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Research Article

Benzene, Phenol, Oil and Grease Content of Petroleum Contaminated Soil

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ABSTRACT

Crude oil contamination of soil due to spillage and leakages around surface oil storage tanks in Eleme, Port Harcourt was investigated. Six petroleum contaminated soil samples from Eleme and one non petroleum contaminated soil sample (control) from Awka were collected within the range for top soil, 0-12cm. The samples were analyzed for benzene, phenol, oil and grease according to the standard methods. The results obtained showed that benzene concentration varied from 0.1031 to 1.0293mg/kg, phenol concentration fell in the range 0.7285-1.8397mg/kg then oil and grease ranged from 6.667-20.899%. The results show elevated levels of benzene, phenol, oil and grease in petroleum contaminated soils when compared with non-petroleum contaminated soil. Benzene concentrations are lower than the upper limit of 5mg/kg stipulated by the Environmental Management (Soil Quality Standards) Regulations, 2007. Continuous monitoring of the environment should therefore be embarked upon so as to avoid the ugly incidence that may occur.

Key words: Benzene, Phenol, Oil, Grease, Contaminated soil.

INTRODUCTION

Soil is said to be contaminated when either solid or liquid hazardous substances get mixed with the naturally occurring soil. These hazardous substances might either have been spilled or buried directly in the soil or might have migrated to the soil and water from a spill that has occurred elsewhere (Okaeanti, 2001). Large scale crude oil spills on soil, leakages from pipelines, underground and surface fuel storage tanks, indiscriminate spills, and careless disposal and management of waste and other petroleum by – products of the society, constitutes the major sources of petroleum contamination in our environment (Okop and Ekpo, 2012).

Pollutants associated with oil spillage are benzene, toluene, PCBs, Chloroform, phenols, petroleum hydrocarbons (C_1-C_{40}), heavy metals, oil and grease and other aromatics (Kostecki and Calabrese, 1989: Finar, 1980). The main components of petroleum and its products are aliphatic and aromatic hydrocarbons. Aromatic hydrocarbons (benzene, toluene, ethyl benzene, xylenes) defined by the common name of BTEX are regarded by the US Environment Protection Agency (USEPA) as primary contaminants due to the threat they pose to human health (Hawrot-Paw, 2010). The contamination of water and soil by petroleum substances negatively affects plant production and puts health of people and animals at risk as most of the substances are toxic for living organisms (Kolwzan *et al*., 2001). The study is carried out to assess the benzene, phenol, oil and grease content of petroleum contaminated soils so as to establish the levels of pollution and possibly proffer solution to the problem.

MATERIALS AND METHODS

Study Area

The study area or sampling sites were located at Eleme, Port Harcourt around surface crude oil storage tanks and utiliy building, Nnamdi Azikiwe University Awka.

At the Eleme site, soil has been subjected to petroleum spillages from tanks.

Eleme coordinates are 4.7994^{o}N, 7.1198^o E. It is located at east of Port Harcourt and covers an area of 138 km^2. At 2006 census, it had a population of 190,884. Precipitation in Port Harcourt averages 2708 mm and the average annual temperature is 26.4^{o}C. The average annual relative humidity is 71.0% (https//weather and climate.com). Awka is found in the south eastern part of Nigeria. It is the capital of Anambra State and is located on Latitude 6^{o}09′N and Longitude 7^{o}12′E. The climate is tropical with an annual rainfall of about 11,450mm, average temperature of 28^{o}C and relative humidity of 91% at dawn (Nwangwu, 2015).

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Sample Collection

Samples were collected randomly within the top soil range of 0-12cm with soil auger and transferred into black polythene bags (Okop and Ekpo, 2012). A total of six petroleum contaminated soil samples were collected from around six crude oil storage tanks and labelled A, B, C, D, E and F. Non petroleum contaminated soil sample was collected from Awka and labelled G. This was to serve as control for comparison with the contaminated soil samples.

Sample Preservation

Samples were collected into black polythene bags and stored in the laboratory fridge at 4^{o}C.

