Paper B10

IMPACT ASSESSMENT OF PETROLEUM DEPOT WASTEWATER ON AGRICULTURAL SOIL: A CASE STUDY OF SULEJA, NIGER STATE

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Abstract

Though petroleum is a vital resource of great economic importance, it is also among the leading pollutants of soil, freshwater and ecosystems. This study aims at assessing the impact of petroleum depot wastewater on agricultural soil in Suleja, Niger state. Soil and water samples around the petroleum depot were collected and analysed for selected heavy metals (Mn, Cr, Cu, Zn and Pb) and the results were compared with World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) standards. The result of the soil analysis indicates that the control soil sample contained 0.06±0.002 mg/kg of Mn, 0.10±0.001 mg/kg of Cu, 0.04±0.001 mg/kg of Cr, 0.13±0.002 mg/kg of Zn and Pb was not detected. The mean concentration of Mn, Cu, Cr, Zn and Pb from the soil samples taken from polluted sites were 0.23±0.05 mg/kg, 0.22±0.004 mg/kg, 0.16±0.03 mg/kg and 0.33±0.04 mg/kg and 0.004±0.03 mg/kg respectively. Also, the metals were detected in the surface water. The relatively high values of some of the metals in soil and surface water when compared to the control and the established standards imply the probable influence of the depot activities on the resources and a threat to agricultural activities and man. Hence, to ensure food security and safety there is a need for remediation.

Key Words: Petroleum, Heavy metals, Agricultural soil, Surface water, Environment.

1. Introduction

Agricultural land is a principal factor of production that determine to a large extent the quality and quantity of food to be produced by individual farmer and the nation at large. Though land seems to be readily available in countries like Nigeria, those with agricultural viable soil are drastically reducing. This is due to extreme events (such as drought) and contamination of existing and potential agricultural lands by diverse pollutants such as petroleum products [1]. Petroleum is an important resource of great economic importance throughout the globe [2]. It is a naturally occurring complex mixture found beneath the earth's surface and is composed of aromatic, aliphatic, hydrocarbons, asphaltenes, and non-hydrocarbon compounds, of which 60-90% are biodegradable [3] The development of the petroleum industries and their associated activities like exploration, transportation, storage and refining have caused pollution of the environment and posed a serious global problem [4].

The toxic substances generated from the aforementioned processes are often discharged into soil and water bodies where they accumulate in surface water, sediments of rivers and/or in groundwater [5, 6]. Hence, the quality of soil and freshwater systems are compromised and consequently, the toxic substances get into the food chain, and consumed by plants, animals and ultimately get accumulate in the body of man [7]. The products had impacted negatively on the urban cities, terrestrial ecosystems and shorelines of most of the states in Nigeria, particularly the oil-producing ones [8].

Nigeria as a nation has 22 Nigerian National Petroleum Corporation/Pipeline and Products Marketing Company (NNPC/PPMC) depots, saddled with the responsibility of efficient evacuation of refined petroleum products from the local refineries as well as transportation, storage and marketing of petroleum products {such as Premium Motor Spirit (PMS), Automotive Gas Oil (AGO) and Dual-Purpose kerosene (DPK)}. In Suleja depot, Niger State, there are a total of twelve (12) storage tanks, which are used for the storage of PMS, AGO, and DPK with each of the products stored in four (4) tanks. Each storage tank of PMS, AGO, and DPK has a capacity of 12.6 million, 7.6 million and 7.6 million litres respectively [9]. These tanks pose a threat to the environment due to leakages and spills associated with loading and offloading of the products as well as washing of the storage tanks [10]. Thus, any contact with the product causes damage to agricultural soil as it results in loss of soil fertility. When soil is polluted, the health and growth of plants as well as man would be affected.

Though pollutants of diverse nature are introduced into the environment by petroleum products, of great concern are the heavy metals. The effects of heavy metals on agricultural soil and water systems have been reported in earlier studies. For instance, [11, 12] reported the negative effects of heavy metals/crude oil on crop yields. However, there is a need for further studies that examine the effects of petroleum products from depots in each state on the immediate environment. Hence, this study aimed at assessing the impact of petroleum depot wastewater on agricultural soil and water around the Suleja petroleum depot.

2. Materials and Methods

2.1 Study Area

The study area is Maje in Suleja, located between latitudes 9° 11' 36" N and 9° 13' 9" N and longitude 7° 9' 30" E and 7° 11' 36" E in Niger state, Nigeria (Figure 1).

