ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

Effects of Drilling Waste on Pedo-Physical, Chemical and Microbiological Properties in EDEGELEM and ONNE Rivers State, Nigeria

OKEKE P.N AND NWEBOR O.M

Department of Environmental Management, Federal University of Technology P.M.B, 1526 Owerri, Nigeria

ABSTRACT: The study examined the effects of drilling waste on pedo-physical, chemical and microbiological properties in Edegelem and Onne, Rivers State Nigeria. The samples were collected at depths of 0-15cm (topsoil) and 15-30cm (subsoil). The soil samples were analyzed using the procedures described by American Public Health Association (APHA),American Standard Test Method (ASTM) and Canadian Society of Soil Science. The parameters determined were: bulk density, infiltration rate, pH, PAHs, organic carbon, Nitrate, phosphate content and heavy metals.Others were Total Hydrocarbon Bacterial Count and the Hydrocarbon Utilization Bacterial Count. Results obtained show that bulk density varied from 1.64 to 2.8 g/cm^{3}in the polluted area and from 2.51to 2.64g/cm^3 for the control. The value of pH, ranged from 5.10s to 6.80 in the polluted area and from 7.10 to 8.10 in the control. The variations of PAHs, organic carbon, sulphate, nitrate and phosphate in the polluted areas were 80.2 to 261.0mg/kg, 1.00 to 165mg/kg, 12.10 to 17.30mg/kg, respectively. PAHs was not detected in the control while the values of organic carbon content, sulphate and nitrate ranged from 2.45 to 290mg/kg, 22.2 to 30.0mg/kg and 19.60 to 21.2mg/kg, in that order. The results further show that the heavy metals such as Chromium, Lead, Barium, Nickel and Manganese had mean concentrations ranging from 80.4 to 130.6mg/kg, 86.7 to 167.0mg/kg, 99.6 to 141.06mg/kg, 0.62 to 0.83mg/kg in the polluted areas, respectively. The mean values of the heavy metals in the control varied from 0.78 to 0.94mg/kg, 0.025 to 0038mg/kg, 0.019 to 0.031mg/kg, 0.021 to 0.021mg/kg and 0043 to 0.049mg/kg respectively. The valuesof the heavy metals in the polluted areas were higher than the world Health Organization (WHO) standards. The Total Hydrocarbon Bacterial Count and Hydrocarbon Utilization Bacterial Count for the polluted area ranged from 310 to 8023 (10cfu/ml) and 100 to 1600 (10 cfu/ml) while the values in the control varied from 47000 to 60200 (10 cfu/ml) and 8100 to 23000 (10 cfu/ml), respectively.

KEYWORDS: Drilling wastes, pedo-physiocal, chemical and microbiological properties, WHO standard, Edegeme and Onne, Rivers State.

I. INTRODUCTION

Nigeria is one of the major oil producing nations. It is the largest in Africa and the sixthin the world[1]. Oil is the mainstay of the country's economy contributing 87.7% of the foreign exchange and 8.5% of her national GDP [2].
The Niger Delta region is the hub of oil exploration and production in Nigeria but despite the benefits accruing to the host communities from oil, it has not been without some negative environmental effects[3]. Oil production activities in this region have adversely impacted on the physical environment and socio-economic wellbeing of the inhabitants. The ecologicl zone is devastated andthis has triggered various forms of youth restiveness, agitation for resource control, and social vices.
Edegelem and Onne communities in Rivers State are among the places where oil companies operate in Niger Delta region. The areas have good fertile land and farming is their main source of livelihood. During oil and gas drilling, significant quantities of mud and cutting wastes are produced. The combination of these two wastes gives rise to drilling wastes [4].Other components of drilling wastes are produced water, hydrocarbons and heavy metals [5]. According to [6], drilling wastes can also be grouped on the bases of drilling fluid that was utilized to drill the well and the accompanying cuttings. They are water-based mud and cuttings which consist of; fresh water mud and cuttings, oil based cutting (OBC), and synthetic based mud and cuttings (SBMC).
The wastes have the potentials to impact negatively on the environment[7]. They are ecocides and have adverse effects on earthworms and other biological properties of soil because of their toxicity [8].

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

The main objective of this study therefore, was to assess the influence of drilling wastes on soil physical, chemical and microbiological properties. This became necessary because some of the constituents of the wastes are toxic, non-degradable and can bio-accumulate at high trophic levels.

