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ASSESSMENT OF HEAVY METAL CONCENTRATION IN A POST REMEDIATED CRUDE OIL SPILL IMPACTED SOIL IN ETCHE LOCAL GOVERNMENT AREA OF RIVERS STATE, NIGERIA

NWANYANWU KINGSLEY UZOMA PhD.
Department of Geography and Environmental Studies,
Ignatius Ajuru University of Education, Port Harcourt,
Rivers State, Nigeria

And

BRIGHT CHIKA AJOKU PhD.
Department of Geography and Environmental,
Studies Ignatius Ajuru University of Education Port Harcourt,
Rivers State, Nigeria

Abstract

This research examined the heavy metal concentration in a post remediated crude oil spill impacted soil in Etche Local Government Area of Rivers State. Four different points were studied and a control which covers a total area of about 14200m^2. The total sampling frame of 158 sampling points / area, with the aid of soil augar soil sample were collected from a soil depth of 0-30cm. Hypotheses tested at 3 and 8 degree of freedom at 0.05 significant level shows that there is a statistically significant variation that exist in the concentration level of soil heavy metal in the study area. The study also shows a significant increase in the values of some heavy metals which is attributed to soil nutrient, Soil enzymes and various micro-organisms such as bacteria and fungi are identified as limiting factors for the biodegradation of metals. It was recommended that adequate and proper remediation techniques should be employed in carryout any remediation work in an oil polluted site.

Keywords: heavy metal, concentration, remediation, crude oil, and spill impacted soil.

Introduction

Environmental pollution through oil spills and industrial effluence can cause serious damages to both aquatic and terrestrial ecosystems and destruction of forest and farmland through deforestation and burning and also severely affects the characteristics and management of agricultural soils (Dambo, 2000).

Crude oil pollution alters chemical, biological and physical properties of soil and degrades the soil fertility. Crude oil exploitation has had adverse environmental effects on soil, forests and water bodies in host communities in the Niger Deta Area of Nigeria (Worgu 2000). Contamination of soil environment by hydrocarbons (mostly petroleum hydrocarbons) is becoming prevalent across the globe especially in Niger Delta Region. This is probably due to heavy dependence on petroleum

as a major source of energy throughout the world, rapid industrialization, population growth and complete disregard for the environmental health.

Heavy metals pose a serious threat to both man and animals in the environment if not properly remediated to the innocuous level. Environmental pollution by heavy metals which are released into the environment through various anthropogenic activities such as mining, energy and fuel production, electroplating, waste water sludge treatment and agriculture is one of the world's major environmental problems. Heavy metals refer to a large group of trace elements which are both industrially and biologically important. Initially heavy metals are naturally present in soils as natural components but as of now, the presence of heavy metals in the environment has accelerated due to human activities. This is a widespread problem around the world where excessive concentration of heavy metals such as pb, zn, cr, cu, cd, Hg and As Can be found in soils.

Soil contamination by heavy metals is consequently the most critical environmental problems as it poses significant impacts to the human health as well the ecosystems. The contaminants are able to infiltrate deep into the layer of underground waters and pollute the ground water as well as the surface water. Heavy metals in the soil subsequently enter the human food web through plants and they constitute risk to the ecosystem as they tend to bio accumulate and can be transferred from one food chain to another. Heavy metals are discovered in various food chains where the results are usually detrimental to micro-organisms, plants, animals and humans alike.

The impact of contamination of the environment should be of significant scientific interest inorder to minimise the threat to soil fauna, surface and ground water.

Literature Review

Previous studies have revealed that many environmentalists have conducted research on various aspects of impact of crude oil contaminated soil parameters in Nigeria and beyond. This section therefore, critically reviews some studies to see how they relate or deviate from the present study with reference to the methodology, findings and conclusions drawn from the studies. Soils may become contaminated by the accumulation of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, waste water irrigation, coal combustion residues, spillage of petrochemicals and atmospheric deposition (S.Kha et al., 2008, and Zhang 2010). Heavy metals constitute an ill-defined group of inorganic chemical hazards, and those most commonly found at contaminated sites are lead (pb), chromium (cr); arsenic (As), zine (zn), cadmium (cd), copper (cu), mercury (Hg), and nickel (Ni) GWRTAC (1997). The overall objective of any soil remediation approach is to create a final solution that is protective of human health and the environment NJDEP (1996).

Remediation is generally subject to an array of regulatory requirements and can also be based on assessments of human health and ecological risks where no legislated standards exist or where standards are advisory. The regulatory authorities will normally accept remediation strategies that centre on reducing metal bioavailability only if reduced bioavailability is equated with reduced risk, and if the bioavailability reductions are demonstrated to be long-term NJDEP (1996). For heavy metal-contaminated soils, the physical and chemical form of the heavy metal contaminant in soil strongly influences the selection of the appropriate remediation treatment approach. Remediation goals for heavy metals may be set as total metal concentration or as leachable metal in soil, or as some combination of these.

