

Original Article

EFFECT OF PETROLEUM PRODUCTS SPILLAGE ON SURFACE WATER IN THE NORTH CENTRAL AREA OF NIGERIA

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ABSTRACT

The study was conducted to evaluate heavy metals in water samples used to assess the contamination of farmland in Eluku/Ojutaye village after a protracted petroleum product spill. Six samples of surface water was collected from different locations which were subjected to physical and chemical analysis using standard methods for the examination of water samples. The concentrations of the various heavy metals in the samples were above compliance limit which may have long-term adverse effects on the people and vegetation of the area. Copper had a range of 0.06 - 1.75mg/L, with sample 3 having a lower concentration closely followed by sample 2 while sample 1 had the highest concentration which is also referred to as our point source of the oil spill. The concentrations of Arsenic ranged from 0.03 to 0.85mg/L; Manganese, from 0.12 to 0.314mg/L while Nickel, Cobalt and Lead had their ranges between 0.03 and 0.17; 0.03 and 0.10mg/L; and 0.04 and 0.09mg/L, respectively.

Keywords: Crops, environment, petroleum products, ions, salts, water

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INTRODUCTION

Over the past few decades, the world has witnessed alarming increases in rates of deforestation, ozone depletion, soil and water pollution, and other forms of environmental degradation, leading many to conclude that the present period is one of "ecological crisis" (Eaton and

Lorentzen, 2003). These various drastic changes in environmental quality have also led many to question the nature of people's relationships with their local environments.

The issue of development vis-à-vis environmental protection has become one problem that has continued to

generate heated debate, especially in developing countries. This is so because, firstly, environmental quality itself is part of the improvement in welfare that development attempts to bring. If, however, the benefits from raising incomes offset the costs imposed on health and the quality of life by pollution, this cannot be called development. Secondly, environmental damage can undermine future productivity (Chukwu, 2008).

In the past few years, man's awareness of the environment has greatly increased, mostly as a result of observing the environmental damage already done. The environment is a huge pool of resources that helps us satisfy our needs and fulfill our wants (Dan, 2006). None of the environmental resources is infinitely abundant. Therein, lays the trap into which we have fallen and which had led to widespread environmental pollution. If man is to survive more than just a few generations, we must re-examine the man-earth relationship and attempt to understand, manage and control, as adequately as possible all our environmental resources. In re-evaluating the inter-relationships between man and the environment, one must not forget the dynamic nature of the environment. Pollution is the undesirable degradation of the environment whether natural or man-made, while, waste (the undesirable substance) accumulated as a result of our inefficient utilization of the environmental resources (Chatterjee, 2005).

In Nigeria, there have been reported cases of petroleum and its

product spillage on soil and water, which led to water shortages and loss of arable land. Examples of which includes the peculiar case of Ikot Ada Udo village in Ikot Abasi local Government area of Akwa Ibom state, Ikarama and Kalaba communities in Yenegoa L.G.A of Bayelsa state. Of particular interest is the case of people of Eluku/Ojutaye village in Ilorin east L.G.A of Kwara state, who are now counting their losses sequel to the oil spill from the broken NNPC tanks located within the community which infiltrates into the soil and the river. The river is known to serve as a major source of irrigation for the farms in the village which leads to the loss of vegetable farms being destroyed due to non-replacement of ageing tanks and pipeline. All these changed when the Nigerian National Petroleum Corporation (NNPC) sited there deport in the area. The full benefit of these farm lands has reduced as petroleum product spillage has taken over the entire area. Petrol is one of the by-products from crude oil, which is a mixture of many organic substances. It has properties that can give rise to fire, explosion, health and environmental hazard. The actual properties of petrol can vary widely depending on its source. Petrol adsorbed into the soil and the surrounding water bodies will because of its known toxicity has a strong effect on the flora and fauna within the contaminated area, its subsequent dispersion will depend on air movement causing evaporation. The extent and duration of the pollution will also depend on the quantity and duration of the petrol released.

The spill of petroleum products has caused severe pollution of both the surface and ground water in the region and has also contaminated agricultural land. Surface water contamination is the result of spill of petroleum products from the NNPC depot which has affected the surrounding surface and ground water bodies located within the Eluku/Ojutaye community in Kwara State. The process of infiltration of these products through the soil might take many years and might take place at a distance from the well where the contamination is found. The aim of this study was to establish the effect of petroleum products spillage on surface water of agricultural areas and the constituent of the water affected by the spillage.

MATERIALS AND METHODS

Study Area

Water samples were collected from the river mainly used as a source of irrigation water for the farms in Eluku/Ojutaye Oke-oyi area of Kwara state. The village is situated very close to the Nigerian National Petroleum Corporation depot which lies between latitude $7^{\circ}15'$ and 11° North and longitude $2^{\circ}30'$ and $6^{\circ}45'$ East.

