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Impacts of Land Use on the Quality of Ala River in Akure Metropolis, Nigeria

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Abstract

This research was carried out to ascertain the impacts of land use on water quality in Ala river within Akure metropolis, Nigeria. Physical, chemical and bacteriological tests were carried out on the water samples collected from eight different sample points along the river. The parameters analyzed were temperature, odour, taste, colour, turbidity, nitrite, nitrate, pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), phosphorus, chlorine, and heavy metals which include copper, cobalt, iron, nickel, zinc, arsenic, selenium, manganese and lead. All the samples indicated contamination alongside the presence of heavy metals. COD values of 160, 300, 580, 220, 400 and 120mg/L observed in points 2, 3, 5, 6, 7, and 8 respectively were above the WHO permissible limit. In point 1, the concentration of heavy metals like iron and lead were above the safe limit. The result showed that amongst the human activities identified to cause water pollution, improper waste disposal and uncontrolled agricultural activities had major effects.

Keywords: Land use; Ala river; Heavy metals; Permissible; Water quality.

1.0 INTRODUCTION

Water quality is described as the measurement of water use for domestic, industrial, agricultural, recreational and other purposes based on physical, chemical and biological factors. However, it varies by weather, location, pollution sources, and time [1]. Among various types of pollution, surface water pollution is a great threat to human health, and the most critical issue for sustainable development. With the growth of human populations, commercial and industrial activities, surface water has received a large amount of pollutants from various sources [2]. Understanding the interaction between land use and river water quality aids in recognizing threats to water quality [3]. Deforestation, excessive use of fertilizers, among other agricultural activities, have all been highlighted as major drivers of land use and land cover change, all of which have an impact on water quality [4]. Niemi *et al.* 2007 [5] reported that anthropogenic activities mainly impact surface water quality through effluent discharges, the use of agricultural chemicals, and uncontrolled exploitation of water resources.

Furthermore, pressure due to increasing population, industrial and urban development and poor sanitary facilities have resulted in the contamination of water supplies by a variety of toxic chemicals and bacteria, resulting in the rapid deterioration of water [6]. Untreated waste is dumped into public channels, streams and other waterbodies, polluting the freshwater reserves both deliberately or accidentally [7]. Surface water pollution not only contaminates, but it also poses a threat to human health, economic growth and ecological balance [8]. The presence of point and non-point sources of pollution makes maintaining water quality a difficult process. Non point sources are natural occurrence that can never be completely eradicated [9]. Water quality evaluation is also considered as critical issue in recent years, especially when freshwater is becoming a scarce resource in the future [10]. Hence, it is imperative to prevent and control the surface water pollution and to have reliable information on its quality for effective management [11]. Also, it is critical to determine the river's water quality in relation to the various landuse in order to determine the degree of impairment or improvement in water quality offered by the various landuse [12].

The objectives of this research is therefore to determine the physical, chemical and biological qualities of surface water samples at selected points on Ala river and its tributaries and juxtapose the land use activities of the sampling points with the water quality established so as to help the government and other stakeholders make good

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decisions in ensuring proper landuse and the improvement of water quality.

2.0 MATERIALS AND METHODS

2.1 Description of study area

Ala watershed drains parts of Akure South and Akure North local government areas in Ondo State. Ala-River traverse the city of Akure, as a result it drains more than 60% of Akure metropolis such as: Oyemekun, Federal University of Technology Akure (FUTA), Alagbaka, Adesida, Shagari Village and Oba-Ile area, this is the major reason it is being considered for this study. The study area is located on latitude 7º 40` N and 7º 80`N and longitude 5º 10` E to 5º 10`E and has a watershed area of 15.6 km² (Figure 1).

Agriculture (crop and livestock farming) is the occupation in the state, as they are the largest cocoa producing state in the country. Other industries in the state are pottery making, rubber and palm oil production amongst others.

