BOD (18.40 mg/l), PO_4^{2-} (1.8 mg/l), SO_4 (150.4), total coliforms (23.3cfu/100ml) and *E. coli* (2.4cfu/100ml). The sources of these pollutants are likely to come from the waste generated by the mini food market located in this location. However, some of this pollutant must have been washed down from the industrial land-use and runoffs from the surrounding area washed into the stream because of the landscape of this location.

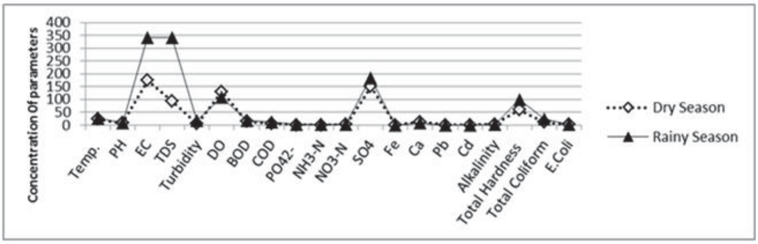

Figure 8: Concentration of Pollutants at the Transportation Land-use Area.

4. Spatial Variations of Pollutant Concentration Levels in Imabolo Stream

The spatial variations in the concentration levels of pollutant build-up in the stream corresponding to identify land-use types in both dry and rainy seasons are presented in Table 5 and discussed briefly below.

Table 5: Variations in Pollutant Concentration levels in Water Samples in the Study Area

Sample Location	Land-use Type	Sample Code	Dry Season			Wet/Rainy Season		
			Names of Pollutants that exceeded the WHO Values	Number of Pollutants that exceeded the WHO Values	% of Pollutants that exceeded the WHO Values	Names of Pollutants that exceeded the WHO Values	Number of Pollutants that exceeded the WHO Values	% of Pollutants that exceeded the WHO Values
Ogaji	Forested	S1	DO	1	5	PO_4^{2-}, DO	2	10
Olubojo	Agricultural	S2	DO, BOD, *E. coli*	3	15	Turbidity, DO, BOD, COD, PO_4^{2-}, Cd, *E. coli*	7	35
Central Residential Area	Residential	S3	DO, PO_4^{2-}, NH_3-N, Total coliforms, *E. coli*	5	30	EC, Turbidity, DO, COD, PO_4^{2-} NH_3-N, SO_4, Fe, Pb, Total coliforms, *E. coli*	11	55
Sabongari	Commercial	S4	Turbidity, DO, BOD, PO_4^{2-}, NH_3-N, SO_4, Total coliforms, *E. coli*	9	45	Temp, EC, Turbidity, DO, BOD, COD, PO_4^{2-}, NH_3-N, SO_4, Fe, Pb, Total coliforms, *E. coli*	13	65
Kogi State College of Education Area	Educational	S5	Temp, DO, PO_4^{2-}, NH_3-N, SO_4, Total coliforms, *E. coli*	7	35	EC, Turbidity, DO, BOD, COD, PO_4^{2-}, NH_3-N, SO_4, Fe, Pb, Cd, Total coliforms, *E. coli*	13	70
Ojelanyi	Industrial	S6	Temp, DO, PO_4^{2-}, NH_3-N, SO_4, Total coliforms, *E. coli*	7	35	Temp, EC, Turbidity, DO, COD, PO_4^{2-}, NH_3-N, SO_4, Pb, Cd, Total coliforms, *E. coli*	12	65
Ojokodo	Transportation	S7	Turbidity, DO, BOD, SO_4, Total coliforms, *E. coli*	6	30	Temp, Turbidity, DO, BOD, PO_4^{2-}, SO_4, Total coliforms, *E. coli*	8	40

Source: Fieldwork, 2012-2014

In dry season (Column 6 of Table 5 and Figure 3), the pollutants that returned values above the WHO limit were 5% at forested land-use (Ogaji area), 15% at Agricultural land-use (Olubojo/St. Charles College Area), 30% at the Residential land-use (Central Residential Area), 45% at Commercial land-use (Sabongari), 35% at the Educational land-use (Kogi State College of Education Area) and Industrial land-use (Ojelanyi) respectively, and 30% at Transportation land-use (Ojokodo).

Column 9 of Table 5 and Figure 3 illustrates the spatial variations in water quality of Imabolo stream in rainy season due to pollutants build-ups in the water samples analyzed. From the analysis, 10% of the pollutants returned values above he WHO at forested land-use (Ogaji area), 35% at Agricultural land-use (Olubojo/St. Charles College Area), 55% at the Residential land-use (Central Residential Area), 65% at Commercial land-use (Sabongari), 70% at Educational land-use (Kogi State College of Education Area), 65% at Ojelanyi (Industrial land-use) and 40% at Transportation land-use (Ojokodo).

