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Impact of Dumpsites on Surface Water Contamination in Selected Settlements of Irewole And Isokan Local Government, Osun State, Nigeria

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ABSTRACT

The availability of safe, accessible water available when needed in homes, schools and health care facilities, whether used for drinking or other domestic uses, directly promotes human health in a myriad of way. However, in developing countries, cities and towns are experiencing urbanization and industrialization, without an effective solid waste management plan to handle the resultant increase in solid waste generation. One major problem with indiscriminate dumping of solid waste on open dumps is the generation of leachate. Leachate is formed from moisture that pass through the solid waste. Leachate contains nutrients and heavy metals that can serve as pollution sources and water. This study examined the spatio-temporal variation in the physico- chemical characteristics of surface water across the study area. This was with a view to determining the impact of dumpsites on surface water quality in the study area. Ground water samples were taken twice (once in the dry season and once in the wet season). These samples were taken from wells within 150 m proximity of a dumpsite using 1 litre high density polyethylene bottles. A control point was purposely selected, 1 km away from any noticeable dumpsite. The water samples were analyzed for physical and chemical parameters according to APHA, 1992 standard. This study concludes that surface water in the study area is contaminate because of the occurrence of lead in all the water samples examined.

Keywords: Dumpsites, leachate, physico-chemical characteristics, spatio-temporal variations, surface water

I. INTRODUCTION

Waste can be defined as an inevitable by-product of human activity (Afon and Okewole, 2007), according to them, it contains physically the same materials that are found in useful products; the only difference being its lack of value. It may also be referred to as a leftover, a redundant product or material of no or marginal use for the owner and which the owner wants to discard (Christenssen, 2011). Waste could be categorized into solid, liquid, gaseous or hazardous.

Solid waste refers to any type of garbage, trash, refuse or discarded material. It can be categorized according to where the waste is generated, for example as municipal solid waste, health care waste and e-waste, (WHO,2021). Municipal solid waste, which is the category of solid waste of interest to this study has been defined as the solid component of the waste stream arising from mainly domestic but also commercial, industrial, government and public premises including waste from council operations, services and facilities that is collected by or on behalf of the council via curbside collection, but does not contain listed waste, hazardous waste or radioactive waste (WHO, 2021).

Solid waste management is defined as the discipline associated with control of generation, separation/sorting, storage, collection, transport/transfer, processing/treatment and disposal of solid waste materials in a way that best addresses the range of public health conservation, economic, aesthetic, engineering and other environmental conditions, (Houemenou et al,2020). Solid waste management is a complex multidimensional activity that has become important due to industrialization, rapid urbanization and population growth throughout the world, (Salau, 1993). The scope of solid waste management activities includes, planning, administrative, financial, engineering and legal functions. In addition, there might also be need for complex interdisciplinary relations among fields such as public health, city and regional planning, political science, sociology, geography, economics, communication and conservation, demography, engineering and material science, (Houemenou et al, 2020), before a proper solid waste management process can be put in place. Solid waste management activities, are becoming problematic in developing countries of the world due to the fact that the composition and quantity of waste generated and disposed vary both in space and time in relation to human activity, socio-economic status, presence and size of industry, and the quantity and type of products that communities consume (Hudson, 2007); population growth, rapid and unplanned urbanization as well as industrialization, (Agbesola, 2013). There are a number of ways by which municipal solid waste can be managed, these are; reduce, reuse, recycle, energy recovery and disposal (solid waste management hierarchy); (WHO, 2021)

Disposal of municipal solid waste on designated open dumps and indiscriminately in places like the middle of roads and water bodies are common practices in many developing countries (Adeolu et al, 2014), Nigeria inclusive. This is because funds and technology are not required to dispose waste in open umps, thereby making it the 'cheapest' of the waste disposal methods. Consequently, as cheap as it is, the use of open dumps for solid waste disposal has negative impacts on the environment that can be very expensive, In open dump sites, the waste is exposed to contact with precipitation which extract contaminants from it in form of leachate. Leachate is formed when water from rain or from within the solid waste percolates through it and causes solubilization of its organic and inorganic constituents through physical, biological and chemical processes (Robinson and Maris, 1979; Kjeldsen et al., 2002). While the amount of leachate generated depends on the quantity and moisture content of the waste, and also on the amount of precipitation that passes through the dump (Rodriguez et al, 2004), leachate composition depends on several factors, these include the composition and type of waste, waste compaction, particle size, soil moisture, types of microorganisms, climate, site operating procedures, age and hydrogeology of the dumpsite (Lee, 2010).

