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INDUSTRIAL WASTE MANAGEMENT PRACTICES IN KADUNA METROPOLIS, KADUNA STATE, NIGERIA (*Vernoniaamygdalina & Allium sativum extracts*)

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ABSTRACT

This paper examined industrial waste management practices in Kaduna Metropolis, Kaduna State, Nigeria. A mixed method was used in carrying out the study as it involved surveys as well the use of GIS for site suitability. A total of 200 copies of the questionnaire were administered by adopting simple random sampling and used for the analysis. A simple lab test was conducted and findings revealed that there is a wide variation in the levels of zinc and nickel availability, though within the standards for drinking water, suggesting a change in water quality at various locations. High mercury levels in one of the samples are a reason for concern. It was recommended based on the findings amongst others that awareness and education regarding appropriate waste management, including collection and disposal, is essential for all construction workforces and should be provided by firms, in conjunction with the industry, The study recommends that the Kaduna State Government should consider measures, such as the introduction of regulatory policy, including site waste management plan (SWMP), Pay-As-YouThrow (PAYT), and landfill ban to divert material wastes from landfills. PPUV is a Pay-Per-Unit volume of waste generated and its purpose is to reduce waste and encourage reuse and recycling management of industries needs to change the misconception that landfilling is a cheaper option when compared to reuse and recycling. The design team should adopt effective design minimization measures, while other professionals are to ensure efficient waste reduction approaches.

Keywords: Management, PAYT, PPUV, Water, Dumpsite

INTRODUCTION

The issue of industrial wastes has become one of the most crucial matters confronting society in general and industries in particular. Public concern on these issues continued to be expressed daily through the media, such as the newspapers, radio and the television. Advocates of environmental protection have drawn the attention of the national policy-makers to the health hazards and potential dangers to natural resources caused by the inadequate management of wastes (Olanrewaju, 2000; Palczynski, 2002). There is a wide variation in both the physical and chemical nature of wastes as one goes from one industry to the other. Waste management is a serious environmental problem that has been the subjects of several studies, conferences, strategic meetings and debates. Its importance lies in its visibility and clear intrusion in the daily lives of people, as well as the numerous secondary result of its negligence, which account for the global and national attempts to improve waste management.

The scientist has spent much time to analyse various stages of waste control system, which is applicable to today's waste generation and disposal means. Waste cannot be eliminated totally from environment as long as production and other engineering activities continue. Waste has been a result of man's activities from his earliest civilization, made more prominent during the industrial revolution, intensified by technology developments of the twentieth century and given political and economic exposure by the passage of solid waste Act of 1965. Waste must be properly managed in a way that minimizes risk to human health and reduce its negative impact on the environment. Just as a botanist regards a weed as a plant in a wrong place, so also waste is a resource in wrong place (Ajero and Ukaga, 2006). Waste is a resource in the sense that if properly managed, can serve as raw material for some industries e.g. Aluminium Industries, rubber and plastic making industries etc. Putting waste in holes for burial as a sanitary landfill has been said that is tantamount to inefficient management of materials (Ayotamuno and Gado, 2000).

All waste generated could be consumed, by serving as raw materials either in the same process or other processes. That is the waste must be recycled or simply used or converts to useable products by another industrial set-up as source of raw material. In destruction however, the wastes simply have to be got rid of in a way that will, as much as possible, of good use to humanity and its environment. Many factories in Kaduna are located on the river banks and use the rivers as open sewers for their effluents.

All industries produce solid wastes and wastewater or effluents in varying quantities and conditions and the accumulation of these solid wastes in heaps at dumping sites or discharge of wastewater and effluents on the soil or streams create pollution in a very short time. Therefore, industries join municipalities in contributing to the cultural damaging of the human environment. As these wastes are necessary end product of industries, the only solution to abating their nuisance effects is satisfactory waste management treatment and disposal methods.

This research thus examines industrial waste management practices in Kaduna metropolis of Kaduna state. More specifically, this research is aimed at answering the following questions

i. What are the effects of industrial waste on soil and water in the study area?

ii. Does the MSW sites meets the suitable standard?

