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Assessment of Oil Spillage on Groundwater and Soil Quality In Ijegun Area Of Lagos State, Nigeria

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ABSTRACT
Oil spillage is a threat to soil and groundwater quality. The aim of this work is to assess the impact of oil spillage on soil and groundwater in Ijegun area of Lagos State with a view of establishing the correlation coefficient matrix for the parameters under consideration. Soil samples were collected from 9 different locations which were stored in different polythene bags labelled SS 1 to SS 9. A control soil sample was taken 1 km from Ijegun community and was labeled SC 1. Groundwater samples were also collected from 10 different locations using 1 litre plastic bottles and were labeled GW 1 to GW 10. The locations were soil and groundwater samples were taken were identified using handheld Global Position System (GPS) for the purpose of universal identification of the sampling locations.The soil samples were analysed for total petroleum hydrocarbon (TPH), total organic carbon (TOC), chromium (Cr), copper (Cu), nickel (Ni), manganese (Mn), iron (Fe), lead (Pb) and cadmium (Cd). Others are zinc (Zn), nitrate (NO_3), phosphorus (P), phosphate (PO_4) and nitrogen (N). The groundwater samples were also analysed for the aforementioned parameters except TOC, phosphorus, phosphate and nitrogen. Others parameters analysed in groundwater samples include biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, electrical conductivity (EC) and total dissolved solids (TDS) using the methods for the examination of water and wastewater as prescribed by American Public Health Association (APHA). The results showed that the concentrations of TPH in the soil varied between 0.27 and 0.7 percent while the concentration in the control sample was 0.04 %. The TOCconcentrations in the soil ranged between 0.36 and 0.98 percent with the control sample having 0.09 percent. The concentrations of chromium and copper in the soil varied between 39.84 and 74.84 mg/kg and between 50.49 and 68.94 mg/kg respectively. The concentrations of chromium and copper in the control sample were 0.09 and 0.96 mg/kg respectively. The concentrations of TPH in groundwater investigated ranged between 0.04 and 2.08 percent while the Nigeria Standard for Drinking Water Quality (NSDWQ) and World Health Organisation (WHO) concentration standardfor TPH was 0.03 percent. The pH values in groundwater investigated varied between 3.10 and 5.9 against the NSDWQ and WHO stipulated limits between 6.5 and 8.5. The correlation coefficient matrices revealed a strong positive correlation between TPH and nickel in the soil and a weak negative correlation between TPH and nickel in the groundwater. It was concluded that the oil spillage in Ijegun has impacted negatively on the soil and groundwater quality. It was recommended that alternative water supply should be provided and appropriate remediation should be carried out on the soil and groundwater.

***KEYWORDS**: Assessment, groundwater, Ijegun, quality, soil and spillage.*

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I. INTRODUCTION

Pollution is the contamination of the environment which makes the environment unfit for living. An oil spillage is the discharge of liquid petroleum or products from refined petroleum into the environment as a result of human activities (Makinde and Tologbonse, 2017 and Osuji and Onojake, 2004). Oil spill is a threat to surface and groundwater resources of the affected areas due to infiltration and seepage of the oil, thereby reducing the quality of the affected resources. It is also a threat to human life, marine life, wild life and micro-organism in the soil (Nwachukwu and Osuagwu, 2004).In Nigeria, the major causes of oil spill include corrosion of pipelines and tankers (accounting for 50 % of oil spill), sabotage (28 %), oil production operation

(21 %), sabotage (28 %) and non-function production equipment accounted for 1 % (Nwilo *et al*., 2007; Nwachukwu and Osuagwu, 2014).

Several scholars have worked on oil spillage (Nnaji and Egwu, 2020; Okoro *et al*., 2011; Udoh and Chukwu, 2014; Makinde and Tologbonse, 2017; Nwachukwu and Osuagwu, 2014; Wekpe and Mgbengasa, 2016; Adams *et al*., 2008; Osuji and Nwoye, 2007 and Wang and Feng, 2009 and UNEP, 2010). Okoro et al. (2011) assessed the soil quality after crude oil spillage and clean up in Oluba community, Warri, Delta State, Nigeria. The assessment revealed there were significantly high levels of diffuse hydrocarbons in the soil. Nwachukwu and Osuagwu (2014) investigated the effects of oil spillage on groundwater quality in Abacheke community in Imo State, Nigeria. The investigation showed that the groundwater in the study area was contaminated as a result of oil spillage.Wekpe and Mgbengas (2016) examined the impact of oil spill on soil properties in Kalaba / Ayamabele community in Yenagoa, Belyelsa State, Nigeria. The examination indicated that oil spillage had impacted on the soil physical and chemical properties.