II. MATERIALS AND METHODS

The study was carried out in two locations; Edegelem and Onne in Rivers State.Edegelem lies within latitudes 4^o27’20”N and 4^o47’20”Nand longitudes 6^o42’20” and 7^o 27’30”E whileOnne can be located between Latitudes 4^o14’20” and 5^o55’20” N, and longitudes 6^o 42’20” and 7^o 27’30”E (figure 1).

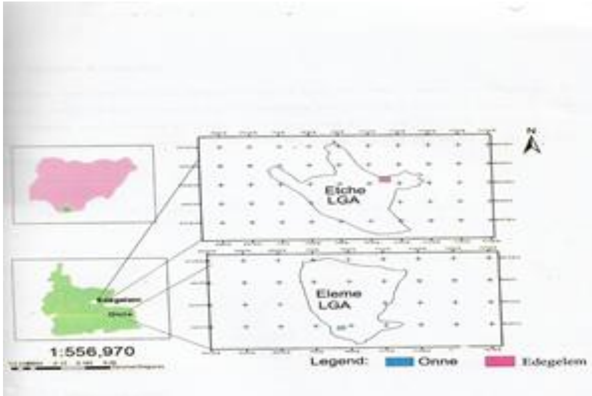

Figure 1: Map of the study

The average annual temperature and rainfall for the two areas were 26.5^{o}c and 2992mm, respectively [9].The soil types vary from sandy to loamy soils while the geology is Benin formation. The major land use activities are agriculture, and oil exploration and exploitation.

A. Sample Collection

Composite soil sample were collected using soil auger from three points at each location: A (Edegelem), B (Onne) and C (control) (figure 2)at depths of 0-15cm topsoil and 15-30 (subsoil).The sampling locations were a 500m from one another. The infiltration rates were determined in-situ. The photo shows one of the drilling wastes impacted locations sampled.

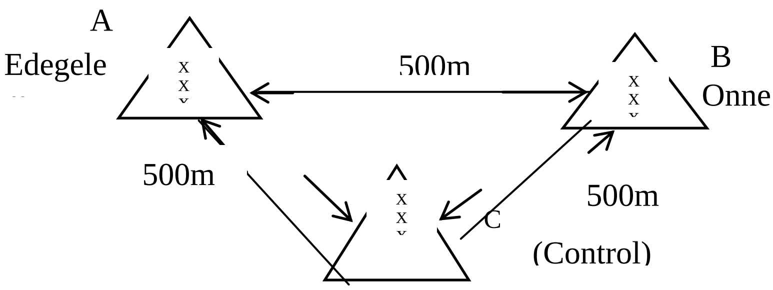

Figure 2: A schematic representation of the sampling

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

Photo: One of the drilling waste impacted locations

The soil samples were properly labeled and taken to the laboratory for preparation and analysis. In the laboratory, some of the samples were air-dried and sieved with 2mm sieve before analysis.

B. Laboratory analysis

The methods described by [10], [11] and [12]were adopted for the analysis. Parameters determined were: particle size, Bulk density, pH, Organic carbon, phosphate, Nitrate and sulphate ions. Others include Polycyclic Aromatic Hydrocarbons (PAHs), Hydrocarbon utilization Bacterial Count (HUBC) and heavy metals (Cr, As, Pb, Ba and Mn). The values of the heavy metals were compared with WHO standards [13].

C. Statistical technique

Statistical package for social sciences (SPSS) version 20 was used for the computation of ANOVA, correlation and t-tests.

III. RESULTS AND DISCUSSION

Table 1 shows the pedo-physical, chemical and microbiological properties of the study locations. The polluted areas (locations A and B) had higher bulk densities than the control (location C). The higher bulk densities could be attributed to the influence of the drilling mud which filled the soil air spaces thereby increasing the soil mass and its resultant bulk densities.High bulk density delays shoot emergence and also reduces free movement of air and water in the soil.

The infiltration rate was lower in the polluted area than the control. This was probably due to the impact of the drilling mud which blocks the pore spaces thereby restricting water inflow and hydraulic conductivity [14].Blockage of pore spaces will cause more runoff and its attendant soil erosion.

The soil in the polluted area was acidic while it was alkaline in the control. The lowpH (table 1 and fig 2) of the polluted area could be linked to the presence of poly-aromatic hydrocarbon (PAHs) in the drilling mud [15]. This is corroborated by the negative correlation (P<0.01) between pH and PAHs in the soil(Tables 2 and 3). However, the pH positively correlated with THBC and HUBC at (p<0.01) and (p<0.05), respectively (tables 2 and 3).The low pH was important because it could affect mobility of toxic metals and also activities of microbes.

