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Impact of Dumpsites on Groundwater Contamination in Selected Settlements in Irewole and Isokan Local Government areas, Osun State, Nigeria

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ABSTRACT

This study examined the spatio-temporal variation in the physico- chemical characteristics of ground water across the study area. This was with a view to determining the impact of dumpsites on ground 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 picked, 1 km away from any noticeable dumpsite. The water samples were analyzed for physical and chemical parametersaccording to APHA, 1992 standard. 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 ground water pH values between the two communities in both wet ($F = 0.102$, $P > 0.05$) and dry ($F = 0.471$, $P > 0.05$) season.

The result showed that the distance of the sample points to the dumpsite did not have a direct influence on water quality in that some parameters that were tested were found to exist more in the control samples than in the mean of the experimental samples. The results also showed that some of the tested parameters existed in higher quantities than both Nigerian and WHO standards for drinking water quality. The study concludes that the dumpsites in the study area has led to contamination of ground water as a result of leachate percolation from the dumpsites.

Keywords: Dumpsites, groundwater, physico-chemical characteristics, spatio-temporal variation, leachate

I. Introduction

Waste is often defined as any material that is considered to be of no further use to the owner and is, hence, discarded (Ojoawo*et al.,* 2011). It may also be referred to as substances or objects which are disposed of or intended to be disposed of or are required to be disposed of according to the provision of a national law (Bakare, 2009). Waste can exist in either solid, liquid or gaseous forms. Solid waste includes categories of household, municipal, commercial and industrial use could be hazardous and toxic (EPDA, 2001) either at its present state or upon decomposition. The composition and quality of waste produced 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). Solid waste management is the supervised handling of waste materials from generation, separation, storage, collection, transportation, treatment to its proper disposal (Zhang *et al*, 2010); therefore, the inability to sustainably maintain these key factors will result in defective and improper waste management (Awopetu*et al.,*2014). There are three major ways of waste management; landfill, incineration and production of compost. However, in most developing countries, waste management poses a serious issue due to poor environmental practice, urbanization, industrialization and increased population (Adeyemo, 2003). Dumping of waste into the nearest open space on land and water bodies has been the principal disposal method for both industrial and domestic waste (Oyeku and Eludoyin, 2015). This method of waste disposal is seen as the cheapest means of waste disposal method by the populace (Nas and Jaffe, 2004). In landfills and open dump sites, the waste is exposed to precipitation which extracts contaminants from it as leachate.

Leachate is formed when water from rain or from the waste itself percolates through the waste and causes solubilization of organic and inorganic constituents of the waste through physical, biological and chemical processes (Robinson and Maris, 1979; Kjeldsen *et al.,* 2002). The amount of leachate generated depends on the 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 like composition and type of waste, waste compaction, particle size, soil moisture, type of microorganisms, temperature of the waste, climate, site operating procedures, age of the dumpsite and hydrogeology of the site (Lee, 2010). The chemicals present in leachates may be assimilated by aquatic species, pass through the food chain, and bioaccumulate upon long term exposure. Several experimental studies using microbial, plant, animal and human cells have shown the potential of leachate to induce acute, chronic and genetic toxicity (Bakare, 2009). Some studies have also shown excesses of birth defects, low birth weight children, liver damage, respiratory problems and certain cancers in human populations around some hazardous waste sites (Bakare, 2009). The United Nations Environmental Programme (UNEP, 2006) observed that in the past two to three decades, rapid urbanization across Africa has led to the growth of large areas of unplanned sub-standard housing in most cities and those residents of such cities or areas usually resort to groundwater as a source of inexpensive, quality domestic water supply. The study further revealed that the uncontrolled expansion of this kind of housing together with sewage and effluent leakage, indiscriminate waste disposal and uncontrolled industrial and commercial activities all led to the increasing pollution and deteriorating quality of groundwater and mounting public health problems. The specific objective of this study is therefore aimed at examining the spatio-temporal variation in the physical and chemical characteristics of ground water sources across 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 was randomly 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).