Makinde and Tologbonse (2017) assessed the impact of oil spillage on soil and groundwater in Ijeododo community in Lagos State, Nigeria. The assessment revealed oil spill had affected negatively the soil and groundwater in Ijeododo community in Lagos State. Nnaji and Egwu (2020) carried out a study to determine the effect of oil spillage on the physicochemical parameters of agricultural soil in Niger Delta. The study showed that the agricultural soil in Niger delta had been affected negatively as a result of oil spillage. Therefore the aim of this work is to assess the impact of oil spillage on soil and groundwater of Ijegun community in Lagos State, Nigeria with a view of establishing the correlation coefficient matrix for parameters under consideration. It also involves determining the suitability of the groundwater for drinking purpose and the suitability of the soil for habitation which justifies this work.

II. MATERIALS AND METHODS

2.1 Study Area

Ijegun community is situated in Igando / Ikotun Local Council Development Area of Alimosho Local Government of Lagos State, Nigeria. It is located between latitude 6° 31' 2'' N and longitude 3° 15' 24'' E (http://nona.net/features/map/placed etail.2246992/Ijegun). It is bounded by Ijeododo. Iseri Osun, Akesan and Ikotun communities. It is one of the major residential areas for people of Lagos state. The major source of drinking water in Ijegun is groundwater source. The soil is red and laterite in nature. A state public secondary school is present in the area which provides educational services to the people in Ijegun and environ. The google map showing Ijegun in Lagos State is shown in Figure 1.

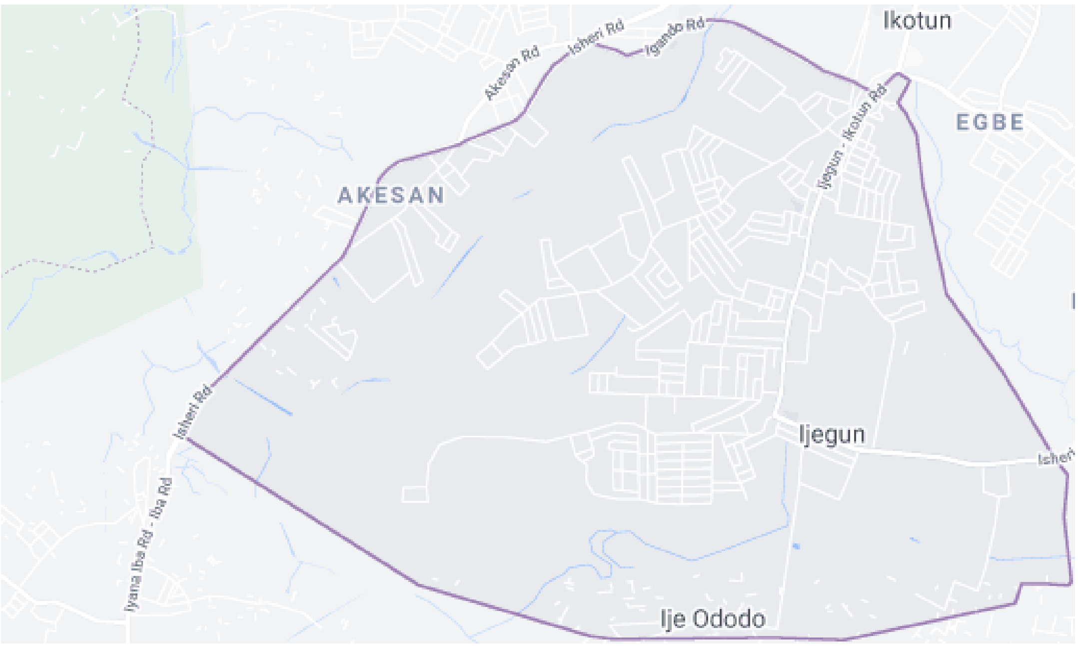

Figure 1. The map of Ijegun in Lagos State
Source: http://nona.net/features/map/placed etail.2246992/Ijegun.

2.2 Sampling Location

9 different sampling points were chosen within Ijegun community for collection of soil samples. 1 location was also chosen 1 km away from the study area where soil control sample was taken. 10 various sampling points were also selected where groundwater samples were taken. All the sampling points were coordinated using handheld GPS (Etrex 12 Garmin model) for the purpose of universal identification of the sampling locations. The specifications of the sampling points are presented in Tables 1 and 2 for soil and groundwater respectively.