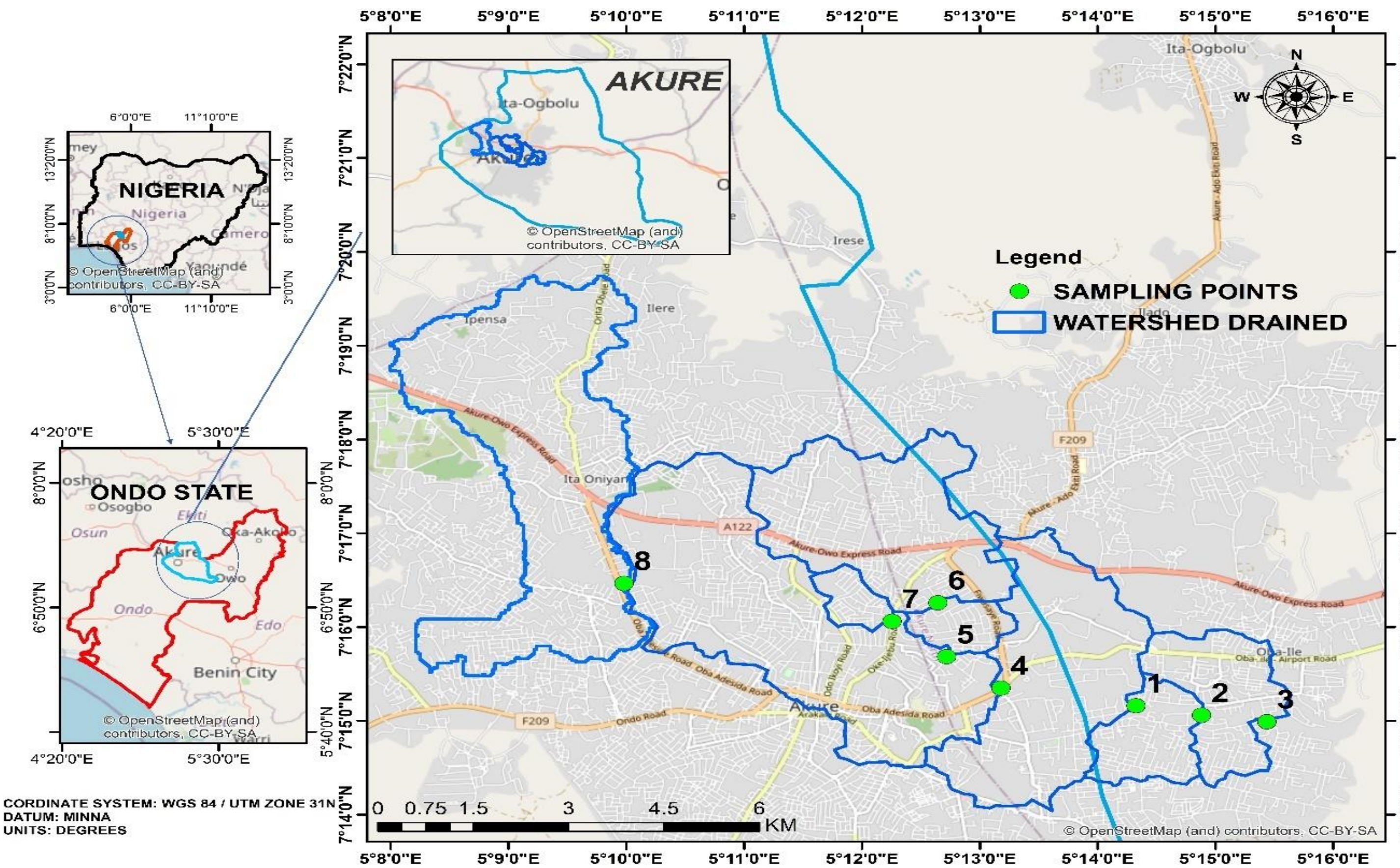

Figure 1: Map of the study area and sample points

__Table 1:__ Sample point, location and land use area

Sample points	Location	Built-up area (km^2)	Vegetation area (km^2)	Hill area (km^2)	Bare-soil area (km^2)
1	Oba-Ile – Road Q	3.65	2.16	3.46	0.90
2	Oba-Ile – Miami Hotel	1.32	0.45	0.41	0.42
3	Oba-Ile – Solafunmi	2.35	0.46	0.48	0.70
4	Oja culvert	11.02	1.82	2.24	0.92
5	Oke-Ijebu – Otenioro	0.91	0.08	0.16	0.17
6	Oke-Ijebu – Oke ijebu	5.35	0.93	2.55	0.53
7	Oke-Ijebu – Joseph Ogunoye	0.74	0.03	0.17	0.02
8	Futa – Aule	16.02	0.86	0.01	0.55

2.2 *Selection of Sample Sites*

Eight sample points from three locations namely; FUTA, Oba-Ile and Oke-Ijebu were selected for this research due to accessibility and the most prevalent landuse activities. The first two locations were along the main flow path of Ala river while the latter is a tributary of Ala River. Oba-Ile and Oke-Ijebu had three sample points each at an interval of 1km, while FUTA had one sample point, with the last sample point midway between FUTA and Oba-Ile (Table 1). From the reconnaissance survey, it was observed that FUTA and Oke-Ijebu had more of residential and office buildings, commercial and industrial operations with less agricultural activities however, Oba-Ile had very little residential buildings, but more of agricultural activities. Therefore, the land use of the sites formed a major criterion for the selection (Figure 2).

2.2.1 Digital Elevation Model

The Digital Elevation Model (DEM) represents the topographic features of the study area and the elevation of the watershed ranges within the height of 450m (high) and 355m (low). For Ala watershed, the Digital Elevation Models (DEMs) was sourced from Earthexplorer.usgs.gov with a resolution 12.5 m.

2.2.2 Land use and Land cover

Sub-watershed level land uses and land cover map derived from the Landsat-8 images 2019. The classification was done with the "Semi-Automatic Classification" SCP plugin on QGIS 3.18 along with NDVI techniques according to the standard classification techniques. Various bands were downloaded and combined based on their distinct purposes, four land use classes; built up, hill area, bare soil and vegetation were derived based on Macro Classification.

However, the accuracy of the classified image is checked through field information along with the Google Earth visualization, pre-existing maps, and also with Envi software.

2.3 *Sample Collection*

The samples were collected into properly labelled sterilized containers. The containers were buried into the river to collect the water samples and at points where easy access was a challenge, fetcher was used to collect the samples and air bubbles were expelled completely. The samples were cooled at a temperature of $4^{o}C$ and carefully transported to the laboratory for analysis [13].