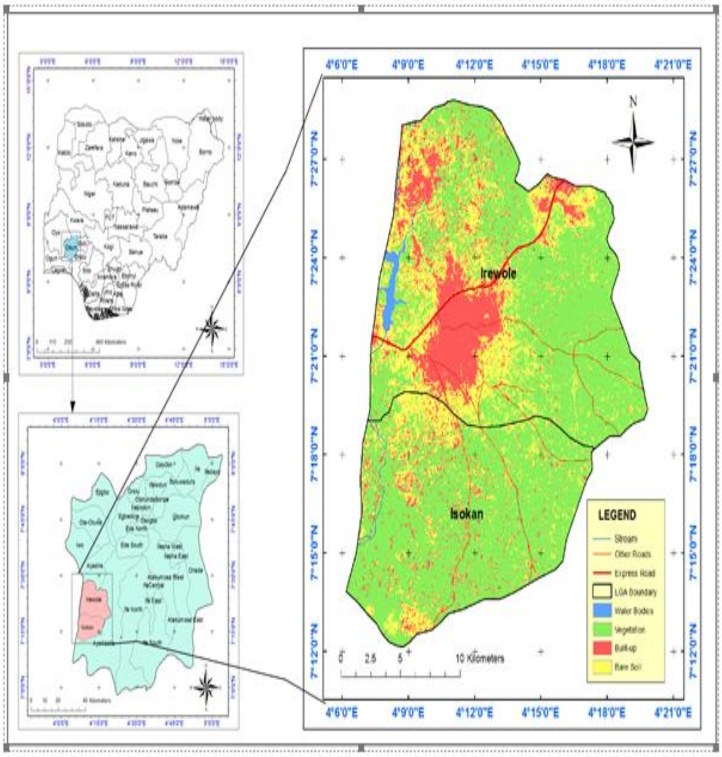

Figure 1: map of Nigeria, Osun state and Irewole and Isokan Local Government Areas

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 is home to one of the campuses of the Osun State University is experiencing its own share of population growth, hence there is always the likelihood of waste management challenges in both Ikire and Apomu which is a neighboring 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 samples were taken twice, between the months of February and August, . The first sample which was taken in February, represents the dry season situation of ground water quality in the study area. While samples taken in July, at the mid of wet season represented the wet season situation of water quality due to the influence of leachate percolation.

The ground water samples were taken from wells within 150 meters proximity of the dumpsites. The ground water samples were collected at the wells using 1 litre high density polyethylene bottles. The sampling bottles were rinsed twice with the water before sampling was done at each site. Water samples were taken from a well at every 50 meters (i.e. 0-50m, 51-100m and 100-150m) within the 150 meters proximity of the dumpsite. This was done in order to assess the spatial variation in ground water quality due to leachate movement. A control point was purposely picked 1km away from any noticeable dumpsite. Consequently, in dry season (February), eight ground water samples were taken, four from each of the study locations. This sampling technique was replicated for wet season (July).

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 ground 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 was 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 sampled points for both surface and ground water, 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 both ground and surface water, in relation to distance away from the dump site.

III. Results and Discussion

Descriptive analysis of selected ground water parameters in both wet and dry season in the Study Area

Table 1: Descriptive analysis of selected ground water parameters in wet season in Ikire

Parameters	Variables	Ikire						
		50 m	100 m	150 m	Mean	S.D	Range	Control
Physical	pH	8.3	8.4	7.8	8.17	0.32	0.6	8.5
	EC	766.33	886.8	1115.9	923.01	177.58	349.57	810.06
	TDS	198.9	265.8	278.5	247.73	42.76	79.6	252.3
Chemical	SO_4^{2-}(mg/l)	20.018	23.863	10.751	18.21	6.74	13.112	28.546
	Cl^- (mg/l)	247.231	294.711	238.541	260.16	30.24	1.5708	352.551
	PO_4 (mg/l)	2.3332	2.1714	0.7624	1.76	0.86	1.409	4.2966
	NO_3^{2-}(mg/l)	57.744	53.742	18.867	43.45	21.38	34.875	106.341
	Cd (ppm)	0.008	0.004	0.019	0.01	0.01	0.004	0.006
	Ni (ppm)	0.008	0.006	0.021	0.01	0.01	0.002	0.007
	Fe (ppm)	0.073	0.114	0.219	0.14	0.08	0.146	0.097
	Pb (ppm)	0.012	0.009	0.017	0.01	0.00	0.003	0.007
	Zn (ppm)	0.11	0.12	0.139	0.12	0.01	0.029	0.121
	Cu (ppm)	0.13	0.129	0.111	0.12	0.01	0.001	0.127

