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Characterization of Crude Oil Contaminated Soils in Niger Delta Nigeria

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Abstract:

This study examined the characterization of crude oil contaminated soils in Niger Delta Nigeria. The objectives of the study include to determine the pH and electrical conductivity of crude oil contaminated soils, ascertain the heavy metal concentration of soils polluted with crude oil as well as establish the petroleum hydrocarbon concentration of crude oil contaminated soils in Niger Delta region. Survey method was employed as the study design. Samples of crude oil contaminated soils were collected from five (5) different locations in Niger Delta where there are obvious layers of oil/petroleum by random sampling. The collected samples of crude oil contaminated soils were stored in polyethylene bags. From the five soil samples, some were kept in a dirt free jar lined with Teflon cap and then cooled down to around 4 degree Celsius in sheaths of ice. Some samples of the soil meant for use in assessing the physicochemical characterization of crude oil polluted soils were dried at a temperature of 24°C, grinded, sieved and the portions tested for pH using meter. Also assessed was the electrical conductivity of the soil sample which was done using conductivity meter. The soil temperatures were assessed using thermometer. Heavy metal concentrations of crude oil contaminated surface water were ascertained using Elmer Model 2280/2380 spectrophotometer. The petroleum hydrocarbons concentration of the crude oil contaminated samples was determined. Results revealed that land areas polluted with crude oil are slightly acidic, have low electrical conductivity, high concentration of heavy metals and petroleum hydrocarbon. Thus contamination of soil with crude oil poses major environmental as well as public health issues that should be drastically addressed. The need for government, non-government organizations, international agencies and related stakeholders to take crucial initiatives towards preventing as well as curbing the contamination of soils and the entire ecosystem with oil pollutants more particularly, crude oils was recommended

Keywords: Characterization, crude oil, contaminated, soils, niger delta, Nigeria

1. Introduction

Pollution of the ambient environment with crude oil is one of the major environmental issues of concern facing rural and urban communities in Southern Nigeria's Niger Delta. Oil spillage ranks high as one of the ways of polluting the ecosystem more particularly soils followed by flaring of gases. Soil contamination from oil pollution is linked with the oil and gas exploration (Imasuen, Galasi & Omorogieva, 2014). The sources of crude oil spillage include accidents involving tankers, oil facilities damage, pipeline corrosion and consequent leakage (Uzoije & Egwuonwu, 2009). Crude oil refers to petroleum in the unprocessed form, a collection of organics with differing constitution (Investopedia.com, 2018). Crude oil in Nigeria has a high composition of mercury, iron, zinc, copper and other metals that threatens humans, plants and animal survival. Onojake and Okonkwo (2011) reports that soils polluted with crude oil spillage have high deposits of metals with Cu in the range of 0.50 – 13.41mg/kg, Cr within the range of 0.2 to 0.85mg/kg, Fe in the range of 6.18 – 8.74mg/kg, Ba within the range of 80 – 108mg/kg, Ni within the range of 0.61 – 4.80mg/kg, V ranging within 4.03 – 9.4mg/kg, exchange power of cations within the range of 43.6 – 57.2 mg/kg in top and lower soil levels.

According to Imasuen and Omorogieva (2013), crops cultivated on crude oil contaminated soil are highly laden with heavy metals. In other words, Soil and water environment polluted with crude oil is concentrated with metals, petroleum hydrocarbons, bacteria all of which exerts effects on the acidity and general physicochemical properties of the different types of soil in some ways. The presence of crude oil contaminants in form of organic and inorganic substances in the soil beyond normal concentrations changes the composition, texture, chemical and overall characteristics of the soil (Aprile, Tatano & Musmeci, 2007). Thus there is a significant alternation in the physicochemical properties of crude oil contaminated soil.

Crude oil contaminated soils have high concentrations of petroleum hydrocarbons such as benzene, toluene, oil and grease, total petroleum hydrocarbon and polynuclear aromatic hydrocarbons with the mean values standing at 581.02 (TPH), 492.55 (oil and grease), 20.41 (PAH), 6.66 (benzene, toluene, ethylbenzene and xylenes) and 4.22 (total inhibitor content) (PAH), ethylbenzene and Xylenes (Okoro, Oviasogie & Oviasogie, 2011). Alinnor, Ogukwe and Nwagbo (2014) reported total petroleum hydrocarbon concentrations in crude oil contaminated soils at different stations to be about 1341.00mg/kg, 1678.25mg/kg, 1366.00 mg/kg and 1242.33 mg/kg. Onojake and Okonkwo (2011) reported that crude oil contaminated soils are characterized by a mean temperature of 30°C, pH of 7.10, electrical conductivity of 0.03, turbidity of 430.00, salinity of 0.01-0.20, dissolved oxygen level of 8.10 and total petroleum hydrocarbon of 84.00. The pollution of soil layers with crude oil and organic materials results in increased deposition of manganese and ferrous ions in levels where they could exert toxic effects on soils and plants (Chukwuma, Ikechukwu & Obinna, 2012). This means that a high level of crude oil pollution of the soil impairs the growth and development of plants.