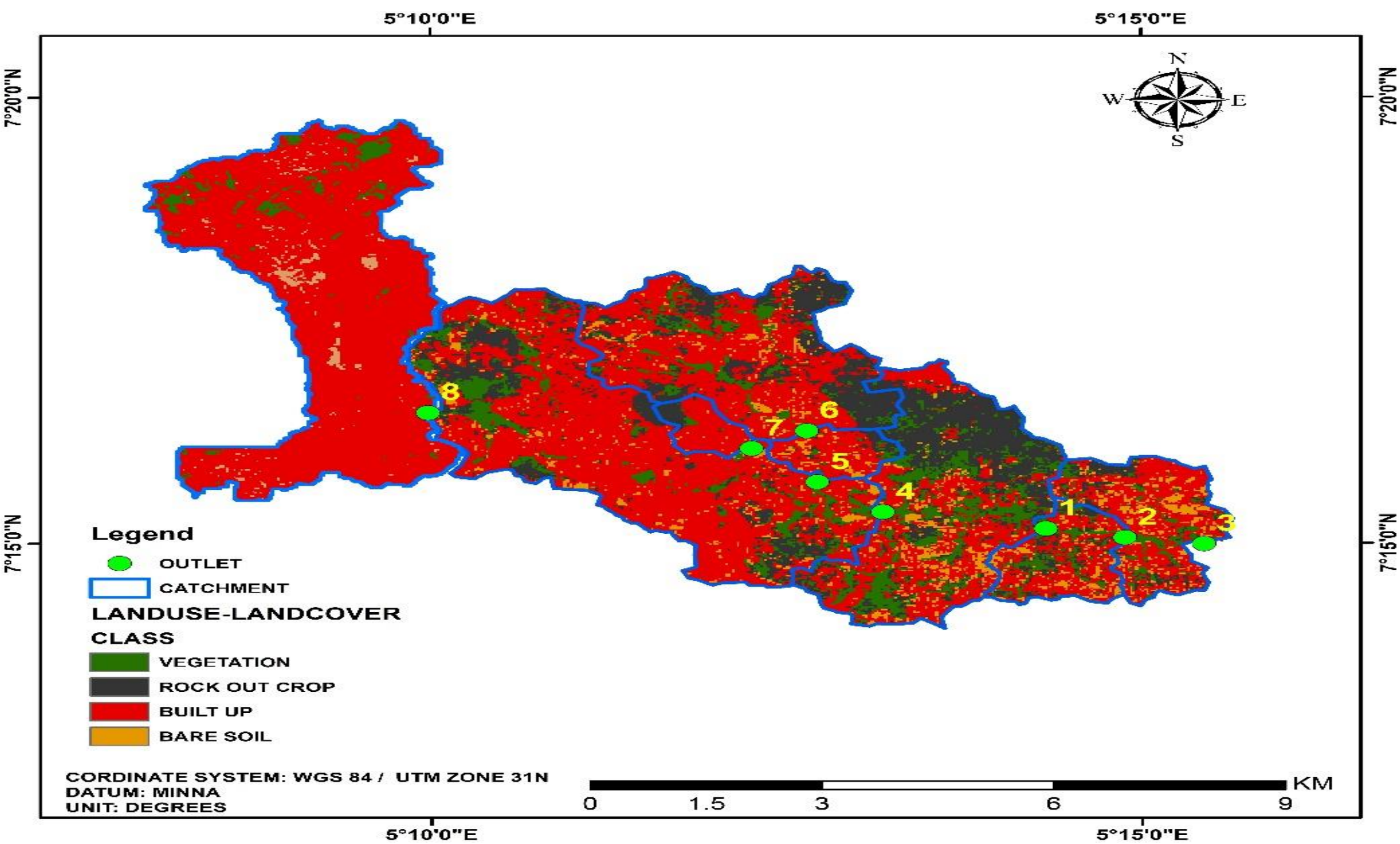

Figure 2: Land use map of the sample points

2.4 Tests on Intensive Parameters

Colour, taste and odour were the tests carried out on the water samples. These were determined by sensual inspection with the aid of the eyes, tongue and nose respectively. While the temperature was estimated using a thermometer.

2.5 Biological Tests

According to Okereke et al. (2019) [14] the culture media were prepared by measuring 3.6 g of Eosin methylene blue agar (EMBA), 4.95 g of MacConkey agar (MCA), 3.6 g of Nutrient agar (NA) and 6.3 g of Salmonella shigella agar (SSA) into individual conical flasks and mixing each one with 100 mL of distilled water which was then dissolved by heating on an electric hot plate. 16 test tubes each containing 9 mL of distilled water together with the dissolved agars were sterilized for 15 mins in the autoclave.

Thereafter, the sterilized water was used for diluting the water samples which were used for the experiment and incubated for 24 hours. Afterwards, the colonies formed in each plate containing the agar were counted using a colony counter then the gram-staining analysis was carried out using a smear of bacteria on a slide, crystal violet solution, iodine, ethanol, safranine and a microscope.

2.6 Chemical Tests

The turbidity and pH of the samples was measured using the turbidity meter and pH meter respectively. The COD was determined using the COD reactor and a multiparameter photometer. The BOD was estimated using the BOD test kit after 5 days of incubating the water samples in the BOD test bottles. The Colorimeter was used to estimate the concentration of other chemical properties such as nitrate, iron, copper, phosphorus, nitrite, chloride, iron, zinc, cobalt, arsenic, selenium, manganese and lead. This was achieved by zeroing the colorimeter, imputing the program number and using the chemical reagents meant for each test [15].