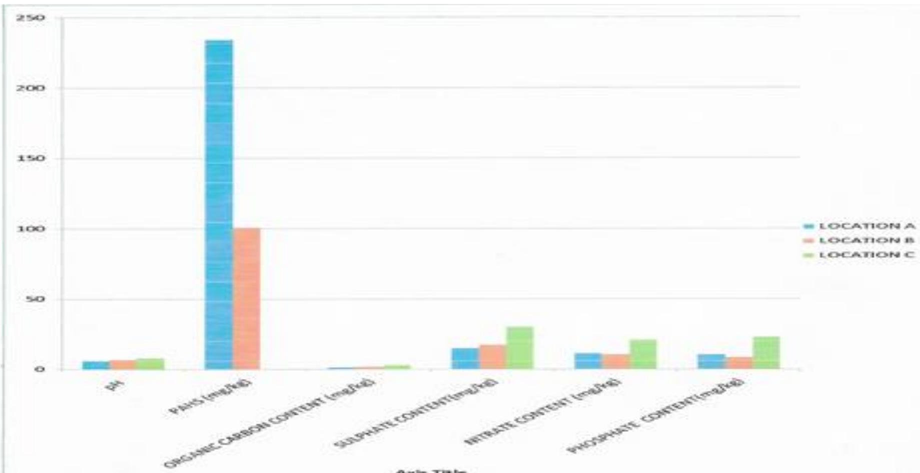

Figure3: Mean values of chemical parameter of locations A, B and C (topsoil)

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

Concentrations of PAHs in the polluted area were above WHO limit of 100mg/kg, indicating that it would have adverse effects on the environment. Polyaromatic hydrocarbons are toxic and carcinogenic [16]. It is an ecocide that can kill both plants and animals.

The values of the selected plant essential nutrients (organic carbon, Nitrates, phosphate and potassium) were higher in the control than the polluted area (table 1) (figure 2). This could be attributed to the adverse influence of the pollutants on the microbes. The pollutants kill the microbes thereby preventing the decomposition of organic compounds into inorganic nutrients. The non-release of these nutrients reduces soil fertility and quality. However, the concentrations of the nutrients were significantly different between the topsoil and the subsoil (tables 4 and 5).

Levels of some of the heavy metals; chromium (Cr), Lead (Pb), and Barium (B) were high and above the control concentrations (figure 3) and WHO limits. Other metals, Nickel (Ni), Arsenic (As), and Manganese (Mn) were however lower than the limits. The high level of the heavy metals in the polluted areas was as a result of the drilling wastes disposed on the soil [17]. There were significant differences in concentrations of the metals between the topsoil and the subsoil in the polluted areas (tables 4 and 5). Heavy metals are carcinogenic to humans [18]

Table 1: values of soil physical, chemical and microbiological properties

	Location A		Location B		Location C		WHO Std
Parameters	0-15	15-30	0-15	15-30	0-15	15-30	Value
Clay (%)	18.2	16.3	17.2	19.4	17.0	19.4	-
Slit (%)	22.7	23.5	42.8	50.2	32.2	30.3	-
Sand (%)s	59.2	60.2	40.0	30.4	50.8	50.1	-
Bulk density (g/cm^3)	2.46	2.55	2.05	2.79	1.52	1.63	-
Infiltration Rate (mm/hr)	21.1	20.2	28.4	27.5	80.3	76.7	-
pH	6.1	5.27	6.63	6.25	7.96	7.05	-
PAHs (mg/kg)	233.93	125.4	100.7	80.6	0.00	0.00	100
Organic carbon content (mg/kg)	1.24	1.14	1.61	1.106	2.86	2.475	-
Sulphate SO_4^{-2}(mg/kg)	14.8	12.17	17.2	15.17	29.9	28.1	-
Nitrate NO_3^- (mg/kg)	11.1	9.05	10.5	8.06	20.85	19.9	-
Phosphate, PO_4^3(mg/kg)	10.3	8.23	8.32	8.10	22.4	21.30	-
Chromium, Cr (mg/kg)	130.6	113.7100 .4	80.4	0.94	0.78	100	
Arsenic, As (mg/kg)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	20
Lead, Pb (mg/kg)	167	165.6	87.0	86.6	0.038	0.025	100
Barium, Ba (mg/kg)	115.9	99.6	141.06	120.96	0.031	0.019	100
Nickel, Ni (mg/kg)	0.83	0.8	0.8	0.62	0.021	0.021	50
Manganese, Mn (mg/kg)	176.7	105.39	140.5	81.47	0.043	0.049	2000
Potassium, K (mg/kg)	0.78	0.67	0.736	0.27	2.35	1.805	1000
Total hydrocarbon bacteria count (10 cfu/ml)	4603	320	8023	2200	60100	47050	-
Hydrocarbon utilization bacteria count (10 cfu/ml)	120	110	1400	130	22500	8200	-