Descriptive analysis of selected ground water parameters in dry season in Ikire

Table 2: Descriptive analysis of selected ground water parameters in wet season in Apomu

Parameters	Variables	Apomu						
		50 m	100 m	150 m	Mean	S.D	Range	Control
Physical	pH	7.8	7.6	8.2	7.87	0.31	0.6	7.9
	EC	885.9	816.6	1000.1	900.87	92.66	193.5	892.8
	TDS	226.7	210.6	250.8	229.37	20.23	40.2	223.6
Chemical	SO_4^{2-}(mg/l)	22.982	24.398	23.001	23.46	0.81	1.416	21.793
	Cl^- (mg/l)	283.831	301.321	284.061	289.74	10.03	17.69	269.151
	PO_4 (mg/l)	2.2176	1.9636	2.3562	2.18	0.20	0.3926	2.6102
	NO_3^{2-}(mg/l)	54.8855	48.5965	58.3155	53.93	4.93	9.719	64.6045
	Cd (ppm)	0.012	0.012	0.011	0.01	0.001	0.001	0.005
	Ni (ppm)	0.008	0.008	0.013	0.01	0.003	0.005	0.009
	Fe (ppm)	0.104	0.093	0.099	0.10	0.01	0.011	0.088
	Pb (ppm)	0.008	0.006	0.007	0.01	0.001	0.002	0.005
	Zn (ppm)	0.111	0.109	0.093	0.10	0.01	0.018	0.099
	Cu (ppm)	0.088	0.1	0.091	0.09	0.01	0.009	0.144

Descriptive analysis of selected groundwater parameters in the wet season in Ikire and Apomu are presented in tables 1 and 2 respectively; that for the dry season for Ikire and Apomu are presented in tables 3 and 4 respectively, while the comparison of Ground water characteristics in Ikire and Apomu is presented in table 5.

Table 3: Descriptive analysis of selected ground water parameters in dry season in Ikire

Parameters	Variables	Ikire						
		50 m	100 m	150 m	Mean	S.D	Range	Control
Physical	pH	7.3	8.9	8.6	8.27	0.85	1.6	7.6
	EC	889.4	674.9	1331.8	965.37	334.97	656.9	933
	TDS	238.9	300.5	316.6	285.33	41.01	77.7	287.5
Chemical	SO_4^{2-}(mg/l)	25.188	29.8	13.918	22.97	8.17	15.882	35.901
	Cl^- (mg/l)	41.1001	27.9188	38.2982	35.77	6.94	13.182	39.0299
	PO_4 (mg/l)	1.4582	1.3571	0.4765	1.10	0.54	0.9817	2.6854
	NO_3^{2-}(mg/l)	10.5094	9.781	4.8277	8.37	3.09	0.9817	19.3541
	Cd (ppm)	0.014	0.007	0.022	0.01	0.01	0.007	0.013
	Ni (ppm)	0.015	0.01	0.014	0.01	0.00	0.005	0.008
	Fe (ppm)	0.051	0.164	0.046	0.09	0.07	0.118	0.12
	Pb (ppm)	0.018	0.016	0.011	0.02	0.00	0.007	0.01
	Zn (ppm)	0.122	0.125	0.133	0.13	0.01	0.011	0.117
	Cu (ppm)	0.216	0.177	0.152	0.18	0.03	0.064	0.166

Table 4: Descriptive analysis of selected ground water parameters in dry season in Apomu