2.3. Soil Sampling and Analysis

The method Odunlami and Salami (2017) was adopted. Soil samples were collected from 9 different points during the month of December, 2020 from surface layer (0 – 20 cm) soil of Ijegun community in Lagos State with the aid of stainless steel auger. The soil samples were stored in different polythene bags and were labeled SS 1 – SS 9. The augur was washed with distilled water each time it was used for collection of sample before using it again. A control sample was taken I km away from the surface layer (0 – 20 cm) soil of Ijegun community and stored in a polythene bag which was labeled SC 1. The soil samples were quickly transferred to the analytical laboratory of University of Lagos for analysis. The soil samples were first air dried overnight in an oven at 32^{o}C. The dried samples were mechanically ground and sieved through 200 mesh size sieve. 5 grams of each sieved samples was placed in an Erlenmeyer flask and 2.5 ml of extracting solution (0.05 M HCl + 0.024 M H_2SO_4) was added after which the mixture was placed in a mechanical shaker for 15 minutes. The resulting solution was filtered through whatmann filter paper into a50 ml volumetric flask and diluted to 50 ml with the extracting solution. The treated samples were analysed for Cr, Cu, Ni, Mn, Pb, Cd, TPC, TOC, and NO_3. Others are P, PO_4, Zn and N according to standard methods for examination of water and wastewater as prescribed by APHA (1994). All experiments were carried out in triplicate and the results were found reproducible within ± 3 % error.The data were statistically analysed by setting up and calculating a correlation coefficient matrix using the in – built software solver tool in Microsoft Excel version 2007.

2.4 Groundwater Sampling and Analysis

The method of Salami *et al.* (2019) was used. Groundwater samples were taken in the month of December, 2020, using 1 litre plastic bottles which had been cleaned by soaking in 10 % nitric acid and rinsed with distilled water in order to avoid contamination and allowed to dry before use. At the sampling locations, the bottles were rinsed three times with water to be sampled prior to filling and they were labeled GW 1 – GW 10. The samples were quickly transferred to the analytical laboratory of University of Lagos for analysis using the standard methods for examination of water and wastewater as prescribed by APHA (1994). The parameters analysed include Cr, Cu, Ni, Mn, Fe, Pb, Cd, Zn, TPH. Others are biochemical oxygen demand (BOD), chemical oxygen demand (COD), NO_3, pH, EC and TDS. All experiments were carried out in triplicate and the results were found reproducible within ± 3 % error. The data were statistically analysed by setting up and calculating a correlation coefficient matrix using the in – built software solver tool in Microsoft Excel version 2007.

III. RESULTS AND DISCUSSION

The specifications of the sampling locations where soil and groundwater samples were taken are presented in Tables 1 – 2 respectively.The characteristics of soil samples from Ijegun community are presented in Table 3. The TPH concentrations ranged between 0.27 and 0.70 percent. The TPH concentration in the control sample was 0.04 percent. This revealed the soils in Ijegun community have been impacted with petroleum products and this is attributed to incessant pillage of petroleum products in Ijegun community resulting from the activities of pipeline saboteurs. Theconcentrations TOC in the soil investigated varied between 0.36 and 0.98 percent while the control sample has a value of 0.09 percent. All the soil samples investigatedexceeded the TOC concentration of the control sample which also indicated that the oil spillage has impacted negatively on the soils of Ijegun community. The high values of TOC in the soil samples investigated compare to the low value in the control sample can be as a result of decomposition or degradation of the spilled oil. Organic matter content increases with the addition of carbonaceous substances, hydrocarbon fuels or condensates (Okoro et al., 2011).

Table 1. Specification of the sampling locations for soil samples

S/N	Coordinates		Sampling location	Sampling elevation	Identification code of samples
	Easting	Northing			
1	003^o 15.469’	06^o 31.041’	Public school	63	SS 1
2	003^o 15.588’	06^o 30.974’	Car wash	43	SS 2
3	003^o 15.531’	06^o 30.965’	Residential building	3	SS 3
4	003^o 15.470’	06^o 30.979’	Along the road	48	SS 4

5	003° 15.620'	06° 30.916'	Along the road	72	SS 5
6	003° 15.574'	06° 31.008'	Five junction	123	SS 6
7	003° 15.587'	06° 31.035'	Tipper garage	12	SS 7
8	003° 15.603'	06° 31.073'	Commercial center	62	SS 8
9	003° 15.610'	06° 30.999'	Event center	22	SS 9
10	003° 15.663'	06° 31.065'	Along the road	84	SC 1

Table 2. Specification of the sampling locations for groundwater samples

S/N	Coordinates		Sampling location	Sampling elevation	Identification code of samples
	Easting	Northing			
1	003° 15.546'	06° 31.012'	Car wash	73	GW 1
2	003° 15.411'	06° 31.037'	Religious house	12	GW 2
3	003° 15.531'	06° 30.995'	Shopping complex	19	GW 3
4	003° 15.563'	06° 31.071'	Residential building	84	GW 4
5	003° 15.529'	06° 30.957'	Residential building	60	GW 5
6	003° 15.445'	06° 30.972'	Residential building	48	GW 6
7	003° 15.428'	06° 30.898'	Residential building	8	GW 7
8	003° 15.614'	06° 30.934'	Residential building	67	GW 8
9	003° 15.686'	06° 30.934'	Residential building	66	GW 9
10	003° 15.563'	06° 31.013'	Gas station	177	GW10

Table 3. Characteristics of soil samples from Ijegun in Lagos State.