This will be achieved through the following objectives which are to;

i. examine the effects of industrial waste on soil and water in the study area
ii. examine the extent to which suitability does compare to existing MSW dumpsites

MATERIALS AND METHODS

The Study Area

Kaduna metropolis is located between latitude 10° 28' 58" and 10° 37' 46" North and longitude 07° 19' 53" and 07° 31' 56" East and occupies an area of about 260km^2. The distance between the eastern and western limits of the city is approximately 13.7KM (Fingesi, 2001). Kaduna south is located between latitude 10° 27' 42" and 10° 26' 57" North and longitude 07° 25' 37" and 07° 25' 49" East (Jeb, 2012) (See Figure 1). As a result of the rapid urbanization and population growth, human activities are on the increase industries of varying scales are erupting thereby generating more volume of waste which if not properly managed, can affect man and his immediate environment. Therefore there is need to know the kind of waste generated by these industries and their method of waste management and disposal and mitigate its effects by the people living there and the authorities concerned (Ali, 2004).

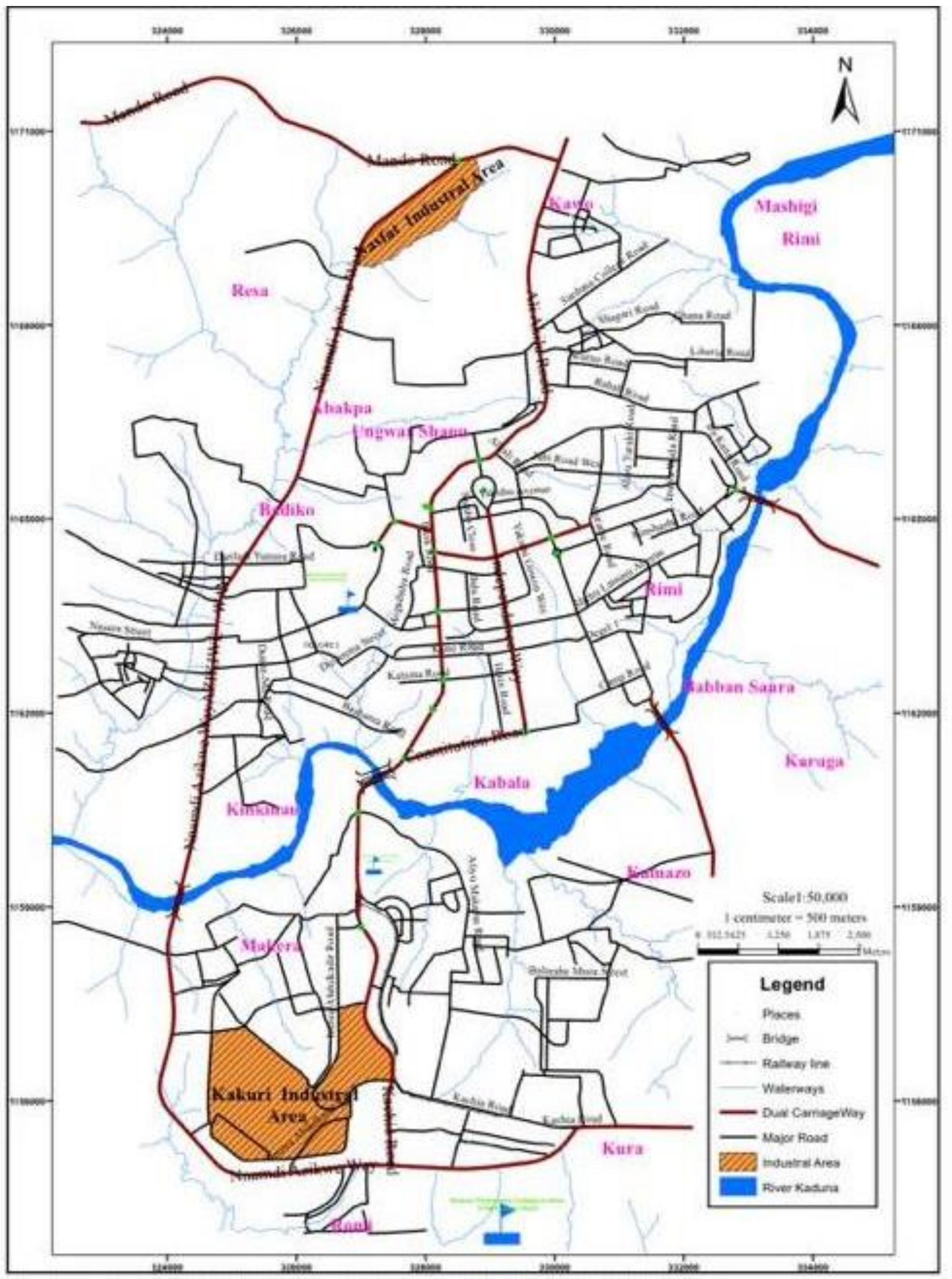

Figure 1: Kaduna Metropolis Showing Industrial Area
Source: Adopted and Modified from Administrative Map of Kaduna State 2021

The data used for the purpose of this study were obtained from a self-structured questionnaire and samples of soil and water were also collected. The method employed for the analysis of data in this study was the mixed method. Data were therefore analysed both descriptively and inferentially using SPSS 20.0 version. All analysis were carried out at 0.05 level of significance.

RESULTS AND DISCUSSION

Effects of Industrial Waste on Soil and Water in the Study Area

