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1. Introduction

Risk is a term used to suggest a tendency for danger especially under legislation (Dumitran and Onutu, 2010). It can be narrowly classified on the basis of health being health risk or the recipient, or receptor of the action or the severity of detrimental effect it has on the biota. The parlance of environmental regulatory bodies has adopted the use of high and low to define the potency of risk to man or other living things. Variables such as time, exposure route and receptor are currently represented in model equation as a predictive approach to risk evaluation (Andretta, et al., 2006). Risk assessment is an evolving multi-disciplinary scientific discipline used to evaluate health and ecological risks associated with our being exposed to various chemicals of concern (COC). This evaluation is essential for formulation of remedial actions and risk-based management plans geared toward risk reduction. In other word, it is an approach to the determination of imminent risk caused by a pollutant to the environmental proxies. Innovations in risk-based studies have been tipped to serve a crucial role in the recovery, identification and application of risk studies. The environmental risk assessment involves calculating the probability for an ecosystem to receive a dose of pollutant or being in contact with it. Quantitative risk assessment examines the dangers and consequence based on variables, which involves estimating the size of such consequences and probability of events (Kester and Brobst, 2005). Risk assessment is technically a cheap and effective approach in the determination of long-term effects on pollution (Karkush and Altaher, 2016). Hence, eco-recovery of impacted media is believed to serve geo-reference benefits. The benefit of this approach is that it offers an all-encompassing strategy ranging from site visit to pollutant

The procedures employed are generally based on the contaminant-trajectory-receptor model (CONCAWE, 2003). It involves the examination of the site characteristics, the environmental behaviour and toxicity of the contaminants, the potential route of entry of the contaminants into the receptors (humans), the exposure of the receptors to the contaminants and their response to the dose. Thus, a baseline study of the environmental media is critical for risk definition. (Carlon et al., 2001).

Impact of crude oil pollution is the most disturbing environmental challenge facing the world today (Nikhil et al., 2013). Introduction of toxic contaminants associated with crude oil leaves a trail of challenges to the ecosystem both known and unknown. Recovery of crude oil pollutants from soil by extraction have been described to be sluggish, time consuming and less efficient. The mere presence of the pollutant on the polluted soil causes fluxes on the biodiversity of the soil. Diesel engine oil is a fraction of crude oil distillation. It solves a great portion of chemical energy need, since it is used in the running of heavy duty engines and vehicles. Transportation of these materials can pose challenges in the occurrence of spills. Diesel is dominated with non-volatile hydrocarbons than the volatile ones. It also has similar components with crude oil ranging from heavy metals to other derivatives (Bona et al., 2011). It can cause a lot of detrimental effects on both flora and fauna. In addition to direct and indirect toxicity, the oil causes interference in the hydric relations of the plants either by asphyxiation or cell damage; this has been described to have an effect on the arability of soil for agricultural purposes. However, exposure of land to contaminants present affect plant growth and yield, although some other researchers have reported that the contaminants could biomagnify and pose more endangering threat (Zahir et al., 2001). Spillage of used motor oils such as diesel or jet fuel contaminates our natural environment with hydrocarbon (Husain et al., 2008). Hydrocarbon contamination in any environmental matrix could be associated with loss of genomic integrity and cancerous effects leading to loss in biodiversity and disruption of ecosystem especially by the major contaminants of concern (Cerniglia and Sutherland, 2001). Liver and kidney dysfunction and damage are associated with the prolonged exposure of animals and plants to contaminants (Loyld and Cackette, 2001).

Because these compounds could be recalcitrant, chronic and life endangering consequences have been reported with its prolonged exposure (van Hamme et al., 2003). The lack of standard practices in the disposal of tank sludge and transfer of the diesel oil into engines and generators could pose a serious threat in a long term exposure (Blodgett, 2001).

Routine evaluation of the impacted areas could give in depth knowledge on the trajectory of progress of the removal of the pollutants

Adverse Effects of Heavy metals and hydrocarbons intake

Poor education and sensitization of the public on the causal effect of pollution have been identified as a leading cause of indiscriminate pollution of the environment. Daily discharge of toxicant by accidental or autochthonous approaches is alarming, another is the accident or anthropogenic activities have left a trail of chronic damages to organs and tissues. Indexed pollutants are heavy metals and (PAHS) (Dash et al., 2013). They cause a wide-rane of health challenges from both acute and chronic exposure (Vinodhini and Naraynan, 2008). The PAHs are regarded as poisons and are toxic to both fauna and flora, thereby changing the population dynamics of the polluted environment (Mangwani et al., 2014). Technological advancement has increased the concentration of pollutant heavy metals and toxicants as they impair body function in higher animals (Da silva and Williams, 2001). Microorganisms in the sediment, soil and water can absorb these toxicants via ingestion and inhalation of particles and metals. Heavy metals can cause damage to neurological depositions, chronic inflammatory disease and also cancer. Metal ions can be a factor to premature aging and other diseases (Chowdhury and Chandra, 2007).