S/N	Parameters mg/kg	Sample code									
		SS 1	SS 2	SS 3	SS 4	SS 5	SS 6	SS 7	SS 8	SS 9	SC 1
1	TPH (%)	0.52	0.70	0.33	0.39	0.44	0.53	0.32	0.27	0.34	0.04
2	TOC (%)	0.87	0.98	0.65	0.96	1.45	0.68	0.95	0.94	0.36	0.09
3	Cr	46.71	39.84	52.44	60.36	43.96	40.96	74.84	58.96	61.84	0.96
4	Cu	58.86	57.79	51.62	58.74	60.37	50.49	68.94	58.29	65.31	0.24
5	Ni	17.52	18.44	17.61	17.61	17.14	14.63	8.20	9.59	7.89	1.44
6	Mn	106.2	46.67	87.67	74.33	44.49	38.46	49.44	43.50	84.61	1.71
7	Fe	144.1	136.3	148.4	160.49	161.44	171.10	164.44	172.84	124.48	1.49
8	Pb	56.33	48.07	34.42	84.98	77.41	48.49	33.67	34.67	72.00	0.23
9	Cd	110.4	163.2	151.7	153.30	135.33	164.12	163.33	100.49	124.61	0.14
10	Zn	2249	2551	1981	3140	3241	2592	2343	2098	2782	3.62
11	NO_3	10.44	14.24	10.98	14.44	16.40	15.80	10.53	11.90	12.84	4.90
12	P	8.67	10.17	8.30	7.65	9.13	9.77	10.23	8.43	9.00	1.47
13	PO_4	26	30.50	24.40	22.40	27.41	29.30	30.70	25.50	27.00	0.20
14	N	3.53	3.83	2.40	3.18	3.60	3.43	3.33	2.62	2.82	2.24

The concentrations of chromium and copper in the soil samples assessed ranged between 39.84 and 74.84 mg/kg and between 50.49 and 68.94 mg/kg for chromium and copper respectively. The concentrations of chromium and copper in the control soil sample were 0.09 and 0.96 mg/kg respectively. This is also an indication of the effect of oil spillage on the soil of Ijegun. The values of nickel and manganese in the soil samples investigated varied between 7.89 and 18. 44 mg/.kg and between 38.46 and 106.21 mg/kg for nickel and manganese respectively while the concentrations of iron and lead ranged between 124.48 and 171.10 mg/kg and between 34.42 and 84.98 mg/kg for iron and lead respectively. The concentrations of nickel, manganese, iron and lead in the control sample were 1.44, 1.71, 1.49 and 0.23 mg/kg respectively.

The concentrations of cadmium and zinc in the soil samples investigated varied between 100.49 and 164.12 mg/kg and between 1981 and 3241 mg/kg respectively. The values of cadmium and zinc in the control soil sample were 0.14 and 3.62 mg/kg respectively. This clearly showed the values of cadmium and zinc in the soil samples investigated exceeded the values in the control samples. The concentrations of nitrate, phosphorus, phosphate and nitrogen in the control sample were 4.90, 1.47, 0.20 and 2.24 mg/kg respectively. In Table 3, it is obvious that all the values of nitrate, phosphorus, phosphate and nitrogen exceeded the values of the control sample. However the concentrations of nitrogen and phosphorus in the soil investigated, including the control soil sample, were lower than the recommended values of 15,000 mg/kg for nitrogen and 2,000 mg/kg for phosphorus for agricultural soil (Nnaji and Egwu, 2020). This revealed that the soil in Ijegun community may not be suitable for agricultural purposes.

3.2 Groundwater

The concentrations of groundwater samples from Ijegun in Lagos State are shown in Table 4. The TPH concentrations varied between 0.04 and 2.08 percent while the NSDWQ standard for TPH was 0.03 percent. This shows clearly that the TPH concentrations in the groundwater samples investigated exceeded the standard which was an indication that oil spillage had contaminated the groundwater. The concentrations of chromium ranged between 0.034 and 0.184 mg/L. The stipulated standard for drinking water by NSDWQ and WHO was 0.05 mg/L for chromium. All the groundwater samples investigated exceeded the stipulated standard for chromium except GW 6. The contamination of the groundwater can be attributed to oil spillage as there were no industries in the vicinity where groundwater samples were collected. The health effect of chromium include ulcers and upset stomach, respiratory problems, weakened immune systems, kidney and liver damage, alteration of genetic material and lung cancer death (Salami *et al*., 2020). The groundwater investigated can lead to any of the aforementioned effects as a result of the level of chromium present in the groundwater hence the groundwater is not suitable for drinking.