Waste has hazardous effect on the environment including every living thing. It does not only pollute the land but also affect indirectly living beings by polluting the air and water body available for consumption in the environment. This section examines the parameters of water and soil from samples collected during field survey to compare with the permissible limit for human consumption. Any of the parameters that have a greater value above the permissible limit is considered to have a serious effect in the study area.

The physico-chemical parameters of ground water and agricultural soil are depicted in Tables 1 and 2 to know the general characteristics and behaviour of ground water and soil

Water Quality Parameters from the Industrial Waste Disposal Site

General characteristics of effluent and heavy metal content are present in Table 1.

Table 1: Physiochemical Properties of Water Samples Collected from Disposal sites

Parameter	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
Temperature	29.7	29.6	29.7	28.8	25.3	22.9	29.3	26.6	22.6	29.7	29.6
Dissolve oxygen	0.42	0.46	0.43	0.43	0.39	0.43	0.41	0.44	0.44	0.45	0.46
Turbidity	0	0.33	0.37	0.38	0	0	0.41	0.37	0.33	0.37	0.37
Conductivity	753	1025	1364	637	531	634	1213	1234	769	567	742
Dissolved solid	638.5	686.8	913.9	426.8	431.9	635.3	879.9	982.1	684.3	678.4	1011.1
pH	6.12	7.12	8.14	5.94	5.71	5.15	5.87	5.15	5.16	6.71	8.12
Manganese	0	0.06	0.022	0.084	0.21	0.091	0.31	0.071	0.27	0	0.25
Ammonia	1.09	0.72	0.48	0.48	0.71	0.91	0.43	1.04	0.46	0.94	0.47
Nitrate	4.83	3.12	2.08	2.08	2.07	4.43	2.01	2.51	2.31	2.1	2.6
Calcium	43	27	29	32	51	44	42	29	27	24	21
Potassium	24.7	6.03	6.03	10.05	6.09	24.1	5.72	24.71	11.01	6.04	6.31
Alkalinity	114	45	59	34	31	101	42	44	39	41	40
Manganese	78.22	33.69	40.15	36.91	71.01	42.12	39.1	38.4	43.02	36.04	32.21