Parameters	Variables	Apomu						
		50 m	100 m	150 m	Mean	S.D	Range	Control
Physical	pH	7.5	7.1	7.9	7.50	0.27	0.8	8.9
	EC	880.3	891.1	993.2	921.53	47.78	112.9	883
	TDS	260.7	243.1	289	264.27	16.49	45.9	271.9
Chemical	SO_4^{2-}(mg/l)	28.728	30.498	29.756	29.66	0.62	1.77	27.552
	Cl^- (mg/l)	26.9639	28.6254	26.8822	27.49	0.76	1.743	42.1811
	PO_4 (mg/l)	1.386	1.2273	1.4726	1.36	0.09	0.2453	1.6314
	NO_3^{2-}(mg/l)	9.9891	8.8446	10.6134	9.82	0.65	1.7684	11.758
	Cd (ppm)	0.018	0.017	0.014	0.02	0.002	0.004	0.011
	Ni (ppm)	0.004	0.005	0.005	0.005	0.0004	0.001	0.004
	Fe (ppm)	0.143	0.122	0.118	0.13	0.01	0.025	0.132
	Pb (ppm)	0.011	0.01	0.011	0.01	0.0004	0.001	0.008
	Zn (ppm)	0.131	0.124	0.112	0.12	0.01	0.019	0.12
	Cu (ppm)	0.1	0.148	0.101	0.12	0.02	0.048	0.205

pH

The ground water pH across the three selected sampled points, i.e. 50m (7.3 and 7.8), 100m (8.9 and 7.6) and 150m (8.6 and 8.2), had a mean ± standard deviation of 8.17 ± 0.32 and 7.87 ± 0.31 in Ikire and Apomu respectively, in the wet season. In the dry season, the result indicated that Ikire (8.27 ± 0.85) had a higher mean pH than Apomu (7.50 ± 0.27). However, the values recorded at the control points, which is 1 kilometre away from any visible dump site, showed that the pH was higher than the mean of the three points in wet season while it exhibited a lower value in the dry season.

The pH of the sampled ground water source at 50, 100 and 150 meters showed that there was a weak correlation between distance from dump site and water pH level in both Ikire ($r = 0.157$) and Apomu ($r = 0.371$) in the wet season while in the dry season, ground water pH in Apomu ($r = 0.897$) exhibited a strong positive correlation with distance from dump site and ground water pH, in Ikire, however, showed a negative correlation ($r = -0.051$).

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 ground water pH values between the two communities in both wet ($F = 0.102$, $P > 0.05$) and dry ($F = 0.471$, $P > 0.05$) season.

Electrical Conductivity (EC)

Electrical conductivity varied between 766.33 and 1115.9 µScm^{-1} in Ikire and between 816.6 and 100.1 µScm^{-1} across the sampled points in Apomu in the wet season. In the dry season, however, ground water electrical conductivity varied between 674.9 and 1331.8 µScm^{-1}; 880.3 and 993.2 µScm^{-1} in Ikire and Apomu respectively. The mean ± standard deviation was 923.01 ± 117.58 and 900.87 ± 92.66 µScm^{-1} in Ikire and Apomu respectively in the wet season, and 965.37 ± 334.97 and 921.53 ± 47.78 µScm^{-1} in Ikire and Apomu respectively in the dry season.

Electrical conductivity showed a weak positive 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 ground water conductivity in the two sampled settlements in both dry ($F = 2.54$, $P > 0.05$) and wet ($F = 4.738$, $P > 0.05$) seasons.

Total Dissolved Solids (TDS)

The range and mean ± standard deviation of ground water TDS in Ikire were 79.6 and 247.73 ± 42.76 respectively in the wet season. In the dry season, ground water TDS varied between 238.9 and 316.6 with a mean ± standard deviation of 285.33 ± 41.01. However, in Apomu, wet and dry seasons' mean ± standard deviation of ground water TDS were 229.37 ± 20.23 and 264.27 ± 16.49.