Table 4. Characteristics of groundwater samples from Ijegun in Lagos State.

S/N	Parameters mg/L	Sample code GW 1	GW 2	GW 3	GW 4	GW 5	GW 6	GW 7	GW 8
1	TPH (%)	0.04	0.14	0.24	0.14	0.07	0.14	0.06	2.08
2	Cr	0.142	0.168	0.129	0.173	0.184	0.034	0.128	0.086
3	Cu	2.431	1.396	1.464	0.015	1.491	1.981	1.363	2.013
4	Ni	0.068	0.048	0.036	0.044	0.036	0.033	0.014	0.022
5	Mn	0.084	0.149	0.128	0.149	0.167	0.138	0.299	0.391
6	Fe	0.236	0.187	0.149	0.14	1.059	0.046	0.063	0.144
7	Pb	0.037	0.016	0.037	0.024	0.038	0.04	0.053	0.044
8	Cd	0.003	0.001	0.003	0.006	0.001	0.004	0.007	0.009
9	Zn	2.149	2.641	1.891	3.443	3.841	2.296	2.443	1.984
10	BOD	5.26	3.16	4.36	2.80	5.40	3.80	2.10	5.10
11	COD	8.99	12.28	7.44	4.84	9.34	6.57	3.63	5.36
12	NO3	9.19	8.28	8.02	7.85	8.55	9.59	8.88	7.96
13	pH	4.3	3.60	3.50	3.10	5.90	4.60	5.10	3.40
14	EC ($\mu s / cm^3$)	220	520	190	130	830	20	720	20
15	TDS	162	372	143	99	5650	26	550	28

Table 4. Characteristics of groundwater samples from Ijegun in Lagos State (Continuation)

S/N	Parameters mg/L	Sample code GW 9	GW 10	NSDWQ	WHO
1	TPH (%)	0.10	0.26	0.03	-
2	Cr	0.128	0.082	0.05	0.05
3	Cu	1.344	1.492	1.00	1.00
4	Ni	0.031	0.026	0.02	0.02
5	Mn	0.371	0.196	0.20	0.05
6	Fe	0.136	0.148	0.30	0.30
7	Pb	0.036	0.043	0.01	0.01
8	Cd	0.002	0.001	0.03	0.003
9	Zn	2.840	3.422	3.00	-
10	BOD	3.80	4.30	-	30*
11	COD	6.57	7.44	-	80*
12	NO_3	6.97	8.92	50	10
13	pH	4.00	3.10	6.5 – 8.5	7.0 – 8.5
14	EC ($\mu s / cm^3$)	270	200	100	-
15	TDS	197	147	500	500

*indicates Federal Environmental Protection Agency (FEPA)

The concentrations of copper in groundwater samples from Ijegun in Lagos State ranged between 0.015 and 2.431 mg/L while the NSDWQ and WHO standard for copper was 1.0 mg/L. All the samples investigated exceeded the NSDWQ and WHO standard for drinking water except GW 4. Copper is essential for good health but very large quantity single or daily intake of copper can be harmful. The effects of copper can be expected to increase with both level and length of exposure. Water containing high level of copper may cause vomiting, diarrhea, stomach cramps and nausea (Salami *et al*., 2020). This is a pointer that groundwater in Ijegun in the area where samples were collected is not fit for drinking.

The concentrations of nickel, manganese and iron varied between 0.014 and 0.068, between 0.128 and 0.391 and between 0.136 and 0.236 mg/L respectively. The NSDWQ and WHO standard for drinking were 0.02, 0.05 and 0.30 mg/L for nickel, manganese and iron respectively. All the samples investigated exceeded the standards stipulated by NSDWQ and WHO for drinking water except GW 6 which was below the regulatory standard in term of nickel. The concentration of lead, cadmium and zinc in the groundwater investigated ranged between 0.016 and 0.053 mg/L, between 0.001 and 0.009 mg/L and between 1.89 and 3.443 mg/L respectively. The threshold stipulated by NSDWQ and WHO for lead and cadmium in drinking water were 0.01 and 0.003 mg/L respectively. The concentrations of lead in the groundwater investigated exceeded the NSDWQ and WHO standards for drinking water. The concentrations of cadmium in GW 4 and GW 6 – GW 8 exceeded the standard limit stipulated by NSDWQ for drinking water. However, all the concentration of cadmium in groundwater samples investigated were within the threshold limit stipulated by WHO for drinking water