3.0 RESULTS AND DISCUSSION

3.1 Sample Point 1

The major land use activities around this sample point are agricultural practices such as plantation, subsistence farming and livestock production both in large and small quantities. The built-up area covers 36 % of the sub watershed of point 1, while the vegetative land use areas is 21 %. From the watershed map, this point has the largest area of vegetation, wetland, forest, and open land surface. The results in Table 2 showed that the water sample was colorless, tasteless but had an irritating smell and a turbidity value of 2.82 NTU. The chemical test in Table 3 and 4, indicates that the concentration of phosphorus and heavy metals such as iron, selenium, manganese and lead exceeded the WHO permissible limit. The bacteriological result (Table 5) shows the water sample had more bacteria, coliform and E-coli counts. Activities such as application of pesticides and fertilizers, uncontrolled irrigation water, dungs from animals that graze at the river bank and the release of wastewater from fish ponds coupled with runoff as a result of erosion has negatively affected the quality of the water.

Table 2: *Result of the tests on physical parameters*

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Temperature (ºC)	25.7	25.8	25.4	25.6	25.6	25.8	25.6	25.3
Color	colourless		brown		colourless			
Taste	tasteless							
Odour	irritating							

Table 3: *Result of the chemical tests*

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**WHO**
Turbidity	2.82	3.18	4.55	4.46	0.93	1.15	0.76	0.88	<1
pH	6.9	6.6	6.6	6.8	7.1	7.2	7.2	6.6	6.5-8.5
BOD	3.04	2.52	1.99	2.8	2.43	3.14	2.8	3.52	50
COD	60	160	300	40	580	220	400	120	<120
Nitrite	0.01	-	0.016	0.031	-	0.054	-	0.025	10
Nitrate	0.46	0.31	0.44	0.49	0.39	0.42	0.38	0.27	<50
Phosphorus	0.675	0.553	1.526	0.043	0.963	0.893	0.674	1.524	0.1
Chlorine	32.2	22.7	58.31	38.1	28.5	28.9	26.9	18.24	<250

Note: Turbidity: Nephelometric Turbidity Units (NTU); Others (mg/L) except pH; - Below Instrument Detection Limit (<0.001); BOD: Biochemical Oxygen Demand, COD: Chemical Oxygen Demand

Table 4: *Result of the heavy metal tests*

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**WHO**
Copper	0.148	0.083	0.125	0.126	0.101	0.118	0.068	0.135	2
Cobalt	0.027	-	0.015	0.015	-	0.019	-	0.017	0.05
Iron	0.629	0.293	0.374	0.427	0.381	0.538	0.863	0.648	0.1
Nickel	0.010	-	0.016	0.031	-	0.054	-	0.025	0.02
Zinc	0.714	0.550	0.734	0.588	0.147	0.283	0.617	0.380	3
Arsenic	0.002	-	-	-	-	0.001	-	0.001	0.01
Selenium	0.013	-	0.011	0.010	-	-	-	0.014	0.01
Manganese	0.089	0.036	0.074	0.047	0.015	0.032	0.013	0.075	0.05
Lead	0.050	-	0.042	0.012	-	0.018	-	0.052	0.01

Note: all parameters are measured in mg/L, - Below Instrument Detection Limit (<0.001)

Table 5: *Result of the bacteriological tests*

Sample points	**Total Viable Bacteria Count**	**Total Coliform Count**	**Total *E. coli* count**
1	226	110	66
2	11	8	4
3	29	16	10
4	420	218	106
5	18	10	6
6	24	16	6
7	22	14	6
8	4	-	-

Note: all counts are in cfu/100mL, - Below Instrument Detection Limit (<0.001)

3.2 Sample Point 2

With the vegetation and bare soil covering an area of 0.45 and 0.42 km^2 respectively (17 % and 16 % of point 2 sub watershed), the land use activities at this point are plantation and poultry farming. The result of the bacteriological test at this point was quite low compared with other sample points, the turbidity, COD, phosphorus and iron test results were more than the WHO permissible limit, and this could be attributed to the effect of decayed plant and poor waste disposal practices along the river bank.