Municipal solid waste has been found to contain appreciable quantity of heavy metals such as Cadmium, Zinc, Mercury, Lead and Copper, (Alloway and Aryes, 1997). Leachate can therefore pose a significant environmental problem to living organisms if it somehow finds its way into surface water.The chemicals present in leachate may be assimilated from such waters by organisms of aquatic or terrestrial species (bioaccumulation) and pass through the food web (bio magnification) upon long term exposure.

The specific objective of this study is therefore to examine the spatio-temporal variations in the physico-chemical characteristics of surface water in the study area.

II. METHODOLOGY

The Study Area

Irewole and Isokan local government areas (represented by Ikire and Apomu respectively) constitute the study area The study area (figure 1) is located within the 7°21'40" North of the equator and 4°11'00" East of the meridian, with altitudes between 121.92 and 298.70 m above the sea level. It covers an area of 271 square kilometers and has a projected population of 143,599 comprising of 74,120 males and 69,479 females (NBS, 2014). The study area is bounded in the north by Ayedire, in the east and south by Ayedaade, and shares boundary with Egbeda Local Government Area of Oyo state to the west. One dumpsite with a stream flowing by it was purposely selected in each of the two towns for the study, and it was ensured that there were no other dumpsites close to the ones that were used for this study. The study area is characterized by two distinct seasons; wet and dry.

The wet season which starts in March and last till end of November, with its peak-period in July. This period is as well characterized by thick cloud cover. August to mid-October forms the transition between wet and dry season, which is characterized by light showers. The dry season runs from November till early March with its peak between December and February. This period is known to be dusty and dry as a result of north-east winds as well as harmattan condition. Most rocks here are commonly granites and granite gneisses while they are rare on schist (Adejuwon and Jeje, 1977). The soil in this area mostly Lixosols and Ultisols (Adeniyi and Olabanji, 2005).

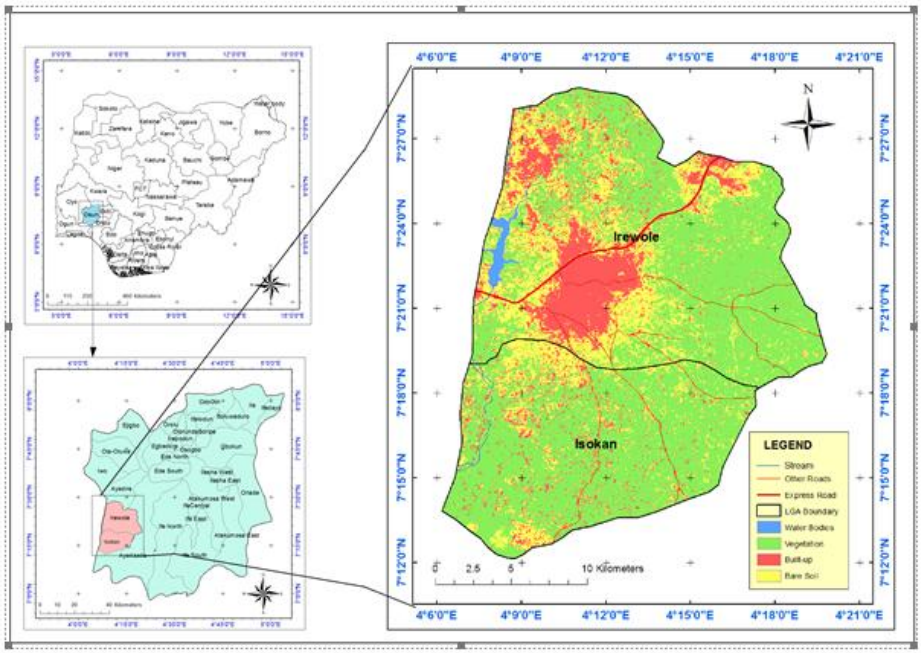

Figure 1: map of Nigeria, Osun state and Irewole and Isokan Local Government Areas

The two local government areas were chosen because of the fact that pipe borne water is not readily obtainable in both settlements, therefore majority of the residents depend on ground and surface water for drinking and other domestic purposes. In addition, Ikire (Irewole local government) which ishome to one of the campuses of the Osun State University isexperiencing its own share of population growth, hence there is always the likelihood ofwaste management challenges in both Ikire and Apomu which is a neighbouring town.

Water Sample Collection

This study was designed to cut across the two recognized seasons of the annual cycle (wet and dry season) in Nigeria. Water samples were collected from each of the sampling sites in the two study locations (Ikire and Apomu). The first set of samples were taken in February, this represents the dry season situation of surface water quality in the study area. While samples taken in July, at the mid of wet season represented the wet season situation of surface water quality due to the influence of leachate percolation.