Total dissolved solids showed a positive correlation with distance away from the dump site at both stations in the two seasons. The result of Analysis of Variance, therefore, showed that there was no significant difference in the ground water TDS in the two sampled settlements in both dry ($F = 2.54$, $P > 0.05$) and wet ($F = 4.738$, $P > 0.05$) seasons.

Sulphate (SO_4^{2-})

Ground water sulphatein Ikire varied between 10.752 and 20.018 mgl^{-1} in the wet season while it had a range of 15.882 mgl^{-1} in the dry season. In Apomu, ground water sulphatehad a range of 1.416 and 1.57 mgl^{-1} in the wet and dry seasons respectively. Values recorded at the control points at Ikire

(28.546 and 35.901 mgl^{-1}) were however higher than the means in both wet (22.97 mgl^{-1}) and dry (18.21 mgl^{-1}) seasons respectively. Apomu on the other hand, has its control values lower than the mean. The strength of relationship, tested using Pearson correlation, between ground water concentration of sulphate and proximity of sampling points from a dump site showed a weak positive correlation in both dry (r = 0.375) and wet (r = 0.362) seasons. In Apomu, the result indicated a relatively strong negative correlation in both wet (r = -0.684) and dry (r = -0.567) seasons

The result of Analysis of Variance showed that there was no statistically significant difference in the mean concentration of SO_4^{2-} between Ikire and Apomu in both wet and dry season (p > 0.05).

Chloride (Cl^-)

The mean concentration of chloride in wet and dry season were 260.16 and 35.77 mgl^{-1} respectively in Ikire and 289.74 and 27.49 mgl^{-1} in Apomuaswell. The mean concentration were lower than the concentration at the control points in both wet (260.16 mgl^{-1}) and dry (35.77 mgl^{-1}) season in Ikire, while in Apomu, ground water concentration of chloride at the control point recorded lower in dry (27.49 mgl^{-1}) season but higher in the wet (289.74 mgl^{-1}) season. The strength of relationship between ground water concentration and proximity of sampling points from a dump site in Ikire showed a very strong correlation in wet (r = 0.742) and a very weak positive correlation in dry (r = 0.150) season. In Apomu, the result indicated a relatively strong negative correlation in both wet (r = -0.684) and a very strong positive correlation in dry (r = 0.871) season.

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

Phosphate (PO_4^{2-})

The ground water concentration of phosphate in the two sampled settlements, Ikire and Apomu, had a range of 1.409 mgl^{-1} and 0.3926 mgl^{-1} in the wet season and 0.9817 mgl^{-1} and 0.2453 mgl^{-1} in the dry season respectively. The mean values were higher in the wet season than dry season. The samples taken a kilometre away from visible dump site (control) was however higher in both wet and dry seasons in the two settlements.

The concentration of the sampled ground water source at 50 meters, 100 and 150 meters showed that there was a very strong positive relationship between distance from dump site and ground water phosphate concentration in both wet and dry seasons at Apomu (r = 0.801 and r = 0.801 respectively) but in Ikire, concentration of ground water phosphate was mildly strong 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 is no statistically significant difference in the level ground water concentration of phosphate in the two communities in both wet (F = 1.89, P > 0.05) and dry (F = 1.89, P > 0.05) seasons.

Nitrate (NO_3^{2-})

Nitrate concentration in Ikire exhibited a very wide range in both wet (18.867 - 57.744 mgl^{-1}) and dry (4.828 - 10.509 mgl^{-1}) seasons. The ground water concentration of Nitrate decreased with distance away from the dump site in Ikire. 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 43.45 ± 21.38 mgl^{-1} and 53.93 ± 4.93 mgl^{-1} respectively in the wet season, while in the dry season, 8.37 ± 3.09 mgl^{-1} and 9.82 ± 0.65 mgl^{-1} were respectively recorded.

The strength of relationship between ground water concentration and proximity of sampling points from a dump site, tested with Pearson correlation, showed a strong positive correlation in Apomu in both wet (r = 0.801) and dry (r = 0.801) season. However, the strength of relationship in Ikire was not so strong in the two 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).