Heavy metal contents of soil are of major significance because of their non-degradable nature and ability to accumulate for long period of time (Gallego et al., 2002, Wu and Zhang, 2010). Overload of metal ions in the soil environment clearly poses a significant risk to the quality of soils plants, natural watersa dn human health (Adraino, 2001).

Studies on heavy metals contamination of soil environments in Nigeria are numerous (Bangbose et al., 2000, Onianwa and Fakayode, 2000, Onianwa 2001, Ana and Sridhar, 2004, Umoren and Onianwa, 2005, Iwegbue et la., 2006 a,b Iwegbue, 2007, Nwajei et al., 2007, Nwajei and Iwegbue, 2007, Osakwe and Egherevba, 2008) with attention paid to industrial sites and contaminated sites in urban centre.

Aim and Objective

The study aimed at to evaluate the concentration level of soil heavy metal in a post remediated crude oil spill impacted soil in Etche Local Government Area of Rivers State.

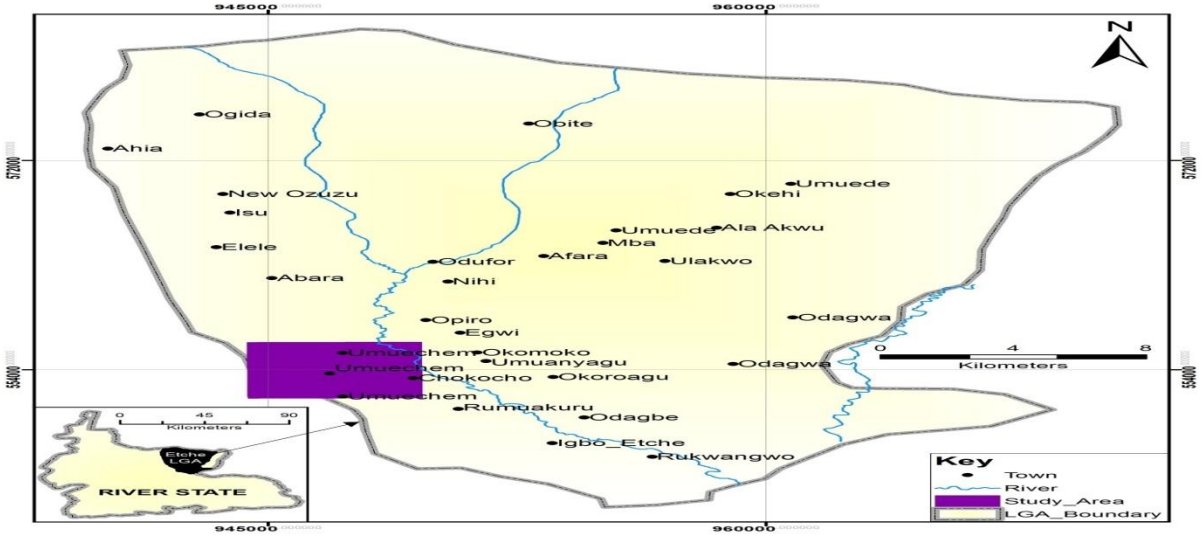
Hypotheses

The Null hypothesis is stated as;

There is no significant variation that exists in the concentration level of soil heavy metals in the study area.

Study Area

The study area is in Etche Local Government Area of Rivers State, is located between latitudes $4^0$50 and $5^0$15' North, of the equator and longitudes $6^0$55' and $7^0$20' East of the Green wich meridian. The study sites comprises of Umuechem, Abara, Umuebulu, Odagwa and Egbu as the control all in Etch Local Government Area of Rivers State. The oil spill remediated site in the study area was remediated through bioremediation and phytoremediation in July and September 2013 and 2015 respectively.



Sources: Digitalized map from Rivers State ministry of Urban planning

Methodology

The study identified four different sites of oil spill remediated environment which covers an area of about 14200m^2 with a control point of non-spilled area. By using a 9x10m matrix to calculate the entire area of 14200m^2, the sampling frame became 158 sampling points.

The primary sources of data were gotten from the field with the aid of soil augar at the soil depth of 0-30cm which was taken to the laboratory for analysis while the secondary sources of data were gotten from journals, textbooks and National Environmental Safety Regulatory Agency (NESRA). The hypotheses were tested using analysis of variance (ANOVA) at 0.05 level of significance.

Result

Laboratory analysis of soil heavy metals in the post remediated and control site

S/N	Paramenters	Control	A	B	C	D
1	Iron, Fe (mg/kg)	2815	2798	2884	2734	2873
2	Nickel, Ni (mg/kg)	0.19	1.80	3.21	2.08	2.68
3	Lead, Pb (mg/kg)	<0.001	<0.001	25.41	14.15	18.08
4	Copper, cu (mg/kg)	0.76	1.70	1.34	1.25	1.44

Researchers field work 2021.