The surface water samples were collected from streams within 200m proximity of the selected dumpsites. The first sample was collected 100m upstream of the dumpsite, the second was collected at the point of contact with the dumpsite, while a third sample was collected 100m downstream of the dumpsite; this was done in order to examine the spatial variation in surface water quality due to leachate movement. A control sample was then collected 1km away from any visible dumpsite. Therefore, in the dry season, (February) eight surface water samples were collected, (four in each study locations). The same sampling technique was replicated in the wet season, (July), in order to examine the temporal variations that might occur as a result of leachate percolation.

Sample Analysis

The physical parameters were determined by probe method in-situ. pH, was determined with a portable Hanna HI98129/30 pH meter, and a Greenspan EC250 were used to determine electric conductivity and total dissolved solids (TDS). The surface water samples were analyzed for the following chemical parameters and heavy metals; nitrate (NO^{3-}), sulphate (SO_4^{2-}), phosphate (PO_4^{3+}), chloride (Cl-), copper (Cu), lead (Pb), iron (Fe), zinc (Zn) cadium (Cd), Nickel (Ni). The chemical analyses were carried out in accordance to standard analytical methods (APHA, 1992), at the Center for Energy and Research Development (CERD), Obafemi Awolowo University, Ile-Ife. Metal digestion was done using the Milestone Acid digestion method. Five milli litre of each water sample was pipetted into 20ml teflon tube. Concentrated acids of 6ml nitric acid (HNO_3, 65%), 3ml of hydrochloric acid (HCl, 37%) and 0.25ml hydrogen peroxide (H_2O_2) were added to each sample. A blank was prepared using 6ml HNO_3 (65%), 3ml of HCl (37%) and 0.25ml H_2O_2. The samples were placed in an ETHOS 900 microwave digester for thirty minutes. After digestion, the samples were allowed to cool to room temperature and the solutions then diluted to 20 ml with distilled water. The liquid extract was then used for the determination of heavy metals using VARIAN AA240FS Fast Sequential Atomic Absorption Spectrometer under the recommended instrument parameters. Two standard reference materials - IAEA 356 from the National Institute of Standards and Technology, USA, and NIVA SLP 0838 PROVE I from Norway were used for the validation of the analytical results.

The concentration of each metal was calculated using the formula below:

Final concentration (mg/l) = concentration of metal x dilution factor x nominal volume/Sample volume (ml).

Data Analysis

The results obtained for the laboratory analysis of the water samples were subjected to descriptive (mean, range and standard deviation) and inferential statistics; Analysis of Variance (ANOVA) and Pearson correlation. Results obtained for the concentration of physical and chemical parameters tested in each of the surface water samples, were compared in the two sampled settlements using ANOVA. Pearson correlation was used to test for statistical difference in concentration of the tested parameters, in the surface water, in relation to distance away from the dump site.

III. Results and Discussions

Physical Parameters

Electrical Conductivity (EC)

In the wet season, electrical conductivity varied between 761.82 and 1180.5 µScm-1 in Ikire and between 884.8 and 1120.5 µScm-1 in Apomu. In the dry season, however, surface water electrical conductivity varied between 899.4 and 1172.3 µScm-1; 800.5 and 1043.6 µScm-1 in Ikire and Apomu respectively. The mean ± standard deviation was 980.36 ± 209.95 and 1011.35 ± 154.36 µScm-1 in Ikire and Apomu respectively in the wet season. In the dry season, the surface water electrical conductivity had a mean ± standard deviation of 1024.30 ± 137.91 and 994.25 ± 69.79 µScm-1 in Ikire and Apomu respectively.

Electrical conductivity showed a strong correlation with distance away from the dump site at both stations in the two seasons. The result of Analysis of Variance showed that there was no statistically significant difference in surface water conductivity in the two sampled settlements in both dry ($F = 1.241$, $P > 0.05$) and wet ($F = 0.466$, $P > 0.05$) seasons.

Total Dissolved Solids

The range and mean ± standard deviation of surface water TDS in Ikire were 104.6 and 248.40 ± 53.19 respectively in the wet season, while in the dry season, surface water TDS varied between 255.4 and 322.8 with a mean ± standard deviation of 292.17 ± 34.12. However, in Apomu, wet and dry seasons' mean ± standard deviation of surface water TDS were 253.10 ± 39.03 and 285.40 ± 58.27 respectively.

Total dissolved solids showed a strong positive correlation across the sampled points in the two seasons in Apomu, while in Ikire, the correlation was strong but negative. The result of Analysis of Variance showed that there was no statistically significant difference in surface water TDS in the two sampled settlements in both dry ($F = 0.387$, $P > 0.05$) and wet ($F = 0.444$, $P > 0.05$) seasons.