Cadmium (Cd)

The mean concentration of ground water cadmium was the same (0.01 ppm) in both wet and dry season in Ikire, while in Apomu, dry season recorded a higher concentration of cadmium (0.02 ppm) than wet season (0.01 ppm). Cadmium concentration across the sampled points recorded a range of 0.002 and 0.004 in dry season in Ikire and Apomu respectively. However, in the wet season, the range was 0.004 ppm and 0.001 ppm in Ikire and Apomu respectively. Furthermore, the concentration of ground water cadmium was lower at the control points in the wet season, while in the dry season, the concentration was higher in Ikire (0.013) but lower in Apomu (0.011). The strength of relationship between the concentration of cadmium in ground water source and the distance from a dump site showed a very strong negative correlation in Apomu in both dry (r = -0.928) and wet season (r = -0.988), but in Ikire, there was a very weak positive relationship in wet (r = 0.036) and dry (r = 0.158) season.

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

Nickel (Ni)

Ground water Nickel, across the sampling points, in Ikire varied between 0.006 ppm and 0.021 ppm in the wet season while it varied between 0.010 ppm and 0.015 ppm in the dry season. But in Apomu, Nickel concentration varied between 0.008 and 0.013 ppm in wet season and 0.004 and 0.005 ppm in dry season. A mean ± standard deviation of 0.01 ± 0.01 and 0.01 ± 0.003 was recorded in wet season in both Ikire and Apomu respectively. However, in the dry season, a mean ± standard deviation of 0.01 ± 0.001 ppm and 0.005 ± 0.0004 ppm were recorded. The relationship between ground water concentration and distance at which samples were taken showed a strong negative correlation in Ikire in the dry season (r = -0.724), while in the wet season, the correlation between between ground water concentration and distance at which samples was very weak (r = 0.069). In Apomu however, the correlation was weak in both wet (r = -0.287) and dry (r = -0.169) season. 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 ground water Iron were 0.09 ppm and 0.13 ppm in Ikire and Apomu in the dry season, while in the wet season, 0.14 ppm and 0.10 ppm were recorded in Ikire and Apomu respectively. The ground water iron concentration as well recorded a range of 0.118 and 0.025 in the dry season, while in the wet season the range were 0.146 and 0.011 in Ikire and Apomu respectively. The strength of relationship between the concentration of iron in ground water source and the distance from a dump site showed a very strong negative correlation in Apomu in the wet season (r = -0.811), but in the dry season, the correlation was weak (r = -0.266). In Ikire, the strength of relationship was positive but weak in both dry (r = 0.237) and wet season (r = 0.181).

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

Lead (Pb)

Lead concentration varied between 0.009 and 0.017 ppmin Ikire and between 0.006 and 0.008 ppm in Apomu in the wet season. In the dry season, however, ground water lead concentration varied between 0.011 and 0.018 ppm; 0.010 and 0.011 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 ground water lead concentration had a mean ± standard deviation of 0.02 ± 0.001 and 0.01 ± 0.0004 ppmin Ikire and Apomu respectively.

Lead showed a very strong negative correlation with distance away from the dump site at both stations in the two seasons except at Ikire in the dry season, where the correlation was weak (r = -348). The result of Analysis of Variance showed that there was no statistically significant difference in ground water concentration of lead in the two sampled settlements in both dry (F = 1.03, P > 0.05) and wet (F = 0.879, P > 0.05) seasons.

Zinc (Zn)

The ground water concentration of zinc in the two sampled settlements, Ikire and Apomu, had a range of 0.029 ppm and 0.018 ppm in the wet season and 0.011and 0.019 ppmin the dry season respectively. The mean values were 0.13 ± 0.01 ppm and 0.12 ± 0.01 ppm in Ikire and Apomu respectively in the dry season. In the wet season, however, the mean values were 0.12 ± 0.01 ppm and 0.10 ± 0.01 ppm respectively. The concentration of the sampled ground water source at 50 meters, 100 and 150 meters showed that there is a positive relationship between distance from dump site and the concentration of zinc in ground water in both wet and dry seasons at Apomu (r = -0.69 and r = -0.597 respectively) but in Ikire, concentration of zinc in ground water source was mildly strong 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 of ground water concentration of zinc in the two communities in both wet (F = 0.051, P > 0.05) and dry (F = 0.351, P > 0.05) seasons.