BOD measures the amount of oxygen required by aerobic organisms to degrade organic matters in water while COD measures the amount of oxygen required to decompose organic and inorganic components in water chemical reactions. The concentrations of BOD in groundwater samples investigated ranged between 2.10 and 5.40 mg/L while the concentrations of COD varied between 3.63 and 12. 28 mg/L. though the standards for BOD and COD were not specified by NSDWQ. However, FEPA specified BOD and COD threshold limits of 30 and 80 mg/L respectively for drinking water (Salami *et al*., 2020).The groundwater samples investigated can be said not to be contaminated in terms of BOD and COD. The concentrations of nitrate in the groundwater ranged between 7.85 and 9.19 mg/L which were below the standard of 10 mg/L stipulated by WHO for drinking water. pH measures the degree of acidity or alkalinity. The pH of groundwater samples from Ijegun community varied between 3.10 and 5.9. The threshold limit set by NSDWQ and WHO ranged between 6.5 and 8.5. The pH of all the groundwater samples from Ijegun were below the pH range set by NSDWQ and WHO for drinking water hence the groundwater investigated were acidic which can be attributed to the result of oil spillage in the area.

EC is a valuable indicator of the amount of materials dissolved in water (Suman *et al*., 2006). The concentrations of EC in the groundwater investigated varied between 20 and 830 mg/L while the NSDWQ standard limit was 100 mg/L. All the groundwater samples from Ijegun community exceeded the set standard by NSDWQ for drinking water except GW 6. TDS indicates the general nature of water quality. High concentrations of TDS decreasethe palatability and may cause Castro-intestinal irritation in human (Salami *et al*., 2020). The concentration of TDS in GW 5 was 5650 mg/L while the concentrations in the other groundwater samples varied between 28 and 550 mg/L. This revealed the GW 5 was not fit for drinking in term of TDS.

3.5 Correlation Analysis

Correlation analysis is a preliminary descriptive technique for understanding statistical relationship between two variables. It is used to understand the association between two variables (Wyesekara *et al*., 2014 and Suman *et al*., 2006). A correlation value (r) is such that $-1 \leq r \leq 1$.A correlation value greater than 0.8 means a strong correlation while a value less than 0.5 is described as weak correlation. A value between 0.5 and 0.8 is described as moderate correlation (Kumar et al., 2007 and Kurumbein and Graybill, 1985). A correlation of zero means there is no correlation between the variables while a correlation of 1 means a perfect correlation between the variables. A positive correlation means an increase in one variable leads to an increase in the other variables and a negative correlation means an increase in one variable results to a decrease in the other variables (Salami *et al*., 2019). The coefficient matrices for parameters investigated in soil and groundwater from Ijegun community are detailed in Tables 5 – 6.

Table 5. Coefficient matrix for parameters investigated in soil from Ijegun of Lagos.

	TPH	TOC	Cr	Cu	Ni	Mn	Fe	Pb	Cd	Zn	NO_3	PO_4	P	N
TPH	1.00													
TOC	0.58	1.00												
Cr	0.27	0.46	1.00											
Cu	0.60	0.65	0.91	1.00										
Ni	0.80	0.67	0.29	0.54	1.00									
Mn	0.38	0.18	0.59	0.63	0.54	1.00								
Fe	0.59	0.73	0.81	0.89	0.65	0.48	1.00							
Pb	0.54	0.55	0.51	0.69	0.61	0.56	0.59	1.00						
Cd	0.73	0.59	0.73	0.84	0.70	0.49	0.86	0.58	1.00					
Zn	0.68	0.72	0.71	0.88	0.68	0.51	0.84	0.91	0.83	1.00				
NO_3	0.72	0.68	0.45	0.69	0.69	0.23	0.77	0.79	0.78	0.91	1.00			
PO_4	0.76	0.64	0.77	0.93	0.60	0.48	0.89	0.55	0.91	0.83	0.75	1.00		
P	0.76	0.65	0.78	0.94	0.61	0.49	0.91	0.57	0.91	0.84	0.76	1.00	1.00	
N	0.86	0.69	0.25	0.56	0.61	0.17	0.52	0.55	0.62	0.67	0.66	0.68	0.67	1.00

In Table 5, all the parameters investigated were positively correlated with one another. TPH was moderately correlated with TOC, copper, iron, lead, cadmium and zinc but strongly correlated with nickel. The strong correlation between TPH and nickel is an indication that oil spillage had impacted on the soil of Ijegun community. Nickel moderately correlated with iron, lead, cadmium, zinc, phosphate and phosphorus. In Table 6, there was a weak negative correlation among TPH, nickel, pH, EC and TDS. It can be deduced that as the concentrations of TPH increase, the pH values decreases. This is apparent as the pH values of all the groundwater samples investigated were below the standard limit set by NSDWQ and WHO.