Chemical Parameters

pH

The result showed that surface water pH across selected sampled points had a mean ± standard deviation of 8.17 ± 0.90 and 8.40 ± 0.71 in Ikire and Apomu respectively in the wet season while in the dry season, the result indicated that Ikire (8.73 ± 1.19) had a higher pH than Apomu (8.10 ± 0.57). The values recorded at the control points, which is 1 kilometre away from any visible dump site, showed that the pH at the control points were higher than the mean of the three points in dry season while it exhibited a lower value in the wet season.

The pH of the sampled surface water at the point of contact with a dump site, 100 meters upstream and 100 meters downstream showed that there was a very strong positive relationship between pattern of stream flow and surface water pH level in both Ikire ($r = 0.837$) and Apomu ($r = 0.817$) in the wet season while in the dry season, Ikire ($r = 0.897$) exhibited a strong positive correlation between distance from dump site and surface water pH, in Ikire, however, distance had no influence on surface water pH level in the dry season ($r = 0$).

The result of Analysis of Variance between values exhibited at the sampled points in Apomu and Ikire showed that there was similarity in surface water pH characteristics in the dry season ($F = 1.17$, $P > 0.05$), while in the wet season, the result showed that there was difference in the pattern of surface water pH characteristics exhibited by the two settlements ($F = 20.952$, $P < 0.05$).

Sulphate (SO_4^{2-})

Surface water sulphate concentration in Ikire varied between 20.784 and 30.083 mgl^{-1} in the wet season while it had a range of 11.27 mgl^{-1} in the dry season. However, in Apomu, surface water sulphateconcentrationhad a range of 18.708 and 23.705 mgl^{-1} in the wet and dry seasons respectively. Values recorded at the control points at Ikire (10.526 and 13.176 mgl^{-1}) were however higher than the mean recorded for the sampled points in both wet (23.89 mgl^{-1}) and dry (30.01 mgl^{-1}) seasons respectively. Apomu on the other hand, has its control values lower than the mean. The strength of relationship between surface water concentration of sulphate and proximity to sampling points, from a dump site (up and downstream concentration), showed a strong negative correlation in both dry ($r = -0.837$) and wet ($r = -0.867$) seasons in Ikire. In Apomu, the result indicated a relatively strong positive correlation in both wet ($r = 0.877$) and dry ($r = 0.895$) seasons

The result of Analysis of Variance showed that there were similarities in the mean concentration of sulphate between Ikire and Apomu in both wet and dry season ($p > 0.05$).

Chloride (Cl^-)

The mean concentration of chloride in wet and dry seasons were 29.51 and 37.14 mgl^{-1} respectively in Ikire but 24.85 and 23.14 mgl^{-1} respectively in Apomu. The mean values were higher than the values recorded at the control points in both wet (13.0011 mgl^{-1}) and dry (20.4544 mgl^{-1}) season in Ikire. in Apomu, surface water concentration of chloride at the control point was higher in the dry (27.0299 mgl^{-1}) season but lower in the wet (23.9911 mgl^{-1}) season. The strength of relationship between surface water concentration and proximity of sampling points (from a dump site at both sides) in Ikire showed a very strong correlation in both Ikire and Apomu in the wet ($r = -0.868$) and ($r = 0.877$) respectively in the wet season and a very weak negative correlation in Ikire in the dry ($r = -0.142$) season. In Apomu, the result indicated a relatively strong correlation in dry season ($r = 0.624$).

The result of Analysis of Variance showed that there was no statistically significant difference in the mean concentration of surface water chloride between Ikire and Apomu in both wet and dry season ($p > 0.05$).

Phosphate (PO_4^{2-})

The surface water concentration of phosphate in the two sampled settlements, Ikire and Apomu, had a range of 0.5775 mgl^{-1} and 1.5301 mgl^{-1} in the wet season and 0.7219 mgl^{-1} and 1.9201 mgl^{-1} in the dry season respectively. The mean values were higher in the wet season than dry season. The sampled taken a kilometre away from visible dump site (Control) was however higher in in the dry season than wet season in the two settlements.

The concentration of the sampled surface water source at point, 100 meters upstream and 100 meters downstream showed that there was a very strong positive relationship between the pattern of flow of the water body and surface water phosphate concentration in both wet and dry seasons at Apomu ($r = 0.904$ and $r = 0.904$ respectively) but in Ikire, concentration of surface water phosphate was as well strong but negative in relation to the distance from the dump site in both seasons.

The result of Analysis of Variance between values exhibited at the sampled points in Apomu and Ikire showed that there was no statistically significant difference in the level surface water concentration of phosphate in the two communities in both wet ($F = 517$, $P > 0.05$) and dry ($F = 517$, $P > 0.05$) seasons.