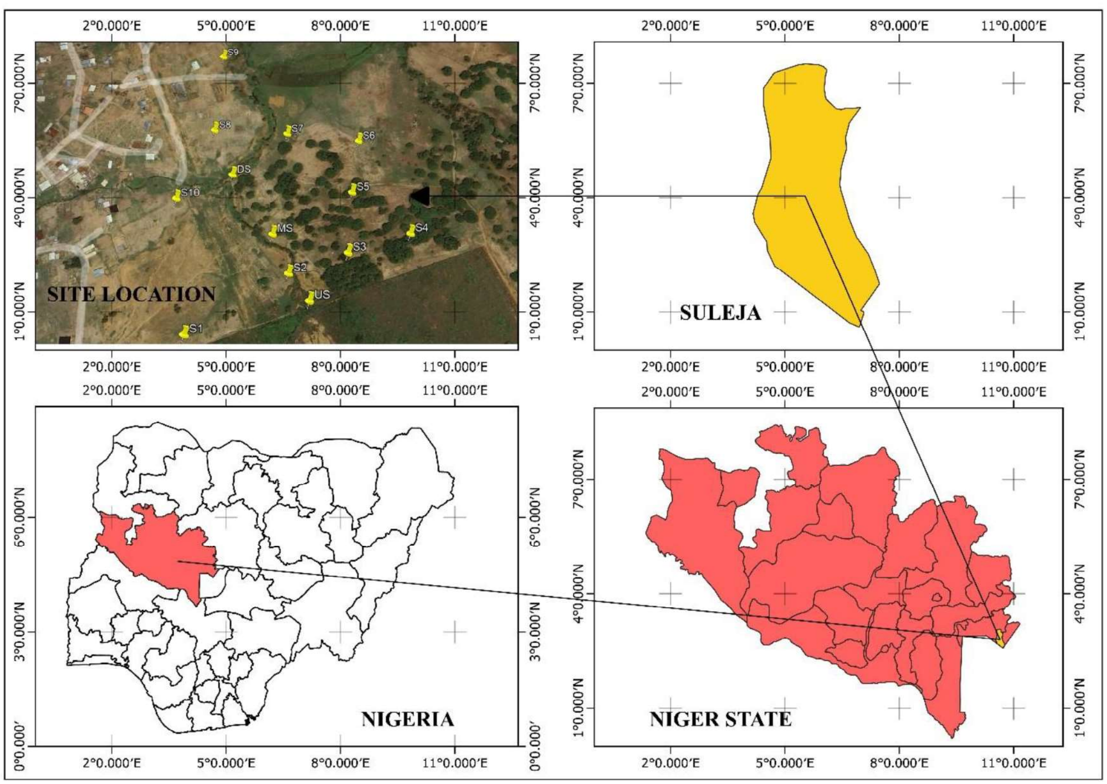

Figure 1: Map Showing Study location.

2.2 Soil and Water Sampling and analysis

A composite of soil sample of 3-4kg was collected at a depth of 0-15cm from each of the selected sites with the help of a stainless-steel soil auger after first stripping away dried grasses to expose the first mineral-based horizon (A-horizon). The samples were randomly collected from ten different locations in the study area, especially along the flow. Soil samples were collected into polyethylene bags and were taken to the laboratory and prepared for analysis.

Water samples from the study area were collected into clean 0.75 litres of plastic containers. The samples were taken at a distance of 100 m away each at the upstream, midstream and downstream. The collected water samples were labelled and transported in an ice pack to the laboratory. Both the soil and water sample were analysed for Lead (Pb), Manganese (Mn), Chromium (Cr), Copper (Cu) and Zinc (Zn). The soil sample was air-dried, crushed, sieved and digested as reported in [13]. Thereafter both the soil and water samples were analysed using an absorption spectrophotometer (AAS)

3. Results and Discussion

The contaminated soil and water around the Suleja depot were assessed for heavy metal contents (Pb, Mn, Cr, Cu and Zn). The results of the analysis are presented in Tables 1, 2 and 3. While the results of the soil sample were presented in Table 1, the remaining two tables are for water sample results. Table 1 showed that the mean concentration of Mn, Cu, Cr and Zn are 0.06+0.002 mg/kg, 0.10±0.001 mg/kg, 0.04±0.001 mg/kg and 0.13±0.002 mg/kg respectively and Pb was not detected. The values were all below the threshold limits of WHO and FEPA. The respective maximum and minimum values of the Mn were 0.32 mg/kg and 0.16 mg/kg while the mean value was 0.23±0.05 mg/kg. Though the value is above the WHO threshold value (0.06) for Mn in soil, it is within the limit (0.48) established by FEPA.