Source: Field Survey (2020); **S = Sites

Table 1 showed that the average temperature of the water at the dumpsites is 27.61ºc, 29.7ºc is the highest recorded at S1, S3 and S10 while 22.8ºc, 22.6ºc were the least recorded at S6 and S8. This shows that the water temperature of the river channel is within the permissible limit for temperature of NESREA which is less than 40ºc. Average concentration of calcium is 33.54mg/l of all the dumpsites while the highest concentration is recorded is 51mg/l at S5. It also shows 21mg/l is the least recorded concentration at S11. The calcium concentration of the water in the river channel is within the permissible limit of NESREA which is 200mg/l. This could mean that excessive chemical from the dumpsites does not contaminate the water sources in the study area. This verifies that most industries process their waste before disposing it. The pH level of the water shows some level of acidic nature as all the most of the water from all the dumpsites has a pH level above the permissible limit of the NESREA which is 6-7. Only six (6) out of the eleven samples have a pH value less than 6.0. This goes to show that mixed agricultural, residential and commercial land use promote acidic conditions as pointed by Al-Amin, (2013). This acidic nature of the water implies that it is not good for consumption for humans and even animals. This corroborates the findings of Chikogu *et al.*, (2012) who found a high acidic concentration in River Romi in Kaduna metropolis which was said to be unhealthy for human and animal consumption.

Average concentration of total dissolved solutes in the water at the dumpsites is 724.45mg/l while 1011mg/l was recorded as the highest concentration and the least recorded was 426.8mg/l. Although the TDS level shows an increase but fluctuating pattern across sample points, which is above the recommended standard of not more than 500 by WHO with only S4 and S5 having below the WHO standard which means the water along that area is not good for human consumption.. As such it could be termed harmful to humans as stated by Chikogu *et al.*, (2012) that in river Romi, TDS concentration is not within permissible limit of the WHO (2004). Electrical conductivity (EC) level of the dumpsites on the average shows 860.8ms/cm. the highest recorded was 1364ms/cm and 531ms/cm as the minimum recorded. Dumpsites S2, S3, S7 and S8 have electrical conductivity above the permissible limit by the WHO, while seven (7) other sample points have below the WHO standard. Total suspended solutes (TSS) in the river on the average for the three courses were 740mg/l for upper, 567.3mg/l for middle and 205mg/l for lower. Going by the 25mg/l permissible limit of TSS as recommended by the NESREA, it can therefore be said that the water is not good for consumption as the TSS at all the courses of the river were higher than the standard. This result is similar to that of Al-Amin (2013) who reported that in river Kaduna, the EC, TDS and TSS concentration in the river were high and as such not safe for consumption.

Table 2: Comparison of Water Parameters with WHO Standards

Parameter	Mean	Standard Deviation	Minimum	Maximum	WHO
Temperature	27.62	0.847	22.6	29.7	23.5
Dissolved oxygen	0.433	0.006	0.39	0.46	10
Turbidity	0.266	0.05	0	0.41	5
Conductivity	860.8	89.15	531	1364	1000

Dissolved solid	724.45	60.54	426.8	1011	500
Ph	6.29	0.332	5.15	8.14	8.5
Manganese	0.124	0.034	0	0.31	0.2
Ammonia	0.703	0.077	0.43	109	NM
Nitrate	2.74	0.3	2.01	4.83	50
Calcium	33.55	2.94	21	51	200
Potassium	11.89	8.35	5.72	24.71	200
Alkalinity	53.64	8.35	31	114	200
Magnesium	44.62	4.6	32.21	78.22	0.2

Source: Authors Analysis (2020).

Average carbon oxygen demand (COD) in the river shows 440mg/l for upper, 442.8mg/l for middle and 388.8 for lower. Oil and grease concentration shows a very high level in the river as it is far above the standard of 10 whereas the river level shows 932.5 at the upper, 766.6 at the middle and 522.5 at the lower. This could be attributed to human activities taking place at the bank of the river such as mechanic shops and other oil handling activities. This is affirmed by the study of Omale (2017) in Lokoja that mechanic workshops greatly increase the pollution level of not only soils but also surrounding water bodies through surface run off. The author particularly made reference to the concentration of oil and grease on the water bodies. Magnesium concentration in the river also shows a high level as it is above the standard of 200 in all the courses of the river. This implies that the river receives much debris or effluent which releases Mg, from the surrounding farmlands via surface run off. This support the position of Butu and Bichi (2013) that vegetation cover along river banks greatly influences the magnesium concentration of the adjoining river water. In the case of lead concentration, at the upper course, it is not detected but 0.08 at the middle and 0.04 at the lower. Cupper concentration is 0.03 at the upper, 0.05 at the middle and 0.04 at the lower course.