Nitrate (NO_3^{2-})

Nitrate concentration in Ikire exhibited a very wide range in both wet (13.836 - 19.553 mgl^{-1}) and dry (12.5906 - 16.2332 mgl^{-1}) seasons. In Apomu, however, the range varied largely from what was observed in Ikire in both seasons. The mean ± standard deviation in Ikire and Apomu were 16.05 ± 3.07 mgl^{-1} and 13.21 ± 9.21 mgl^{-1} respectively in the wet season, while in the dry season, 14.08 ± 1.91 mgl^{-1} and 12.27 ± 9.26 mgl^{-1} were respectively recorded.

The strength of relationship between surface water concentration and proximity of sampling points from a dump site, tested with Pearson correlation showed a very strong positive correlation in Apomu in both wet (r = 0.904) and dry (r = 0.903) season. However, the strength of relationship in Ikire was negative and also strong in the both wet (r = -0.782) and dry (r = -0.736) seasons. The result of Analysis of Variance showed that there was no statistically significant difference in the mean concentration of Nitrate between Ikire and Apomu in both wet and dry season ($p > 0.05$).

Heavy Metals

Cadmium (Cd)

The mean concentration of surface water cadmium was the same (0.01 ppm) in both wet and dry season in the two sampled communities. Cadmium concentration across the sampled points recorded a range of 0.001 and 0.004 in dry season in Ikire and Apomu respectively. However, in the wet season, the range value were 0.003 ppm and 0.013 ppm in Ikire and Apomu respectively. Furthermore, the concentration of surface water cadmium was lower at the control point than the estimated means in wet and dry season in Apomu, but was higher in Ikire in both seasons. The strength of relationship between the concentration of cadmium in surface water source and the distance from a dump site showed a very strong negative correlation in the two settlements in both seasons.

The result of Analysis of Variance showed that there was no statistically significant difference in the mean concentration of surface water cadmium between Ikire and Apomu in both wet and dry season ($p > 0.05$).

Nickel (Ni)

Surface water Nickel concentration, around the sampling points, in Ikire varied between 0.005 ppm and 0.017 ppm in the wet season while it varied between 0.011 ppm and 0.022 ppm in the dry season. But in Apomu, Nickel concentration varied between 0.011 and 0.013 ppm in wet season and 0.008 and 0.02 ppm in dry season. A mean ± standard deviation of 0.01 ± 0.01 and 0.01 ± 0.001 was recorded in wet season in both Ikire and Apomu respectively. However, in the dry season, a mean ± standard deviation of 0.02 ± 0.01 ppm and 0.001 ± 0.001 ppm were recorded. The relationship between surface water nickel concentration and pattern of water flow showed a very strong negative correlation in Ikire in the wet (r = -1.00) and dry (r =-0.988) season. In Apomu, however, the correlation was very weak but positive in the dry season (r = 0.075) and positive in the wet season (r = 0.50). The result of Analysis of Variance showed that there was no statistically significant difference in the mean concentration of Nickel between Ikire and Apomu in both wet and dry season ($p > 0.05$).

Iron (Fe)

The mean concentration of surface water Iron were 0.10 ppm and 0.06 ppm in Ikire and Apomu in the dry season, while in the wet season, 0.10 ppm and 0.05 ppm were recorded in Ikire and Apomu respectively. Iron concentration as well recorded a range of 0.131 and 0.072 in the dry season, while in the wet season the range was 0.014 ppm in both Ikire and Apomu. The strength of relationship between the concentration of iron in surface water source and the distance from a dump site showed a strong negative correlation in Ikire in the wet season (r = -0.985), but in the dry season, the correlation was positive (r = 0.752). In Apomu, the strength of relationship was positive but weak in both wet (r = 0.06) and negative in the dry season (r = -0.619).

The result of Analysis of Variance showed that there was no statistically significant difference in the mean concentration of surface water Iron between Ikire and Apomu in both wet and dry season ($p > 0.05$).

Lead (Pb)

Lead concentration varied between 0.008 and 0.011 ppmin Ikire and between 0.006 and 0.01 ppm in Apomu in the wet season. In the dry season, however, surface water concentration of lead varied between 0.004 and 0.016 ppm; 0.009 and 0.015 ppm in Ikire and Apomu respectively. The mean ± standard deviation was 0.01 ± 0.001 ppm both in Ikire and Apomu in the wet season. In the dry season, the surface water lead concentration had a mean ± standard deviation of 0.01 ± 0.01 and 0.01 ± 0.001 ppmin Ikire and Apomu respectively.