3.3 Sample Point 3

Sample point 3 has a large expanse of land majorly for subsistence farming of food crops and livestock such as pigs, poultry and catfish. Built-up, vegetation and bare soil are 59 %, 12 %, 18 % of the point 3 sub watershed respectively (Table1). Although these activities are beneficial, they have caused a heavy pollution with a relatively high bacteria count, alongside high turbidity (4.55 NTU) and phosphorus (1.526 mg/L) values with a brown colour, an irritating smell and excess concentrations of heavy metals such as iron, selenium, manganese and lead as shown in Table 3. Surface run off, poor management practices such as disposal of dead and decayed plant and animal wastes, washing of farm implements at river banks and channeling of wastewater that contains residue of fertilizers, animal feeds and other chemicals into the river could have led to the introduction of foreign materials into the water body.

3.4 Sample Point 4

This point drains mostly built-up area (69 %) of residential and commercial buildings. The market and commercial activities, has resulted to a change in certain properties of the water samples such as colour, odour, turbidity, and increase in the concentration of phosphorus and some heavy metals (cobalt, iron, nickel and lead) which are above the permissible limits. Of all the sampled points, this area is known to possess the highest viable bacteria, coliform and E-coli count. This is due to proximity to a landfill, leachate of sewers to the river and indiscriminate burning of both residential and market wastes at the river floodplains.

3.5 Sample point 5

This point drains a sub watershed with built-up area and vegetation area of 69 % and 6 %. The bacteriological test gave a result that was considerably lower than other sample points, while the physiochemical parameters tested on this water sample fell within the WHO acceptable limit, with the exception of the odour, phosphorus and iron with slightly high concentrations. The COD was the highest of all the recorded values with a great difference from the required limit. The variation of the result from standard could be as a result of improperly disposed waste from commercial and industrial activities carried by water as it drains into the river.

3.6 Sample Point 6

The land use activity at this point is majorly residential, although the settlement is mostly peri-urban. Land use like this should not cause significant pollution to water bodies, but lack of waste management by the residents has affected certain water properties such as the odour, turbidity, COD, phosphorus and also increased the concentration of iron, nickel, lead and bacteria in the water. In the sub watershed broken sewers, refuse dumpsites, old and worn-out metallic pipes were observed. A lot of improper channelization of effluents from fishponds have caused pollution in the river.

3.7 Sample point 7

This point is similar to sample point 6, considering the land use activities; only that the settlement here is more of the urban type with better recreational centers, and construction sites. The water sample from this point had the highest iron content with an irritating odour and a considerably high concentration of COD and phosphorus. The river has unpleasant properties because of the corrosion of metallic pipes, existing municipal dumpsite on the river bank and erosion of waste building materials during the rainy season. The built-up and vegetation areas are 77 % and 3 % of the watershed respectively.

3.8 Sample Point 8

This is mostly a built-up area with offices, schools and companies. The water sample from this point had an irritating smell with a slight increase in phosphorus and a number of heavy metals (iron, nickel. Selenium, manganese and lead). Although, it also had the best bacteriological result with a total viable bacterium count of 4 cfu/100 mL and 0 cfu/100 mL coliform and E-coli count as shown in Table 5. The waste generated by some small-scale companies and homes are disposed directly into the water channels thereby polluting the river.

4.0 CONCLUSION

This study has revealed that land use activities have an undesirable impact on the physiochemical and biological characteristics of the water samples, especially at points that drain areas with commercial and farming activities. The watershed was mostly built-up with commercial and residential activities; however, the downstream parts were mostly vegetation. The pollution of the river was due to unregulated waste management practices. As a result of this, it is recommended there should be proper allocation of land for diverse commercial, industrial and farming activities and stringent regulation against improper waste disposal.

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