Cadmium level is not detected at the upper, 0.04 at the middle and 0.08 at the lower course. Lead, cupper and cadmium concentrations shows not harmful in the water as it is within the standard of less than 1 as outlined by NESREA. Although lead concentration is low in the water, yet it is pertinent to know that Lead exposure across a broad range of blood lead levels is associated with a continuum of path physiological effects, including interference with heme synthesis necessary for formation of red blood cells. Also, anemia, kidney damage, impaired reproductive function, interference with vitamin D metabolism, impaired cognitive performance, delayed neurological and physical development, and elevations in blood pressure (U.S. Environmental Protection Agency, 1988). Manganese concentration in the water is not detected at the upper course, 0.23 at both the middle and lower courses.

Manganese concentration is also within the permissible limit of 5. Concentration of nickel on the average is 0.25 for the upper course, 0.24 for the middle and 0.18 for the lower which is within the standard of less than 0.5. Chromium level in the water is within the standard of less than 1 at the upper course (0.5 mg/l) and the lower course (0.5 mg/l) while at the middle course it is 1.3 mg/l as such above the standard. Chromium in excess is toxic thus leading to liver and kidney damage, internal hemorrhage, and respiratory disorders, as well as causing cancer in humans and animals through inhalation exposure, but it has not been shown to be carcinogenic through ingestion exposure (U.S. Environmental Protection Agency, 1985; U.S. Environmental Protection Agency, 1991).Iron concentration in the river is very low as the upper course has an iron level of 0.005 µg/l, middle 0.003 µg/l and lower 0.007 µg/l and all fall far below the standard of 20. This implies that the water is deficient of iron concentration in all the three courses of the river. Average concentration of dissolved oxygen in the river is 1.4 mg/l for the upper, 0.9 mg/l for the middle and 1.9 mg/l for the lower course.

Table 2 showed that biological oxygen demand level in the water is very low at the upper (0.43 mg/l) and middle (0.48 mg/l) courses of the river while at the lower course, it is 8.9 mg/l. the BOD level in all the three courses of the river channel is below the NASREA standard of 50 mg/l.Thus this study is similar to the findings of Al-Amin (2013) and Chikogu (2012) on the concentration of temperature, Ca, TDS, Pb, Cu, Cd, Mn, Ni, Cr, Fe and BOD which were also found by the authors to be within permissible limits in rivers Kaduna and Romi respectively.

Analysis of Variance (ANOVA)

To confirm the significant differences between the levels of concentration of chemical elements and parameters along river Kaduna, the Analysis of variance (ANOVA) as well as the F-test were used to statistically confirm the significance difference at 0.05 level of significance. Table 3 summarizes the result of the ANOVA and F-test carried out to show the differences in chemical element and parameters concentration along the river.

Table 3: Analysis of Variance showing differences in concentration between the three courses

Parameter	F Ratio	Sig.	Remark
Temperature	7.69	0.382	Not significant
Conductivity	3.54	0.114	Not significant
Total dissolved solids(TDS)	6.43	0.304	Not significant
Total suspended solids(TSS)	9.26*	0.008	Significant
pH	2.89	0.255	Not significant
Dissolved oxygen(DO)	8.76*	0.016	Significant
Calcium(Ca)	2.91	0.074	Not significant
Chemical oxygen demand(mg/l)	1.58	0.496	Not significant
5 day Biological oxygen demand(BOD)	3.22	0.069	Not significant
Oil and grease	3.83	0.055	Not significant
Chromium(Cr)	1.33	0.514	Not significant
Iron (Fe)	0.53	0.819	Not significant