Lead showed a strong positive correlation with distance away from the dump site at both wet (r = 0.655) and dry (r = 0.982) season in Ikire, but there was no relationship between pattern of water flow and surface water concentration in Apomu in the dry season (r = 0). The result of Analysis of Variance showed that there was no statistically significant difference in surface water lead concentration in the two sampled settlements in both dry ($F = 0.767$, $P > 0.05$) and wet ($F = 0.794$, $P > 0.05$) seasons.

Zinc (Zn)

The surface water concentration of zinc in the two sampled settlements, Ikire and Apomu, had a range of 0.054 ppm and 0.012 ppm in the wet season and 0.02and 0.019 ppmin the dry season respectively. The mean values were 0.12 ± 0.01 ppm and 0.10 ± 0.01 ppm in both Ikire and Apomu in the dry season. In the wet season, however, the mean values were 0.11 ± 0.01 ppm and 0.08 ± 0.001 ppm respectively. The concentration of the sampled

surface water at point (0 meters), 100 meters upstream and 100 meters downstream showed that there is a negative relationship between distance from dump site and surface water zinc concentration in both wet and dry seasons at Apomu (r = -0.829 and r = -0.526 respectively) but in Ikire, concentration of surface water zinc were very weak and negative in the wet season (r = -0.069) but positive in the dry season (r = 0.044).

The result of Analysis of Variance between values exhibited at the sampled points in Apomu and Ikire showed that there was no statistically significant difference in the level of surface water concentration of zinc in the two communities in both wet (F = 0.543, P > 0.05) and dry (F = 1.136, P > 0.05) seasons.

Copper (Cu)

The mean surface water concentration of copper were 0.12 ± 0.02 ppm and 0.14 ± 0.06 ppm in both dry and wet season in Ikire, while in Apomu, dry season recorded a higher mean concentration of copper (0.13 ppm) than wet season (0.10 ppm). Copper concentration across the sampled points recorded a range of 0.102 and 0.101 in dry season in Ikire and Apomu respectively. However, in the wet season, the range value were 0.044 ppm and 0.026 ppm in Ikire and Apomu respectively. Furthermore, the strength of relationship between the concentration of copper in surface water source and the distance from a dump site showed a very strong positive correlation in Ikire in the dry season (r = 0.862) while it was weak at other seasons and locations.

The result of Analysis of Variance showed that there was no statistically significant difference in the mean concentration of surface water copper between Ikire and Apomu in both wet and dry season (p > 0.05).

Tables 1 and 2 below represents the descriptive analysis of the selected surface water parameters in the study areas for the wet and dry seasons respectively, while table 3 represents the comparison of surface water characteristics in the study area.

Table 1. Descriptive Analysis of the Selected Surface Water Parameters in the study area in the wet season

Variables	Ikire							Apomu						
	US	Point	DS	Mean	SD	Range	Ctrl	US	Point	DS	Mean	SD	Range	Contro
Ph	7.6	7.7	9.2	8.17	0.90	1.6	8	7.9	8	8.9	8.40	0.71	0.1	7.9
EC	1180.5	998.77	761.82	980.36	209.95	418.68	884.8	902.2	884.8	1120.5	1011.35	154.36	237.7	800.11
TDS	295.1	259.6	190.5	248.40	53.19	104.6	221.2	225.5	221.2	280.7	253.10	39.03	59.5	200.6
SO_4^{2-} (mg/l)	20.811	30.083	20.784	23.89	5.36	9.299	10.526	11.006	10.526	29.234	20.12	12.89	18.708	19.426
Cl^- (mg/l)	25.7081	37.1521	25.6681	29.51	6.62	11.484	13.0011	13.5921	13.0011	36.1041	24.85	15.92	23.103	23.991
PO_4 (mg/l)	1.3976	1.9751	1.4899	1.62	0.31	0.5775	0.4967	0.6352	0.4967	2.0328	1.33	0.99	1.5301	1.4669
NO_3^{2-} (mg/l)	13.8358	19.553	14.7501	16.05	3.07	5.7172	4.9168	6.2889	4.9168	20.1247	13.21	9.78	15.2079	14.521
Cd (ppm)	0.007	0.01	0.003	0.01	0.00	0.003	0.011	0.016	0.011	0.003	0.01	0.01	0.013	0.001
Ni (ppm)	0.011	0.017	0.005	0.01	0.01	0.012	0.012	0.011	0.012	0.013	0.01	0.00	0.002	0.012
Fe (ppm)	0.1	0.114	0.074	0.10	0.02	0.014	0.045	0.06	0.045	0.046	0.05	0.01	0.014	0.172
Pb (ppm)	0.011	0.008	0.01	0.01	0.00	0.013	0.008	0.01	0.008	0.006	0.01	0.00	0.002	0.013
Zn (ppm)	0.117	0.105	0.104	0.11	0.01	0.054	0.092	0.079	0.092	0.08	0.08	0.00	0.012	0.16
Cu (ppm)	0.095	0.122	0.139	0.12	0.02	0.044	0.117	0.091	0.117	0.105	0.10	0.01	0.026	0.172