Water Analysis

The technique described by Nathanail and Bardos (2004) was used. Briefly 50ml of the water sample was placed in a beaker, agitated and 5ml concentrated HNO_3 was added to it. The content of the beaker was boiled slowly on a hot plate and allowed to evaporate to about 20ml.

Another 5ml of concentrated HNO_3 was added. It was then covered with a watch glass and heated. Concentrated HNO_3 was been continually added until the solution appears light coloured and clear indicating the completion of digestion.

Determination of Heavy Metals

A mixed calibration standard containing heavy metal was prepared, by pipetting aliquots of 1000mg/l standard solution into a series of volumetric flask (100ml). 1ml of concentrated nitric acid was added to each flask and was diluted to the mark. The Atomic Absorption Spectro-photometer (AAS) was switched on and the appropriate hollow cathode lamp was selected and the lamp current adjusted to the recommended value in the instrument manual. The monochrometer and slit settings were also set to the recommended value. The wavelength setting was fine-tuned and the beam was aligned.

The gain setting was then optimized, and the fume hood turned on, switching on the flame according to the recommended procedure. The sample was aspirated, standard and blanked into flame of Atomic absorption Spectrophotometer (AAS) equipped with the appropriate hollow cathode lamp and operated at the wavelength recommended.

Determination of Major Anions

The major anions present in the water sample were tested for, by titrating with standard 0.0141M NaCl solution. 20mL aliquots of the standard NaCl

solution in 100ml conical flask was pipetted into a conical flask and the pH adjusted between 7 and 10. 1ml of the chromate indicator solution was added and titrated with AgNO_3 to the first appearance of the red Silver chromate. The result of the first titration was discarded and the titration repeated three times on separate aliquots of NaCl solution. A blank titration was carried out by adding 1ml of chromate indicator solution to 20ml of laboratory water and titrated with AgNO_3 . The volume of the titrant required for the blank titration was subtracted from the volume of titrant required for the titration of NaCl solution and molarity of the standard AgNO_3 solution was calculated.

Anion Analysis (Cl)

This was done by pipetting 100mL of water sample into a 250mL conical flask and the pH was adjusted to between 7 and 10. A pH paper was used instead of a pH meter as the electrode may contaminate the sample. The indicator was added and titrated as above. A blank titration was also repeated using 100m of distilled water and corrected the volume of titrant used. The titration was repeated with three aliquots of each sample and the average taken. The concentration of the chloride in the sample was obtained from the concentration of standardized AgNO_3 solution. Also corrected volume of titrant used and the volume of the sample were calculated.

Anion Analysis (SO_4^{2-})

100mL of sample was measured into a 250mL conical flask and placed on a magnetic stirrer, 20ml of the NaCl-HCl solution and 20ml of Glycerol-ethanol solution was added while stirring. Approximately 0.3g of barium chloride was added and then stirred for two minutes.

Some of the solutions were immediately poured into an absorption cell and the absorbance at 420nm after exactly 3 minutes was measured. A series of calibration standard was prepared by pipetting aliquots of standard sulphate solution corresponding to between 0.5 and 5mg SO_4^{2-} (i.e. 5-50ml) into a 100ml volumetric flask and made up to the mark with water.

Analyzed in the same way as the samples, some blanks were prepared by adding all the reagents except barium chloride to 100ml of sample and the absorbance measured. Blanked readings obtained were subtracted from each sample reading and by using the same sample to compensate for sample colour and turbidity.

A calibration graph of absorbance against mg SO_4^{2-} was prepared. The amount of sulphate in the samples was read off using the corrected absorbance reading and the concentration in the sample which was calculated for using the equation below:

$$\text{Mg SO}_4^{2-}/\text{L} = 1000 \times \text{mg SO}_4^{2-} / V$$

Where V = volume of sample (ml)

pH Determination

The combination of pH electrode and meter was calibrated using a two-point calibration with buffer solutions of pH 7 and 4. Then the pH electrode was immersed in the water sample and a measurement taken, after the solution had come to rest.

The working Potassium chloride (KCl) standard solution was placed in a beaker, and the conductivity cell was suspended, holding it 1.5cm above the bottom of the beaker, making sure it was not in contact with any part of the beaker walls. The conductivity reading was adjusted to 100µmho/cm. The cell was

rinsed with pure water and the measurement carried out on the sample.

RESULTS AND DISCUSSION

The results obtained from the analysis of the three water samples as presented in Table 1 below shows the various concentrations of some major heavy metals present within the water bodies of the Eluku/Ojutaye community in the North Central area of Nigeria. This water bodies can be said to have been contaminated because WHO, (1995) recommended that no trace of heavy metals should be seen in any water samples to be used for domestic purposes because of their carcinogenicity.