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

Table 2: Correlation analysis for PAHs, THBC and HUBC for top soil (0-15cm)

Parameters	**Correlation coefficient**	**Sig**
pH with PAHs	-0.950**	0.01
pH with THBC	0.924**	0.01
pH with HUBC	0.896**	0.05

Table 3: Correlation analysis for pH, PAHs, THBC and HUBC for sub-soil (15-30cm)

Parameters	**Correlation coefficient**	**Sig**
pH with PAHs	-0.979**	0.01
pH with THBC	0.964**	0.01
pH with HUBC	0.866**	0.05

Table 4: Two-way ANOVA analysis for soil nutrients and heavy metals for location

Location A	**f-calculated**	**f-critical or f-tabulated**	**Inference**
Soil nutrients	1180.08977	2.764199	Significant
Heavy metal	211.307586	2.11916569	Significant

Table 5: Two-way Anova analysis for soil nutrients and heavy metals for location B

Location A	**f-calculated**	**f-critical or f-tabulated**	**Inference**
Soil nutrients	8379.7832	2.764199	Significant
Heavy metal	41696.93	2.11916569	Significant

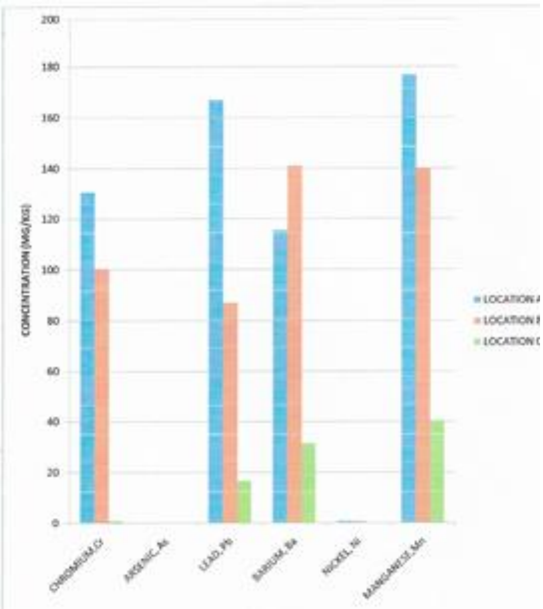

Figure 4: Mean concentrations of heavy metals in locations A,B and C (topsoil)

The soil microbial population which comprised of the Total Hydrocarbon Bacterial Count (THBC) and Hydrocarbon Utilizing Bacteria (HUB) (table 1) were lower in the polluted areas than in the control soils (figure 4). The low population of the microbes in the polluted areas was probably due to the toxic effect of the drilling waste[18]. Microbes enhance soil fertility [19] through enzymatic decomposition of organic matter during nutrient cycle.

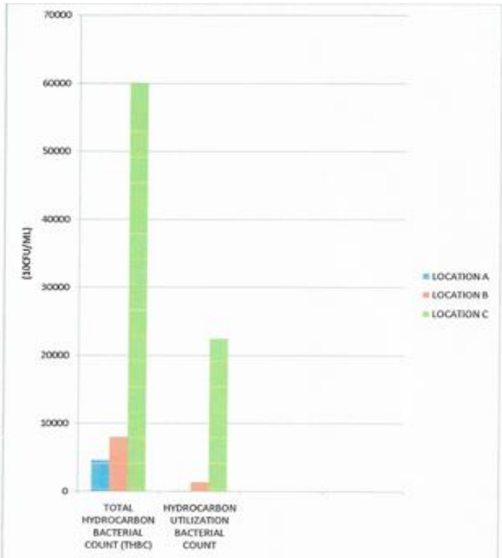

Figure 5: Mean values of microbial parameters in Locations A,B and C (Topsoil)

The oil drilling activities in Edegelem and Onne communities generated wastes which were being disposed on agricultural land. These wastes adversely impacted on the soil physical, chemical and microbiological properties. The concentrations of PAHs and heavy metals in the polluted areas were above WHO limits and also higher than the control values. Conversely, the values of the selected nutrient elements were lower in the polluted areas than the control. This was an indication that drilling wastes polluted and reduced the soil fertility and quality. Consequently, food security in the affected communitiesis being threatened. There is an urgent need therefore to control further disposal of drilling wastes on the arable lands.