Copper (Cu)

The mean concentrations of ground water copper were 0.18 ± 0.03 ppm and 0.12 ± 0.01 ppm in both dry and wet season in Ikire. In Apomu, dry season recorded a higher concentration of copper (0.12 ppm) than wet season (0.09 ppm). Copper concentration across the sampled points recorded a range of 0.064 and 0.048 in dry season in Ikire and Apomu respectively. However, in the wet season, the range value were 0.001 ppm and 0.009 ppm in Ikire and Apomu respectively. Furthermore, the concentration of ground water copper was higher at the control points in the wet season than the dry season. The strength of relationship between the concentration of copper in ground water source and the distance from a dump site showed a very strong positive correlation in Apomu in both wet (r = 0.884) and dry season (r = 0.788), but in Ikire, there was a slight relationship in wet (r = -0.235) season, but in dry season, the correlation was negative and strong (r = -0.705).

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

Table 5: Comparison of ground water characteristics in Ikire and Apomu

Parameters	Wet						Dry				
					ANOVA					ANOVA	
	Location	Mean	SD	R	F	P	Mean	SD	R	F	p
pH	Ikire	8.17	0.32	0.157	0.102	0.955	8.27	0.85	-0.051	0.471	0.719
	Apomu	7.87	0.31	0.371			7.50	0.27	0.897		
Conductivity	Ikire	923.01	177.58	0.12	4.738	0.084	965.37	334.97	0.263	2.54	0.195
	Apomu	900.87	92.66	0.247			921.53	47.78	0.094		
TDS	Ikire	247.73	42.76	0.501	1.325	0.383	285.33	41.01	0.481	1.604	0.322
	Apomu	229.37	20.23	0.129			264.27	16.49	0.46		
SO_4^{2-} (mg/l)	Ikire	18.21	6.74	0.362	1.07	0.456	22.97	8.17	0.375	0.913	0.51
	Apomu	23.46	0.81	-0.684			29.66	0.62	-0.567		
Cl^- (mg/l)	Ikire	260.16	30.24	0.742	0.909	0.512	35.77	6.94	0.15	1.227	0.409
	Apomu	289.74	10.03	-0.684			27.49	0.76	0.871		
PO_4 (mg/l)	Ikire	1.76	0.86	0.557	1.89	0.272	1.10	0.54	0.557	1.89	0.272
	Apomu	2.18	0.20	0.801			1.36	0.09	0.801		
NO_3^{2-} (mg/l)	Ikire	43.45	21.38	0.557	1.89	0.272	8.37	3.09	0.615	1.998	0.257
	Apomu	53.93	4.93	0.801			9.82	0.65	0.801		
Cd (ppm)	Ikire	0.01	0.01	0.036	1.791	0.288	0.01	0.01	0.158	0.783	0.562
	Apomu	0.01	0.001	-0.928			0.02	0.002	-0.988		
Ni (ppm)	Ikire	0.01	0.01	0.069	4.889	0.08	0.01	0.001	-0.724	0.191	0.898
	Apomu	0.01	0.003	0.287			0.005	0.001	-0.169		
Fe (ppm)	Ikire	0.14	0.08	0.181	1.077	0.453	0.09	0.07	0.237	0.782	0.563
	Apomu	0.10	0.01	-0.811			0.13	0.01	-0.266		
Pb (ppm)	Ikire	0.01	0.00	-0.348	0.876	0.524	0.02	0.00	-0.922	1.03	0.469
	Apomu	0.01	0.001	-0.832			0.01	0.001	-0.828		
Zn (ppm)	Ikire	0.12	0.01	0.396	0.051	0.983	0.13	0.01	-0.313	0.351	0.792
	Apomu	0.10	0.01	-0.69			0.12	0.01	-0.597		
Cu (ppm)	Ikire	0.12	0.01	-0.235	1.056	0.46	0.18	0.03	-0.705	0.512	0.695
	Apomu	0.09	0.01	0.884			0.12	0.02	0.788		