Sample Analysis

Samples for benzene determination were extracted and analyzed using the method described by AOAC, 1990. Phenol was determined spectrophotometrically according to the method outlined by Kirk and Sowyer, (1991). Oil and grease was determined using soxhlet extraction method described by AOAC, (1990).

RESULTS AND DISCUSSION

The benzene results presented in Table 1 compare favourably with those of Zacharyasz *et al*., (2012).

The results are within the limit prescribed by the Environmental Management Regulations -EMR, (2007). Benzene is present in all the samples including sample G (control) which is not petroleum contaminated. However, sample G has the least concentration. Aromatic compounds occur naturally in petroleum and coal tar (Finar, 1980 and Murray, 1983) and are also traceable to laboratory and refinery effluents (Kostecki and Calabrese, 1989). The presence of benzene in sample G is traceable to effluent from school laboratory. Benzene is known to cause lung cancer when inhaled or ingested (Sharma, 2010).

The results of the analysis show the presence of phenol in all the samples with the highest value being obtained in petroleum contaminated soil as shown in Table 2.

The presence of phenol in the petroleum contaminated soil samples tallies with the findings obtained from the chemical analysis of a facility for waste oil storage and recovery by Bridgeport Rental and oil Storage Services New Jersey, USA (Kostecki and Calabrese, 1989). The presence of phenol in all the samples shows the possible contamination of virtually everything around us by phenol even foodstuffs. Higher levels are obtained near sources of pollution or in materials contaminated with phenol. Sources of phenol are petroleum (Kostecki and Calabrese, 1989; Finar, 1980), coal tar (Murray, 1983) and burning of wood. Phenol is used as an antiseptic and disinfectant and in the preparation of dyes, drugs and bakelite (Finar, 1980).

The results of the oil and grease analysis found in Table 3 are also in agreement with those of Zacharyasz *et al.*, (2012).

Oil and grease are present in all the samples with the least concentration found in sample G (non petroleum contaminated soil). Oil contamination can affect soil physical and chemical properties (Wang *et al*., 2013). Oil usually anaerobic environment in soil by smothering soil particles and blocking air diffusion in the soil pores and affects soil microbial communities (Townsend *et al*., 2003; Labud *et al*., 2007). Heavy crude oil pollution can cause complete mortality of marsh vegetation (Lin and Mendelssohn, 2012). In addition, crude oil contaminated soils are hydrophobic compared with pristine sites (Quyum *et al.,* 2002). Soil pH values are also affected (Hu *et al*., 2006).

Table 1: Benzene content of soil samples

Samples	Benzene (ppm)
Sample A	0.8867
Sample B	0.2478
Sample C	1.0293
Sample D	0.4975
Sample E	0.2121
Sample F	0,2002
Sample G	0.1031

Table 2: Phenol content of soil samples

Samples	Phenol (mg/L)
Sample A	0.9289
Sample B	0.8610
Sample C	1.8397
Sample D	0.7285
Sample E	1.1475
Sample F	1.2932
Sample G	0.9836

Table 3: Oil and grease content of soil samples

Samples	%Oil and Grease Content
Sample A	19.756
Sample B	10.711
Sample C	19.000
Sample D	14.177
Sample E	12.289
Sample F	20.899
Sample G	6.667

As observed by Dallyn (1953), chlorophyll destruction appears to be the major symptom of oil injury to green plants. When oil gets to leaf surface, it penetrates the leaves thus interfering with its physiological functions mainly reducing transpiration and photosynthesis. Where oil pollution is light, leaves become yellow and drop soon after, but under heavy contamination, complete shedding of leaves results. The adverse effects of chlorosis and leaf fall is that the vigour of the plant may be reduced or death may result (Dallyn, 1953). Oil contamination on soil creates conditions which make nutrients unavailable to plants (Odu, 1977). Plants have a toxicity range of 10^4-10^5 ppm for fresh crude oil (Moore *et al*., 1973) and experimental evidences show that with plants toxicity increases along the series, alkanes (paraffins)-cycloalkanes (naphthene-alkenes (olefins)-aromatics (Crafts and Riber, 1948; Harvis, 1950).

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