Table 2. Descriptive Analysis of the Selected Surface Water Parameters in the study area in the dry season

Variables	Ikire							Apomu						
	50 m	100 m	150 m	Mean	S.D	Range	Control	50 m	100 m	150 m	Mean	S.D	Range	Control
pH	7.3	8.9	8.6	8.27	0.85	1.6	7.6	7.5	7.1	7.9	7.50	0.27	0.8	8.9
EC	889.4	674.9	1331.8	965.37	334.97	656.9	933	880.3	891.1	993.2	921.53	47.78	112.9	883
TDS	238.9	300.5	316.6	285.33	41.01	77.7	287.5	260.7	243.1	289	264.27	16.49	45.9	271.9
SO_4^{2-}(mg/l)	25.188	29.8	13.918	22.97	8.17	15.882	35.901	28.728	30.498	29.756	29.66	0.62	1.77	27.552
Cl^- (mg/l)	41.1001	27.9188	38.2982	35.77	6.94	13.182	39.0299	26.9639	28.6254	26.8822	27.49	0.76	1.743	42.1811
PO_4 (mg/l)	1.4582	1.3571	0.4765	1.10	0.54	0.9817	2.6854	1.386	1.2273	1.4726	1.36	0.09	0.2453	1.6314
NO_3^{2-}(mg/l)	10.5094	9.781	4.8277	8.37	3.09	0.9817	19.3541	9.9891	8.8446	10.6134	9.82	0.65	1.7684	11.758
Cd (ppm)	0.014	0.007	0.022	0.01	0.01	0.007	0.013	0.018	0.017	0.014	0.02	0.002	0.004	0.011
Ni (ppm)	0.015	0.01	0.014	0.01	0.00	0.005	0.008	0.004	0.005	0.005	0.005	0.0004	0.001	0.004
Fe (ppm)	0.051	0.164	0.046	0.09	0.07	0.118	0.12	0.143	0.122	0.118	0.13	0.01	0.025	0.132
Pb (ppm)	0.018	0.016	0.011	0.02	0.00	0.007	0.01	0.011	0.01	0.011	0.01	0.0004	0.001	0.008
Zn (ppm)	0.122	0.125	0.133	0.13	0.01	0.011	0.117	0.131	0.124	0.112	0.12	0.01	0.019	0.12
Cu (ppm)	0.216	0.177	0.152	0.18	0.03	0.064	0.166	0.1	0.148	0.101	0.12	0.02	0.048	0.205

Table 3. Comparison of Surface water characteristics in the study area

		Wet					Dry				
					ANOVA					ANOVA	
Parameters	Location	Mean	SD	R	F	P	Mean	SD	R	F	p
pH	Ikire	8.17	0.90	0.837	20.952	0.007	8.73	1.19	0.922	1.71	0.302
	Apomu	8.40	0.71	0.817			8.10	0.57	0		
Conductivity	Ikire	980.36	209.95	-0.564	0.466	0.722	1024.30	137.91	-0.989	1.241	0.405
	Apomu	1011.35	154.36	0.897			994.25	69.79	0.994		
TDS	Ikire	248.40	53.19	-0.65	0.444	0.735	292.17	34.12	-0.629	0.387	0.769
	Apomu	253.10	39.03	0.897			285.40	58.27	0.796		
SO_4^{2-} (mg/l)	Ikire	23.89	5.36	-0.867	0.539	0.681	30.01	6.31	-0.837	0.589	0.654
	Apomu	20.12	12.89	0.877			25.83	15.63	0.895		
Cl^- (mg/l)	Ikire	29.51	6.62	-0.868	0.538	0.681	37.14	13.07	-0.142	1.539	0.335
	Apomu	24.85	15.92	0.877			23.14	14.46	0.624		
PO_4 (mg/l)	Ikire	1.62	0.31	-0.782	0.517	0.693	2.03	0.39	-0.782	0.517	0.693
	Apomu	1.33	0.99	0.904			1.67	1.24	0.904		
NO_3^{2-} (mg/l)	Ikire	16.05	3.07	-0.782	0.517	0.693	14.08	1.91	-0.736	0.635	0.631
	Apomu	13.21	9.78	0.904			12.27	9.26	0.903		