The inimical consequence of crude oil on the environment varies with the ecological system where spillage occurs (Onwurah, Ogugua, Onyike, Ochonogor & Otitoju, 2007). The consequences of the presence of contaminants from crude oil in the soil have over the years been an issue of worry to Nigerian government and international agencies. Soil contamination with crude oil has in recent times been associated with health problems. According to Chukwuma, Ikechukwu and Obinna (2012), soils polluted with crude oil produce polluted food and water. The content of crude oil could harm humans by bringing about a disruption in synthesis of protein and causing significant injury to plasma membrane (Prescott, Harley & Klan, 1996). Furthermore crude oil concentrations in crops have been associated with impairment in reproductive function of humans, exacerbation of respiratory and related health issues (Kaladumo, 1996; Prescott, Harley & Klan, 1996; Onwurah, 2002).

Knowledge of the characterization of crude oil contaminated soils is needed to adequately remediate the soil environment polluted with crude oil. This paper therefore investigated the characterization of crude oil contaminated soils in Niger Delta, Nigeria

2. Materials and Method

Survey method was employed as the study design. Samples of crude oil contaminated soils were collected from five (5) different locations in Niger Delta where there are obvious layers of oil/petroleum by random sampling. The collected samples of crude oil contaminated soils were stored in polyethylene bags. From the five soil samples, some were kept in a dirt free jar lined with Teflon cap and then cooled down to around 4 degree Celsius in sheaths of ice. Some samples of the soil meant for use in assessing the physicochemical characterization of crude oil polluted soils were dried at a temperature of 24°C, grinded, sieved and the portions tested for pH using meter. Also assessed was the electrical conductivity of the soil sample which was done using conductivity meter. The soil temperatures were assessed using thermometer. Heavy metal concentrations of crude oil contaminated surface water were ascertained using Elmer Model 2280/2380 spectrophotometer. The petroleum hydrocarbons concentration of the crude oil contaminated samples were determined

3. Results and Discussion

3.1. Results

Soil Samples	Ph	EC (Mscm_1)
1	5.90	124.4
2	5.56	123.5
3	5.93	136.4
4	6.40	128.8
5	5.98	138.4
Mean	5.95	130.3

Table 1: Ph and Electrical Conductivity of Crude Oil Contaminated Soil Samples in Niger Delta, Nigeria

Table 1 shows the pH and electrical conductivity of crude oil contaminated soil samples in Niger Delta. The pH of 5.95 and EC (mScm_1) of 130.3 shows that crude oil contaminated soils are slightly acidic and electrical conductivity is lower in crude oil polluted soils

Soil Samples	Zn	Fe	Cu	Cr	Co	Pb	Cd	As	Ba	Hg	Ni	V
1	0.55	173.3	0.63	1.02	0.57	2.30	1.88	0.00	0.10	0.22	0.20	0.01
2	0.57	157.1	0.67	0.89	0.55	2.32	1.92	0.10	0.04	0.00	0.01	0.00
3	0.60	177.3	0.66	1.10	0.51	2.34	1.96	0.12	0.20	0.20	0.10	0.00
4	0.52	172.7	0.59	1.00	0.59	2.21	1.90	0.41	0.12	0.12	0.24	0.22
5	0.50	171.3	0.69	0.92	0.57	2.11	1.95	0.22	0.00	0.00	0.10	0.00
Mean	0.55	170.3	0.65	0.99	0.56	2.26	1.92	0.17	0.09	0.11	0.13	0.05

Table 2: Heavy Metal Concentration [mg kg⁻¹] of Crude Oil Contaminated Soil Samples in Niger Delta Nigeria

Table 2 reveals the heavy metal concentration of crude oil contaminated soils in Niger Delta Nigeria. The mean concentrations of Zn, Fe, Cu, Cr, Co, Pb, Cd, As, Ba, Hg, Ni and V include 0.55, 170.3, 0.65, 0.99, 0.56, 2.26, 1.92, 0.17, 0.09, 0.11, 0.13 and 0.05 respectively. This indicates that there is a high concentration of heavy metals in crude oil contaminated soils in Niger Delta Nigeria.