Table 6. Coefficient matrix for parameters investigated in soil from Ijegun of Lagos.

	TPH	Cr	Cu	Ni	Mn	Fe	Pb	Cd
TPH	1.00							
Cr	- 0.36	1.00						
Cu	0.30	-0.46	1.00					
Ni	- 0.35	0.41	0.14	1.00				
Mn	0.58	-0.22	0.06	-0.70	1.00			
Fe	- 0.14	0.53	0.03	0.14	-0.19	1.00		
Pb	0.23	-0.51	0.41	-0.62	0.43	-0.05	1.00	
Cd	0.64	0.25	-0.07	-0.39	0.48	-0.40	0.39	1.00
Zn	0.37	0.43	-0.56	0.04	-0.10	0.58	-0.21	-0.43
BOD	0.35	-0.07	0.60	0.31	-0.11	0.53	0.13	-0.23
COD	-0.26	0.35	0.28	0.61	-0.50	0.40	0.61	-0.76
NO_3	-0.22	-0.40	0.48	0.31	-0.53	0.02	0.32	-0.05
pH	-0.34	0.17	0.28	-0.09	-0.04	0.63	0.37	-0.13
EC	-0.41	0.61	-0.11	-0.12	-0.01	0.62	0.06	-0.30
TDS	-0.40	0.61	-0.11	-0.15	0.02	0.57	0.09	-0.25

Table 6. Coefficient matrix for parameters investigated in soil from Ijegun of Lagos (Continuation).

	Zn	BOD	COD	NO_3	pH	EC	TDS
Zn	1.00						
BOD	-0.04	1.00					
COD	0.12	0.36	1.00				
NO_3	-0.10	0.08	0.10	1.00			
pH	0.18	0.12	0.06	0.36	1.00		
EC	0.42	-0.16	0.26	0.05	0.70	1.00	
TDS	0.39	-0.21	0.22	0.04	0.68	0.99	1.00

IV. CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

The assessment of oil spillage on groundwater and soil quality in Ijegun area of Lagos State has been carried out. The concentrations of the parameters investigated in soil of Ijegun community exceeded the concentrations in the control sample. This revealed that the soil within the vicinity of the investigated area has been contaminated which was as a result of incessant oil spillages in the area. The concentrations of parameters investigated in the groundwater from Ijegun community also exceeded the threshold limits stipulated by NSDWQ and WHO for drinking water in terms of TPH, chromium, copper, nickel, electrical conductivity and pH. This revealed the groundwater is not fit for drinking. The correlation matrices showed a strong correlation between TPH and nickel in the soil while a negative correlation existed between TPH and pH in the groundwater. It is obvious that the oil spillage in Ijegun community has impacted negatively on the soil and groundwater of the community.

4.2 RECOMMENDATIONS

Based on the finding in this work, the following are recommended.

- People living in the vicinity of the investigated area should be properly informed about the contamination of their soil and groundwater.
- People living in the vicinity of the investigated area should be informed not to drink the groundwater in their community hence an alternative water supply should be immediately provided.
- Assessment of soil and groundwater quality outside the investigated area should be conducted to ascertain the quality of the soil and groundwater.
- Appropriate remediation should be carried out on the soil and groundwater in the identified contaminated areas.
- The people in the community should work in synergy with the governments and security officials to prevent the activities of the pipeline vandals.

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REFERENCES

[1]. Adams, R.H., Guzman, O. and Zavala-Gruz, F.J. (2008). Water repellency in oil contaminated sandy and clayey soils. International Journal of Environmental Science and Technology, 5(4): 445 – 454.

[2]. American Public Health Association, (APHA) (1994). Standard methods for examination of water and wastewater, Washington.