REFERENCES

[1] https://en.wikipedia>wiki>petroleum-industry-in-NigeriaRetrieved October, 2019.
[2] https://africacheck.org>reports>nigeria-economyservices-drive-gdp-but-- Retrieved October, 2019.
[3] Ekpo, M.A and Nwaugo, V.O (2008). Effects of Drilling Mud Additives on the physiological characteristics of Cassava plant under Intercrop in the Tropics, Nigeria. Journal of Microbiology. 22(1) :1634-1642.
[4] Ewa, S. Barbara, K. Kazimere G;Justyna, K. and Rental, K. (2012). ChemicalComposition and Properties ofWeathered Drilling Waste.Environmental Protection Engineering.Pub.University of Science and Technology. 38(1) :129-138.
[5] Det Norske Veritas (DNV) (2013). Offshore Services Modulus: Standard for Certification.http://www.dnv.com 2:7-12.
[6] Ohio Environmental Protection Agency (2012). Facts Sheet Drilling Cuttings from Oil and Gas Exploration in Marcellus and Utica Shale.Publisher, Department of Natural Resources, www.ohioshaleinfo.com.Pp1-2.
[7] Onwukwe, S.I. andNwakaudo, M.S. (2012).Drilling waste generation and management Approach: An International Journal of Environmental Science and Development. 3(3): 252-257.
[8] Karen, M.C and Jonathan, G.M. (2002). Drilling Fluid chemicals and Earthworm Toxicity. Developed and Hosted by College of Information Science and Technology, Pennsylvanian University Press Publishers, (2):1-16.
[9] http://en.climate-data.org>Africa>Nigeria>Rivers. Retrieved October, 2019.
[10] American Public Health Association (APHA) (1995). Standard Methods for the examination of water and waste water (20th Ed.)Washington, D.C. American Public Health Association, WPCF, and AWWA.
[11] American Standard Test Methods (ASTM) (1998). Standard Test Method for Soil Analysis. ASTM, 100BarHarber Driver West Conshohocken, United States, Pp 1-8.
[12] Canadian Society of Soil Science (2006). Soil Sampling and Methods of Analysis. 2nd edition by M.R. Carter and E.GGregorich (eds).By Taylor and Francis Group, LLC.

[13] Chiroma, T.M; Ebewele, R.O' Hymore, F.K (2014). Comparative Assessment ofHeavy Metals Levels in Soil, Vegetables and Urban Grey waste water used for Irrigation in Yola and Kano. International Referred Journal of Engineering and Science. 3(2):01-09.
[14] Sheikh, A.M. (2010).Environmental Management of Drilling Mud.International Journal of Environmental Waste ManagementUnderscienc Publishers. Vol. 17:1-230.
[15] Bauder, T.A; Barnarick, K.A;Ipolito, T.A; Shanhan, J.F and Ayers, P.D. (2005). Soil Properties Affecting Wheat yields Following Drilling Fluid Application. Publication: Asa CSSA and SSSA 677 Segoe Road Madison Wl 53711.
[16] World Health Organization (1993). Guidelines for Drinking Water Quality Recommendations. 2nd edition, Geneva, WHO In:Gbadebo, M.A; Taiwo M.A and Eughela, U. (2010): Environmental Aspect of oil and water based drilling muds and cuttings from Dibi and Ewan offshore wells in the Niger Delta, Nigeria. African Journal of Environmental Science Technology, 4(5): 284-292.
[17] Iselema, R.U; Adie, D.B andOkufu, C.A (2012).Evaluating the Levels of Pollutants from spent Drilling Fluids in Oil Field in Niger Delta, Nigeria.Journal of Technology. www.ajol.info/index.php/article. 31: 269-279.
[18] Nwaugo, V.O;Onyeagba, R.A;Azu, N. andNworie, O. (2007). Petroleum produced water induced Changes in Bacterial Quality and Soil Enzymatic Activities in Farmlands in Egbema, Southern Nigeria. PUCR Publishers, EstudBiol (66): 89-97.
[19] Zhang H.L.Y; Zhang C.G. and Chien, G.X. (2005).Petroleum containing waste water Irrigation on Bacterial Diversities and Enzymatic Activities in Paddy Soil Irrigation Area. Journal of Environmental Quality Vol. 34: 1073-1080.