Soil Samples	TPH (mg kg ₋₁)	Oil and Grease (mg kg ₋₁)	PAH (mg kg ₋₁)	BTEX (mg kg ₋₁)
1	581.0	489.6	22.80	5.86
2	576.5	492.5	18.96	6.42
3	588.3	490.1	20.41	6.66
4	583.1	493.2	19.02	6.47
5	581.3	496.3	22.50	6.33
Mean	582.0	492.3	20.74	6.35

Table 3: Concentration of Total Petroleum Hydrocarbon, Oil and Grease and Polynuclear Aromatic Hydrocarbon in Crude Oil Contaminated Soil Samples in Niger Delta Nigeria

Table 3 shows the concentration of total petroleum hydrocarbon, oil and grease and polynuclear aromatic hydrocarbon in crude oil contaminated Soil samples in Niger Delta Nigeria. The concentrations of TPH, Oil and Grease, PAH and BTEX in mg kg₋₁ include 582.0, 492.3, 20.74 and 6.35 indicating a high concentration of total petroleum hydrocarbon, oil and grease, polynuclear aromatic hydrocarbon and Benzene, Toluene, ethylbenzene and xylenes in crude oil contaminated soils in Niger Delta.

4. Discussion

Findings from the study showed that crude oil contaminated soils are slightly acidic and electrical conductivity is lower in crude oil polluted soils; there is a high concentration of heavy metals crude oil contaminated soils in Niger Delta Nigeria; a high concentration of total petroleum hydrocarbon, oil and grease, polynuclear aromatic hydrocarbon and Benzene, Toluene, ethylbenzene and xylenes in crude oil contaminated soils in Niger Delta. These results indicate that crude oil polluted soils are slightly acidic with less conductive abilities, laden with heavy metal and hydrocarbons in varying volumes. These results are in line with the findings of the study conducted by Onojake and Okonkwo (2011) which revealed that soils polluted with crude oil spillage have high deposits of metals with Cu in the range of 0.50 – 13.41mg/kg, Cr within the range of 0.2 to 0.85mg/kg, Fe in the range of 6.18 – 8.74mg/kg, Ba within the range of 80 – 108mg/kg, Ni within the range of 0.61 – 4.80mg/kg, V ranging within 4.03 – 9.4mg/kg, exchange power of cations within the range of 43.6 – 57.2 mg/kg in top and lower soil levels. The submission of Imasuen and Omorogieva (2013) that there is a heavy concentration of trace/ heavy metals in crude oil contaminated soils also substantiates the results of this study. This characterization of crude oil polluted soils with slight acidity, low electrical conductivity, high level of heavy metals and petroleum hydrocarbon has negative implications for existence, survival and overall public health. According to Chukwuma, Ikechukwu and Obinna (2012), soils polluted with crude oil produce polluted food and water. Prescott, Harley and (1996) noted that the content of crude oil could harm humans by bringing about a disruption in synthesis of protein and causing significant injury to plasma membrane Kaladumo (1996) reports that crude oil concentrations in crops have been associated with impairment in reproductive function of humans, exacerbation of respiratory and related health issues. Thus the introduction of crude oil into the soil is an environmental as well as public health problem.

5. Conclusion

Since the discovery of petroleum in Nigeria's Niger Delta, the exploration and production process has continued to threaten the ambient ecosystem of the region. Complaints abound on cases of oil pollution especially crude oil contamination of soils which has made subsistence difficult. This study on the characterization of crude oil contaminated soils in Niger Delta Nigeria, concludes that land areas polluted with crude oil are slightly acidic, have low electrical conductivity, high concentration of heavy metals and petroleum hydrocarbon. Thus contamination of soil with crude oil poses major environmental as well as public health issues that should be drastically addressed. There is therefore the need for government, non-government organizations, international agencies and related stakeholders to take crucial initiatives towards preventing as well as curbing the contamination of soils and the entire ecosystem with oil pollutants more particularly, crude oils.

6. Acknowledgement

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7. Abbreviations

pH: Potential for Hydrogen

Pb: Lead

Cd: Cadmium

Zn: Zinc

Ni: Nickel

Cr: Chromium

Cu: Copper

Ni: Nickel

V: Vanadium

Fe: Iron

Co: Cobalt

Hg: Mercury

As: Arsenic

Ba: Barium

TPH: Total Petroleum Hydrocarbon

PAH: Polynuclear Aromatic Hydrocarbon

BTEX: Benzene, Toluene, Ethylbenzene and Xylenes

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