Table 1: Quality parameters of the water samples

S/NO	PARAMETER	SAMPLES		
		1	2	3
1	pH	9.10	8.7.00	6.40
2	ECR/Km ⁻¹	177.00	139.00	229.00
3	CL ⁻ (mg/l)	474.80	272.60	201.00
4	SO ₄ ²⁻ (mg/l)	451.00	523.00	247.00
5	Lead (mg/l)	0.09	0.082	0.04
6	Manganese (mg/l)	0.31	0.300	0.12
7	Nickel (mg/l)	0.14	0.17	0.03
8	Cadmium (mg/l)	0.01	0.02	0.05
9	Cobalt (mg/l)	0.09	0.10	0.03
10	Copper(mg/l)	1.74	1.62	0.06
11	Boron (mg/l)	1.89	1.75	0.82
12	Arsenic(mg/l)	0.85	0.61	0.03
13	Mercury (mg/l)	NA	NA	NA
14	Silver (mg/l)	NA	0.03	NA
15	Barium (mg/l)	0.06	0.06	0.02

The metals present in lower concentration are barium, Cobalt lead, Cadmium, manganese. Mercury was not present in any of the three water samples, while Silver was found present only in the second sample. The other metal present in a large amount was Boron which ranged from 0.82 to 1.89mg/l. It was observed that sample 3 had the lowest concentration since it was about 120meters away from the source of pollution. This is an indication of diffusion of the metal soluble in the water while the highly toxic Copper had a range of between 0.06 - 1.75mg/l with sample 3 having a lower concentration closely followed by sample 2 while sample 1 had the highest concentration which is also referred to as our point source of the oil spillage, Arsenic had average of between 0.03 and 0.85mg/l, Manganese had a range of 0.12 and 0.314mg/l while Nickel, Cobalt and Lead had their ranges between 0.03 and 0.17; 0.03 and 0.10mg/l; and 0.04 and 0.09mg/l respectively.

As the residue of most of the chemical constituents carried by the water bodies in this area leaves there effect within the soil, the consequences of these chemicals cannot be over emphasized. From the analysis of the soil sample, it was observed that the Total Heavy Metal (THM) at site1 had a total content of 40.08mg/l. The affected soil at site 2 had a Total Heavy Metal of 36.64mg/l which shows a significant reduction from site 1 while the heavy metal were virtually absent in site 3 which had Total Heavy Metal of 3.33mg/l. The water samples were less affected, as the water from site 1 had Total Heavy Metal content of

5.18mg/l and that from site 2 4.74mg/L in Total Heavy Metal content, it was also not much in the control water, which had a THM content of 1.15mg/l. The Cl^- ion which is a major ion in the surface water varies between 201- 474.8mg/l in the water samples while SO_4^{2-} which is also a major ion occurring in natural water was found to be between 247 - 523mg/L in water, the level of both Cl^- and SO_4^{2-} in water samples were very high which exceeds the maximum amount admissible for water for irrigational purposes, thus having a harmful effect on plant (Miroslav and Vladimir, 2001). The level of chloride in water supplies is limited to 250mg/l, at higher concentration as in the case of the samples from the two sites, chlorides impacts a salty taste which make the water unsuitable for irrigational purposes. High chloride concentration are harmful to plants, some damages may occur at levels as low as 70-250mg/l. This also contributes synergistically to the salt toxicity in plants which in turn inhibits plant growth and electron flow through the photo system. However, the synergistic effect of sodium and chlorides shows that neither of these ions alone is responsible for salt stress induced damage (Mackay, 1988). This also applies in the case of SO_4^{2-} . The Sodium Adsorption Ratio (SAR) of the soil sample varies between 0.052 - 0.234mol/kg.

The Electrical Conductivity (EC) for the water sample ranged between 139 and 229 which when these results were compared with the standard values of the United Nation as presented by

Carballeria *et al.* (2000), the values obtained from the study area were discovered to be too high which is an indication that there are high concentration of heavy metals within the soil and water samples which do not support the growth of crops.

For irrigational purposes, the level of Copper in the water samples (0.06 - 1.74) is high, as the irrigation water quality criteria for heavy metal for Copper is 0.2mg/l. Copper being very toxic, affects majorly the growth of the plants. The presence of the heavy metals in excess of the standard greatly affected the growth of the plants, by inducing temporary effects like narcosis and tainting of tissues, which usually subsides over time. (Andrade *et al.*, 2002).

CONCLUSION

As expected, the degree to which the study area is been affected, as reflected by the THM contents of the polluted soils, differed widely. However, all the polluted soils exhibited, as the main microscopic effect of the pollution, a desk, compact crust with significantly lower porosity and greater resistance to penetration than those of unpolluted soils at the same sites.

Pollution also significantly lowered intrinsic permeability raised hydrophobicity, and increased greatly the concentrations of Cr, Cu, Fe, Pb and Ni.

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