The above table shows the concentration levels of soil heavy metals in the study area. It was observed that iron (fe) has the highest value of 2884mg/kg at point B followed by point D with a value of 2873mg/kg, followed by the control point with a value of 2815mg/kg, and point A and C has values of 2798mg/kg and 2793mg/kg respectively.

In the case of Nickel point B recorded the highest value of 3.21mg/kg, followed by point D with a value of 2.68mg/kg, followed by point C an A with the following values of 2.08mg/kg and 1.80mg/kg respectively while the control recorded the lowest value of 0.19mg/kg.

Lead (Pb) recorded a higher value of 24.41mg/kg at point B followed by point D and C with their respective values of 18.08mg/kg and 14.15mg/kg while control and point A recorded the lowest values of less than 0.001mg/kg.

Lastly copper (cu) also had the highest value of 1.70mg/kg at point A followed by point D, B and C with the following values of 1.44mg/kg, 1.34mg/kg and 1.25mg/kg and at the control point recorded the lowest value of 0.76mg/kg.

Hypotheses Testing

The statistical tool used in the hypothesis testing is analysis of variances (ANOVA) at 0.05 significance level.

The null hypotheses stated that there is no significant variation that exists in the concentration level of soil heavy metals in the study area.

Table 2: Summary of the ANOVA Testing of Hypothesis

Sources of variance	Summary of square	DF	F-ratio calculated	F-ratio table	Alpha level	Result	Decision
BSS	4475	3	936.7	3.49	0.05	Significant	H1 Accepted
WSS	16766794	12					H0 Rejected
Total	16771269	15					

Result / Comment

The summary of hypothesis tested above shows that f-ratio value of 936.7 is greater than F-ratio table value of 3.49 with 3 and 12 degree of freedom at 0.05 significant level,

therefore we reject the null hypothesis of the study, thereby accepting the alternation which states that there is a statistically significant variation that exist in the soil heavy metals in the post remediate site area.

Discussion of Findings

The heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Crude oil pollution typically increases the concentration of some heavy metals and thus the elevated concentrations of the heavy metals observed in the post remediated soil compared to the control soil. This findings corroborates with the work of Akubugwo et al., (2015) who reported a similar increase in the heavy metal concentration of soils polluted with crude oil. The significant increase ($P<0.05$) at the concentration level of iron (Fe) in the study area shows that the concentration level of iron in the study area is above the baseline value report of 500mg/kg DPR (2002). This findings agrees with the work of mengel and Kirkby (2001), which states that when soils are water logged, a reduction of Fe^{3+} to Fe^{2+} takes place accompanied by an increase in Fe solubility, by this process, the insoluble Fe^{3+} compounds become soluble and Fe^{2+} is dissolved in the soil solution. This reduction is brought about by anaerobic bacteria which use Fe oxides as e^- acceptors in respiration (Munch and Ottow, 1983).

This may be the likely reason why an increase in Fe concentration was recorded as its indicated in the remediated site. The significant increase in copper concentration of the remediated soils may be attributed to its response to soil acidification as the soil reaction may have more acidic over time (Rutkowska et al., 2013). However the significant reduction of the heavy metals recorded in the corresponding control soils may be due to physicochemical, biological and environmental factors. The analyses of heavy metals in the post remediated soil show that cooper and lead were below the critical values of 36ppm and 140ppm respectively (FTPA, 2002).In general metals tend to accumulate in the clay fraction of the soil because clay-sized particles have a large number of ionic binding sites due to a higher amount of surface area (Ohanmu, 2017). Similarly metals could tightly bind to the organic matter.

The following were the findings of the study.

1. There is significant increase of heavy metal concentration level in the study area. Therefore it showed that heavy metal concentration values are above the baseline values according to Department of Petroleum Resources.
2. The hypothesis tested shows that there is a statistically significant variation that exist in the soil heavy metals in the study area.

Conclusion

The importance of soil recovery in a crude oil remediated site cannot be over-emphasized mostly in this era of environmental movement and sustainable development across the oil producing communities in the Niger Delta. The levels of heavy metals found in the present study were generally above the DPR target values for metals in soil. Consequently series of remediation, technology have been implemented or /and are still ongoing in the contaminated soil in order to restore the environment from heavy metals. The study therefore concludes that continuous post recovery assessment should be made to ascertain soil status to improve agricultural productivity.

Recommendations

The study therefore recommends the following;

1. There is need for timely remediation activities in a soil polluted environment so as to forestall the high concentration level of heavy metals which have economic implication on agricultural productivity in the rural communities.
2. The body responsible for environmental regulation should always carried out a periodic assessment, evaluation and monitoring in a remediated soil environment to checkmate the concentration level of heavy metals.

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