An

Cd (ppm)	Ikire	0.01	0.00	-0.997	1.385	0.369	0.01	0.00	-0.866	0.657	0.62
	Apomu	0.01	0.01	-0.61			0.01	0.01	-0.655		
Ni (ppm)	Ikire	0.01	0.01	-1.00	0.94	0.5	0.02	0.01	-0.988	1.849	0.279
	Apomu	0.01	0.00	0.5			0.01	0.01	0.075		
Fe (ppm)	Ikire	0.10	0.02	-0.985	0.274	0.842	0.10	0.07	0.752	0.807	0.552
	Apomu	0.05	0.01	0.06			0.06	0.05	-0.619		
Pb (ppm)	Ikire	0.01	0.00	0.655	0.794	0.558	0.01	0.01	0.982	0.767	0.569
	Apomu	0.01	0.00	-0.5			0.01	0.00	0		
Zn (ppm)	Ikire	0.11	0.01	-0.069	0.543	0.678	0.12	0.01	0.044	1.136	0.435
	Apomu	0.08	0.00	-0.829			0.10	0.01	-0.526		
Cu (ppm)	Ikire	0.12	0.02	0.383	1.684	0.307	0.14	0.06	0.862	3.013	0.157
	Apomu	0.10	0.01	-0.461			0.13	0.04	-0.404		

overview of the results shows that some of the tested parameters exhibited different patterns of occurrence in the sampled points as they occurred in higher concentrations in sample points farther away from the selected dumpsites. The pH value at the control point was higher than the mean of the three sampled points in the dry season, but exhibited a lower value in the wet season. For sulphate, valoes recorded at the control points at Ikire (10.526 and 13.176 mgl^{-1}) were higher than the mean recorded for the sampled points in both wet (23.89 mgl^{-1}) and dry (30.01 mgl^{-1}) seasons respectively. Cadmium also exhibited a higher concentration value at the control point than the value of the mean concentration of the other three sampling points in Ikire, both in the dry and wet season.

The relationship between the surface water concentration of nickel concentration and water flow pattern showed a very negative correlation in Ikire in the wet season (r= -1.00) and in the dry season (r= -0.988). Iron concentration in surface water samples (Ikire) also exhibited a strong negative correlation with the distance from the dumpsite (r= -0.985), but the correlation was however positive in the dry season (r=0.752). In Apomu, the strength of relationship between iron occurrence and flow of surface water was positive but weak in the wet season (r=0.06)and negative in the dry season (r= -0.619).

The results from the analysis of variance (ANOVA) showed no statistically significant difference ($P > 0.05$) in the pattern of occurrence of all the examined parameters within the study area in both wet and dry seasons, except for pH which exhibited no statistically significant difference in its pattern of occurrence ($f=1.17$, $P=>0.05$) in the study area in the dry season, but exhibited a statistically significant difference in its pattern of occurrence in the ($F=20.952$, $P<0.05$) study area during the wet season.

CONCLUSION

This study was undertaken to examine the spatio-temporal variations in the physical and characteristics of surface water in the study area

Several studies have highlighted that due to leachate formation and its percolation into close by ground and surface water, its concentration is usually higher at this point than areas farther to the source of contamination (from dumpsite), (Mor et al., 2006; Dharmarathne, 2013). Furthermore, for surface water, upstream of the source of contamination usually exhibits a lower concentration of the contaminants, (Kassenga and Mbuligwe,2009; Faure et al,2015). This study concludes that this is not always the case as sulphate concentration in Apomu occurred higher at the upstream sampling point ($14.777mgl^{-1}$) than at the point of contact with the dumpsite ($13.176mgl^{-1}$) in the dry season and 11.006 (upstream) and 10.526 (point) in the wet season. Similarly, lead also exhibited a similar pattern of occurrence in Ikire where the concentration was 0.008 at the upstream and 0.004 at the point of contact with the dumpsite in the dry season; The concentration of lead was also higher at 0.01 ppm (upstream) than 0.008 ppm (point of contact) during the wet season.

The United States Environmental Protection Agency (2023) has set the maximum contaminant level goal for lead in drinking water at zero because lead is a toxic metal that can be harmful to human health even at low exposure levels. Lead is persistent, and it can bioaccumulate in the body over time. Young children, infants, and fetuses are particularly vulnerable to lead because the physical and behavioral effects of lead occur at lower exposure levels in children than in adults. A dose of lead that would have little effect on an adult can have a significant effect on a child. In children, low levels of exposure have been linked to damage to the and peripheral nervous system, learning disabilities, shorter stature, impaired hearing, and impaired formation and function of blood cells. Going by these assertions made by USEPA, this study concludes that the surface water in the study area has been contaminated because of the occurrence of lead at all the sampling points throughout the duration of the study.

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