Lead (Pb)	0.86	0.208	Not significant
Copper (Cu)	1.50	0.723	Not significant
Cadmium(Cd)	2.68	0.429	Not significant
Manganese(Mn)	0.06	0.125	Not significant
Magnesium(Mg)	5.34	0.611	Not significant
Nickel(Ni)	3.37	0.865	Not significant

Level of Significance: * = 0.05
Field Survey, 2020

The result clearly indicates a statistical significant difference in dissolved oxygen and total suspended solutes. This result is similar to that of Okorafor *et al.,* (2013) who found statistical significant difference in the level of TSS and DO also, across the Calabar river channel. But the findings of this study, contradicts the findings of Al-Amin (2013) who revealed no significant difference in TSS and DO across same river Kaduna. Whereas temperature, electrical conductivity, total dissolved solutes, pH, calcium, chemical oxygen demand, biological oxygen demand, oil and grease, chromium, iron, lead, copper, cadmium, manganese, magnesium and nickel were not significantly different across the eleven dumpsites sampled. This is similarly to the findings of Butu, (2013) who also found out not significant difference in metal concentration across the channel of Kubanni River in Zaria. From the results obtained it can be concluded that the water quality is undergoing change and there is presence of heavy metals in some samples

Soil Quality Parameters from the Industrial Waste Disposal Site.

The soil quality parameters from industrial waste disposal sites are displayed on Table 4. Soil texture is a fundamental soil property which influences soil susceptibility to erosion, its infiltration capacity, moisture and Nutrient retention (Madaki, 2011; Afolabi et al., 2014). The soil composition shows has a larger number of soil in the dumpsites are mainly composed of sand soil with about 7 of the dumpsites having above 60% composition. This was closely followed by silt soil with only four of the dumpsites are having above 30% composition. However, clay soils is the least type of soil found in the waste dumpsites in the area.

Generally, the composition of the soil indicates that the soils in the study area are sandy clay loam. Although they are well drained, the dominance of sand fractions predispose the soil to erosion due to the micro pores in the soil. The macro pores result in low moisture retention by soils and nutrients loss through translocation by soil wash and leaching.

The critical limit for organic matter content for soil under natural conditions in the savannah is greater than or equal to 2%. Out of all the sampled site S2, S3, S5, S7 and S10 have a normal organic matter content of 2.7%, 4.3%, 4.5%, 4.1%, and 2.1% respectively, which is within the permissible limit. However, dumpsites with lower organic matter includes S1, S4, S6, S8, S9 and S11 could be as a result of sparse vegetation cover and persistent use of the land. Those with higher organic matter content are areas where waste from industries are disposed and consequently burnt. Studies have shown that intensive disturbance of soil could destroy the soil structure through compaction, loss of soil moisture, increased bulk density and make it susceptible to soil wash and loss of basic cations (Jaiyeoba, 1995, Afolabi et al., 2014). Loss of organic matter is directly related to intensive dumping of refuse and rapid mineralization of humus under savannah climate.

Table 4: Soil Quality Parameters from the Industrial Waste Disposal Site

SITE	SAND	SILT	CLAY	PH	Calcuim Carbonate	Organic Matter	Bulk density
S1	63	24	13	7.5	56.12	1.5	1.45
S2	57	30	13	6.9	76.33	2.7	0.08
S3	61	26	13	7.8	46.5	4.3	1.71
S4	65	28	7	7.8	50.12	0.7	1.49
S5	60	25	15	7.8	56.2	4.5	0.09
S6	61	24	15	6.9	55.12	0.8	0.29
S7	59	30	11	7.7	50.2	4.1	1.64
S8	69	20	11	7.3	65.1	1.1	0.16
S9	58	32	10	7.45	67.12	1.3	1.14
S10	63	24	13	5.4	58.2	2.1	1.49
S11	72	20	8	8	57.1	1.6	0.09