[3]. Bello, O.S. and Anobeme, S.A. (2015). The effects of oil spillage on the properties of soil and environment around the marketing outlets of some Petroleum Marketing Companies in Calabar, Cross River State, Nigeria. Mayfair Journal of Soil Science, 1(1): 1 – 14.
[4]. HSE – ENV (2004). Accompanying guidelines for SPDC EIA process – Data collection. Vol. 111. HSE – ENV, SPDC – 0002712.
[5]. Kumar, M., Kumari, K., Ramanathan, A.L. and Saxena, R. (2007). A comparative evaluation of groundwater suitability for irrigation and drinking purposes in two agriculture dominated districts of Punjah, India. Environmental Geology. Doi: 10.1007/500254 – 007 – 0672 – 3.
[6]. Kurumbei, W.C. and Graybill, F.A. (1985). An introduction to statistical model in geology, New York, Mc GrawHill.
[7]. Makinde, E.O and Tologbonse, A.S. (2017). Oil spill assessment in Ijeododo area of Lagos State, Nigeria using geospatial techniques. Ethiopian Journal of Environmental Studies and Management, 10 (4): 427 – 442.
[8]. Nnaji, J.C. and Egwu, A.C. (2020). Physiochemical characteristics of oil spill impacted agricultural soils in three areas of the Niger Delta. Singapore Journal of Science Research, 10: 137 – 144.
[9]. Nigerian Standard for Drinking Water Quality (NSDWQ) (2015). Guideline for drinking water quality in Nigeria.
[10]. Nwachukwu, A.N. and Osuagwu, J.C. (2014). Effects of oil spillage on groundwater quality in Nigeria. American Journal of Engineering Research, 3(6): 271 – 274.
[11]. Nwilo, S.F., Okpala, K.A. and Nwoke, H.A. (2007). Impact of spill on the ecosystem. UNN Publishing, Nsukka.
[12]. Odunlami, M.O and Salami, L. (2017). Evaluation of soil contamination status in approved mechanic villages in Lagos State, Nigeria. Nigerian Journal of Engineering and Environmental Sciences, 2(1): 169 – 180.
[13]. Okoro, D., Oviasogie, P.O. and Oviasogie, F.E. (2011). Soil quality assessment 33 months after crude oil spillage and clean up. Chemical Speciation and Bioavailability, 23 (1): 1 – 6.
[14]. Osuji, L. C. and Onojake C. M. (2004). Trace metals associated with crude oil: A case study of Ebocha oil spill polluted site in Niger Delta, Nigeria. Chemistry and Biodiversity, 1: 1708 – 1715.
[15]. Osuji, L.C. and Nwoye, I. (2007). An appraisal of impact of petroleum hydrocarbons on soil fertility; the Owaza experience. African Journal of Agriculture, 2(7): 318 – 324.
[16]. Salami, L., Susu, A.A. and Keleola, O. (2020). A comprehensive assessment of grou ndwater quality in the vicinity of the three Soluos dumpsites in Igando area of Lagos State, Nigeria. Greener Journal of Environmental Management and Public Safety. 9(1): 1 – 18.
[17]. Salami, L., Susu, A.A., Gin, W.A. and Musa, U. (2019). Evaluation of groundwater contamination status in Igando area of Lagos State, Nigeria. Journal of the Nigerian Society of Chemical Engineers, 34(1): 17 – 25.
[18]. Salami, L., Willoughby, A., Patinvoh, R.J., Folami, N.A. and Salami, K.B. (2019). Comparative assessment of air quality status of Ikeja and Isolo industrial estate of Lagos State, Nigeria. Journal of Industrial Research and Technology, 8(1): 126 – 139.
[19]. Sumar, M., Khaiwal, R. and Dahiya, R.P. (2006). Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site. Environmental Monitoring Assessment, 8 (1 - 3): 435 – 456.
[20]. Sumar, M., Khaiwal, R., Dahiya, R.P. and Chandra, A. (2006). Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site. Environmental Monitoring Assessment, 8 (1 - 3): 435 – 456.
[21]. Udoh, B.T. and Chukwu, E.D. (2014). Post – Impact assessment of oil pollution on some soil characteristics in Ikot Abasi, Niger Delta Region, Nigeria.
[22]. UNEP Environmental Assessment of Ogoniland (2010). Assessment of contaminated soil and groundwater: 96 – 150.
[23]. Wang, X. and Feng, J. (2009). Effects of crude oil redial on soil chemical properties in oil sites, Momgage wetland, China. Environmental Monitoring Assessment, 161 (1 - 4): 271 – 280.
[24]. Wekpe, V.O and Mgbengassa, S. (2016). Oil spill and soil quality in a tropical deltaic environment of South – South, Nigeria. Journal of Geographic Thought and Environmental Studies, 14 (1 – 2): 1 – 15.
[25]. World Health Organisation (1997). Guideline for drinking water quality, healthcriteria and other supporting information, 2(2): 940 – 949.
[26]. World Health Organisation (WHO) (2004). WHO guidelines for drinking water quality, 3rd ed., WHO Geneva, Vol. 1.
[27]. Wyesekara, S., Onia, S., Sirwardana, A.R. and Nalin, S. (2014). Fate and transport of pollutants through municipal soild waste landfill leachates in Sirlanka. Environmental Earth Science, 72(5): 1707 – 1719.

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