An overview of the result showed that these parameters exhibited different and unusual patterns of occurrence in the sampled points, as some of the parameters occurred in higher concentrations in sample points farther away from the dumpsites. This is contrary to the opinion 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). In this study, water pH values for both ground and surface water were within the alkaline/base pH threshold (pH > 7). The pH values recorded were within the World Health Organization (WHO) and Nigeria's standard of 6.5 - 8.5 pH for water quality. Electric conductivity was higher in the water sample than Nigeria water quality standards at 150m mark in both settlements in the wet season, but in the dry season it only exhibited high concentration at 150m mark in Ikire.

Total dissolved solids (TDS) also exhibited a similar pattern as its value was higher at 150 meters (away from the dumpsite) in the two settlements in both seasons. However, the result further suggest that TDS is within the WHO water quality standard for TDS. The tested anions (Cl^-, SO^{2-}_4, NO_3, and PO_4) were in some cases higher at the control points than other sampled areas. These higher concentrations, recorded at the control points may be the effect of some land use activities taking place around the control point area. The mean concentration of all the tested anions, were higher in Ikire than Apomu in both dry and wet season, this implies that further studies on the rock and soil characteristics may be required to ascertain the reason for this variation as the two settlements are adjacent to each other. The concentration of all the sampled anions was higher in the wet season than dry. Also, the concentration of the tested anions was lower than the WHO and Nigeria's standard of water quality in the dry season, but in the wet season, ground water Chloride and Nitrate were higher than the WHO and Nigeria's standard for ground water quality.

In this study, the heavy metals occurred within the narrow range of 0.00 and 0.216 mgl^{-1}, with their respective seasonal mean concentrations higher in the dry season than wet season, this is probably due to evaporation and salt accumulation effect. Lead which is known to cause cancer and as well interfere with vitamin D metabolism in the human body, recorded a high concentration at the 100m mark Ikire in the dry season than both the WHO and Nigerian standard, of 0.01ppm, for water quality. Iron, on the other hand, known for its aesthetic and organoleptic effects rather than toxicologic ones, which tends to impact tenacious and objectionable stains to laundry and plumbing fixing in the two sampled settlements occurred in all the sampled points, less than 0.3mgl/lwhich is the WHO and Nigeria's threshold for water quality. Other sampled heavy metals were also lower than the WHO and Nigeria's tolerable level for water quality.

Conclusion

This study was undertaken toexamine the spatio-temporal variation in the physical and chemical characteristics of ground water sources in selected settlements of Irewole and Isokan Local Government areas of Osun State. The result showed that the ground water in the study area is contaminated as some of the tested physical and chemical parameters were above the threshold of water quality standards. These parameters include chlorides. nitrates and lead which occurred in some points at concentrations higher than both WHO and Nigeria Standards for water quality, and electric conductivity which occurred at the 150m mark in concentrations that are higher than that specified in the Nigeria water quality standards. This is however not uncommon as recent studies across the world have shown that both surface and groundwater quality is under pollution threats fromgeology and the geochemistry of the environment, rateof urbanization, landfill/dumpsite leachates, heavymetals, organic matters and influence of seasons (Scott, 2016). All the same, thisportends danger of health hazard of utilizing the ground water sources for drinking and other domestic use, without any form oftreatment. This calls forappropriate measures to protectand remedy polluted groundwater for safety purposes.

From this study, we have established that water samples collected far away from the dumpsites (control) have similar concentrations compared to those from the vicinity of the dumpsites. Perhaps, this could be as a result of past activities that might have taken place in the areas where the control point samples were taken. Also, the geology and soil of the study area might have as well influenced the high values at the control point. Further studies will be however required to ascertain the reason for this unusual similarity.

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