This implies that though the Mn may not be a source of threat when soil is in contact with the body, it may not be suitable for agricultural purposes. Similar values have been reported in the earlier study [14].

The values detected for Cu ranged from 0.14 to 0.27 mg/kg with a mean value of 0.22±0.04 mg/kg. The obtained value exceeds the established limit for Cu in soil by both WHO and FEPA. This implies that excess Cu can cause toxicity and degradation of the soil thereby affecting crop growth. The detected values for Cr ranged between 0.11 and 0.22 mg/kg while the mean value was 0.16±0.03 mg/kg. Though the value was above 0.10 mg/kg set by WHO, it is below 0.30 mg/kg stated for FEPA.

Also, the values for Zn ranged from 0.26 to 0.41 mg/kg with a mean value of 0.33 mg/kg which exceeds both the WHO and FEPA standards. thereby calling for concern as its usage for agricultural purposes poses a threat to man. As observed by [15] the metals are non-biodegradability which is responsible for their accumulation and persistence in the environment. However, lead was found to be below the established limits set by the WHO and FEPA. Most of the values reported here were under similar ranges to those observed in earlier works [16].

Table 1: Descriptive statistical analysis of soil (mg/kg) compare with acceptable limit.

	Mn	**Cu**	**Cr**	**Zn**	**Pb**
Mean	0.23	0.22	0.16	0.33	0.004
Min	0.16	0.14	0.11	0.26	0.000
Max	0.32	0.27	0.22	0.41	0.010
SD	0.046	0.042	0.031	0.042	0.004
Control	0.06+0.002	0.10±0.001	0.04±0.001	0.13±0.002	-
WHO	0.06	0.10	0.10	0.30	0.01
FEPA	0.48	0.05	0.30	0.75	0.42

The river receiving the effluents from the depot was also assessed for the same metals (Table 2). The Mn concentration in the water sample at the upstream, midstream and downstream was 0.20, 0.19 and 0.28 mg/L respectively. The highest value was observed downstream. The value in each of the locations exceeds the threshold limit (0.05 mg/L) by both the WHO and FEPA. Hence, the water is not suitable for domestic usage and its usage for irrigation needs caution. The mean values for Cu and Cr were 0.20±0.03 mg/kg and 0.15±0.04 mg/kg respectively and all exceed the established limits of WHO and FEPA for metals in water. A high load of some of the metals as mentioned in this study has also been reported in other studies [17]. However, the Zn (0.14±0.03 mg/kg) and Pb (0.02±0.01) mean values were below the established limit of both WHO and FEPA. Comparing the value obtained for the metals in surface water with that of soil, the high values detected in some of the metals can be attributed to the same source. To keep the environment safe, the depot activities should be properly checked and the environment has to be monitored through regular studies.

Table 2: Concentration of heavy metals (mg/L) in water samples.

Parameters	Upstream	Midstream	Downstream
Mn	0.20	0.19	0.28
Cu	0.16	0.20	0.24
Cr	0.18	0.10	0.18
Zn	0.10	0.15	0.18
Pb	0.02	0.01	0.03

Table 3: Descriptive statistical analysis of water (mg/l) compare with acceptable limit.

	Mn	Cu	Cr	Zn	Pb
Mean	0.22	0.20	0.15	0.14	0.02
Min	0.19	0.16	0.10	0.10	0.01
Max	0.28	0.24	0.18	0.18	0.03
SD	0.04	0.033	0.038	0.033	0.008
WHO	0.05	2.00	0.05	5.00	0.01
FEPA	0.05	0.10	0.05	5.00	0.05

3. Conclusion

The unselective use of soil and water for agricultural activities has become a major concern as it could lead to the consumption of produce that is rich in heavy metal contents. This study assesses the heavy metal concentrations in soil and river around the Suleja depot. The results of the analysis showed that there is a higher concentration of most of the assessed metals in the soil. In the same vein, the concentrations of most of the heavy metals in the water sample are above the established limit of the WHO and FEPA. This suggests a need for caution in using the soil for agricultural activities to avoid the uptake of the metals. Also, the river receiving effluent from the depot is not suitable for domestic use. There is a need for regular monitoring of the activities of the depot to avoid aggravated levels of the metals in the soil.

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