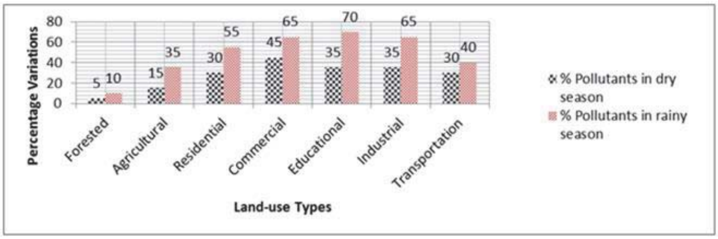

Figure 3: Spatial Variations of Pollutant Build-ups in water Samples at different Land-use Types in both Dry and Rainy Seasons

5. Seasonal Variation in Pollutant Concentration levels of Imabolo Stream Land-use Types

The influence of seasons on the water quality among the identified land-use types along the stream course was analyzed using independent-samples *t*-test. The analysis revealed that there was significant difference $t(12) = 3.225$, $p < 0.05$, $d = 0.255$ between concentration levels of pollutant in the sampled water in dry and rainy seasons among the land-use types. An analysis of the group means indicates that the pollutants in water sampled in rainy season ($M = 56.12$, $SD = 7.38$) are lower (water quality index) significantly than those in rainy season ($M = 66.73$, $SD = 4.62$).

6. Water Quality Index (WQI) of Imabolo Stream at the identified Land-use Types

Table 6: Water Quality Index of Imabolo Stream in both Rainy and Dry seasons

Sample Locations	Sample Codes	Land-Use Types	Rainy Season			Dry Season		
			WQI	Class	Status (Brown et al.,1972)	WQI	Class	Status (Brown et al.,1972)
OGAJI	S1	Forested	69.08	C	Medium	72.76	B	Good
OLUBOJO AND ST. CHARLES COLLEGE AREA	S2	Agricultural	62.44	C	Medium	71.27	B	Good
CENTRAL RESIDENTIAL AREA	S3	Residential	57.14	C	Medium	59.55	C	Medium
SABONGARI	S4	Commercial	54.12	C	Medium	64.57	C	Medium
KOGI STATE COLLEGE OF EDUCATION AREA	S5	Educational	49.30	E	Bad	69.43	C	Medium
OJELANYI	S6	Industrial	51.14	C	Medium	64.77	C	Medium
OJOKODO	S7	Transportation	49.63	E	Medium	64.77	C	Medium
Mean WQI			56.12	C	Medium	66.73	C	Medium

Source: Author, 2012-2014

The water quality index of the stream showed significant variations from the upper (Ogaji) to the lower (Ojokodo) course during the rainy season. Sample at forested land-use (Ogaji) returned value of 69.08, Agricultural land-use (Olubojo/St Charles College) was 62.44, Residential (Central Residential Area) was 57.14, Commercial land-use (Sabongari) was 54.12, Educational land-use (Kogi State College of Education Area) was 49.30, Industrial (Ojelanyi) was 51.14 and Transportation (Ojokodo) was 49.63 (Table 6). The WQI from the stations showed that the status water in the stream can be ranked as medium for all the stations except Kogi State College of Education Area and Transportation land-use zones that revealed bad status in terms of water quality categorization during this season. The water quality index among stations was in the pattern S1>S2>S3>S4>S5<S6>S7 which showed the decrease in the quality of water down the stream channel. The decrease in value along stations is a reflection of different types of pollutants entering the stream due to various activities such as discharge of domestic sewage, runoff water from agricultural lands near the banks of the stream (see Table 6)**.**

In dry season, the minimum and maximum water quality indexes were recorded at Central Residential Area and Ogaji. The calculated WQI values at Forested, Agricultural, Residential, Commercial, Educational, Industrial and Transportation land-uses were 7.2.76, 71.27, 59.55, 64.57, 69.43, 64.77 and 64.77 respectively. The water quality rating among the land-uses decreases from Forested land-use at Ogaji to the Transportation land-use at Ojokodo in this season. However, a sharp decrease was observed at Central Residential Area (59.55). The drop in water quality rating is probably due to contaminants from incessant activities such as solid wastes and excreta disposal directly into the stream, car wash effluents, washing of cloths, etc. that are constantly taking place at this section of the stream. In terms of water quality status, the values the water can be ranked as medium for all stations which is an indication of fair quality of water in the stream channel during this season (Table 6).

7. Conclusion and Recommendation

Imabolo stream is negatively impacted on by land-use activities within the Anpka urban area. The observed high pollutant loads result probably from industrialization effluents, wastes disposed along water pathways, agricultural fields and from runoffs. The impacts of land-use patterns on the stream water quality during dry and rainy seasons in seven zones studied were found to vary. The pollutant concentration levels were found to be remarkably higher during the rainy season. Considering the relative concentration levels of pollutant loads among land-uses, commercial land-use contributed more pollutants to the stream. This is followed by mixed land use, industrial land use, residential land use, transportation land use and finally agricultural land use in that order. Change in seasons is a significant factor in the variability of some pollutants concentration levels particularly, temperature, EC, turbidity, BOD, COD, PO_4^{2-}, NH_3^-N, SO_4, Fe, Pb, Total coliforms, and *E. coli*.

The implications of these findings are that residents who depend on this source of water for domestic uses are exposed to health risks, especially during the rainy season. This study recommends improved land-use optimization, water pollution control, water source protection and awareness creation among the urban residents.

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