Source: Field Survey 2020

From the Duncan multiple range tests presented in Table 4, site ten (S10) among others have the least soil pH of 5.4. The highest soil pH fall in the third, fourth and fifth dumpsite examined having a pH value of 7.8 each. In fact, all PH values of the analyzed soil samples in this research work were mostly acidic since PH is one of the factor that influence the bioavailability and transport of heavy metal in the soil, this is decrease with increase in soil PH. Heavy metals are generally more mobile at pH < 7 that at pH > 7 as reported by Akan., et al., (2010). The soil pH varies significantly from one farmland to another ($p < 0.005$), as a result of human activities occurring in such sites. In the present study, the PH values of different irrigation sites of Kaduna metropolis were determined and found that most of these sites were acidic. Radujevic and Bechkin (1999) explained that acidic soils with pH from 4.0 – 5.5 can have high concentration of soluble aluminum and manganese ions, which may be toxic to the growth of some plant. Mohammed (2014) stated that toxicity may rise if pH below 5 and also reported that a pH range of approximately 6 to 7 can release most readily available plant nutrients. This is also as a result of excessive waste composition especially from agrochemicals manufacturing industries as well as other industries in the study area, thereby polluting the soil and water in the area. It is obvious to know that, the absorption and accumulation of heavy metals in plant tissues depend upon soil pH and nutrient availability.

The soil bulk density shows statistically significant differences amongst the various waste dumpsites. The lowest value is recorded over the sites (0.09g/cm3). This is followed by the same value (0.49g/cm3) over the scrubland and the fadama land. The highest values of 1.71g/cm3 and 1.64 are recorded over the badland site such as S3, S7, S10. S4 and S1, respectively. The coefficient of variability percent is consistently very low, less than 7%, an indication of relative homogeneity within each landuse category. Overall, all soils are very high in bulk density value. For a normal mineral soil, the value is about 1.25g/cm3 (Brady, 1990). Such high value no doubt is a reflection of soil degradation that has taken place in the study area. On the other hand, the feature could be due partly to the granitic nature of soil parent material over the study area.

The results obtained from soil samples suggest that the soil characteristics have changed. All metals or chemicals that have a significant presence in the raw materials are also reporting high in test results of soil samples, thus suggesting that the change in soil characteristics is on account of discharge of waste from industries in the locality.

Perceived Impact of Industrial Waste Disposal

Table 5: Implications of Industrial Waste Disposal

Impact	Mean	Ranking
Offensive odour	1.5	4th
Irritating sight	1.9	1st
Breeding ground for vectors/vermins	1.7	3rd
Loss of aquatic animals	1.4	5th
Loss of aquatic plants	1.1	7th
Influences flooding	1.0	8th
Causes ailment to direct users	1.8	2nd
Contaminate crops grown using the water	1.3	6th

Table 5 showed the implications of industrial waste disposal on the residents in Kaduna. From the mean rank, irritating sight is one major effect of industrial waste disposal in the study area with a mean rank score of 1.9 while loss of aquatic life and influence on flooding attracted mean rank scores of 1.1 and 1.0 respectively implying that the waste disposal have less effect on the aquatic plants as well as flooding. Other effects including breeding ground for vectors and vermins, offensive odour as well as causing ailments to people who live directly around areas where the wastes are being deposited.

Site Suitability of the Industrial Waste Dumpsites

The analysis of the suitability of dumpsites for industrial waste in Kaduna was analysed using the network analysis in ArcGIS 10.3 to calculate the distance from major features like road, source of water and condition of the place. The results on the suitability of the dumpsites is presented in Table 5.

Effective waste management is an important component of a strategy for improving environmental health, waste that is not properly managed, especially uncollected solid wastes from households and other communal activities are serious health hazard which could manifest through the spread of infectious diseases.

CONCLUSION

There is a wide variation in the levels of zinc and nickel, though within the standards for drinking water, suggesting change in water quality at various locations. High mercury levels in one of the samples are a reason for concern. This result throws up serious questions on the use of this water for drinking purposes and the need for further intensive studies. Soil results at both sites confirm changes in soil parameters as compared to the respective control samples and also if compared to standards from other countries. Some of the metals found in the soil are the input materials or residues discharged into soil. There is clear evidence of changes in soil characteristics at both recycling sites and this directly relates to the activities and input materials of the waste recycling sector.

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