Risk Assessment

(Carlon et al., 2001) suggested that risk assessment is a mechanism for resolution of challenges of associated with any kind of pollution .One of the critical elements used in the assessment is the source of the pollutant. This would be incomplete, without detailed site characterization, corrective actions (Sharma and Reddy, 2004). Risk can be categorized as unacceptable or acceptable. CONCAWE, (2003) suggested that this study quite an array of procedures.

Qualitative risk assessments are designed to give an indepth definition on the level of harm that could be exposed using the variables that define the point and nature of pollutant (Mark, 2007).

Quantitative risk assessment quantifies consequences using variables specific to the pollutant (Kester and Brobst, 2005). To do risk analysis due to environmental pollution generated by specific equipment on extraction, gas-oil separation activity the proposed methodology is divided into five modules, interrelated, each with a series of steps and stages of work.

Risk Assessment Methods

This approach to risk estimation and categorization is divided into two, based on the United States Environmental Protection Agency (USEPA) and the American Society for Testing and Materials (ASTM), both are USA based standards.

USEPA Method

The method of United States Environmental Protection Agency (USEPA) is human-health defined and it takes into account human exposure. This method consists of four steps:
(1) Data collection and evaluation, (2) Exposure assessment, (3) Toxicity assessment
(4) Risk characterization.

RBCA Method

The risk-based corrective action (RBCA) method provides a procedure for risk assessment of petroleum contaminated sites (ASTM, 2002). This method integrates exposure and risk assessment practices with site assessment activities and remedial measurement selection, ensuring that the chosen action is protective of human and the environment. The RBCA process utilizes a tiered approach in which corrective action activities are tailored to site-specific conditions and risks (Sharma and Reddy, 2004). The risk assessment method consists of three tiers with increasing the gradation of difficulty and accuracy. This tiered approach will ensure that simple cases can be completed relatively quickly with minimum efforts and cost. More data collection and tests are required to assess the risk of complex cases and potentially serious situations. Information can be gradually expanded to reduce the uncertainty and subsequently improve the rationale for making a decision.

2. Materials and Methods

Study Location

The samples were obtained from the diesel generator house facility at Delta Park, University of Port Harcourt, points of the sample collection from Delta, were mapped using a pocket-size global positioning system (GPS) device (Fig.1)

Development of conceptual site model

Montana Department of Environmental Quality, (2016) approach was adopted for risk and conceptual site model development. Information collected concerned receptors (Adults and Children, Adult workers, and Adults in industrial settings of the pollution, exposure pathways (proximity to potable water sources, farms and homes etc) and routes (ingestion, dermal contact or inhalation).

Sample collection

The modified method of Karkush and Altaher, (2016) was employed in the collection of the soil samples in and around the diesel polluted site using a soil auger. Surficial soil within 0-500 meters from the polluted site. Soil samples were also obtained from pristine surficial soil. The samples were packed in sterile containers and transported in an ice chest to the laboratory of the Department of Microbiology, University of Port Harcourt.

Figure 2: Google Map of Delta Campus, University of Port Harcourt, showing the location of the Heavy-duty Engines.

Qualitative risk analysis and Quantitative risk analysis of the site

The method of Mannan (2012) was employed for qualitative risk analysis of the site. Causes, major effects, and possible preventive or corrective measures are identified and listed by performing a preliminary hazard analysis. The quantitative analysis of the site was employed in the calculation of the hazard quotients (HQ) from the specified exposure (ASTM, 2002).

Conceptual Site Model (CSM) of Diesel Generator site, Delta Park, University of Port Harcourt.

The result presented in Figure 3 examined the possible primary sources either from improper disposal or feed system. The conceptual site study took into consideration a possible leak or spills. The study also considered a possible transportation either from volatilization or run-offs or seepages. Other variables considered were exposure as a function of inhalation, dermal contact and ingestion. The target risks exposure to contaminants of concern namely total petroleum hydrocarbon, PCBs, BTEX and metals.

Calculation of Risk

The health risk associated with[3] exposure of children and adult via dermal contact, inhalation and ingestion are calculated using the formula below as stated by Kamunda et al. (2016)

Where ADI_{dems} is the exposure dose[3] via dermal contact in mg/kg/day, ADI_{ing} = exposure dose via ingestion in mg/kg/day and ADI_{inh} = exposure dose via inhalation in mg/kg/day. Cs is the concentration of heavy metal in soil in mg/kg, SA is exposed skin area in cm2, FE is the fraction[3] of the dermal exposure ratio to soil, AF is the soil adherence factor in mg/cm2, ABS is the fraction of the applied dose absorbed across the skin. EF, ED, BW, CF and AT are as defined in table below

$$HQ = \frac{ADI}{RfD} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

HQ is a unit less number that is expressed as the probability of an individual suffering an adverse effect. It is defined as the quotient of ADI or dose divided by the toxicity threshold value, which is referred to as the chronic reference dose (RfD) in mg/kg-day of a specific heavy metal as shown in equation 4. Kamunda et al (2016).

Bioremoval of heavy metals

Bioremoval of Lead (Pb) presented in Figure 4 during the remediation of the diesel polluted soil. The samples obtained from the set amended with fungal consortium were observed to have reduced from 13.27 mg/kg to 11.85 mg/kg between the 0 to 28th day. Furthermore, the set amended with bacterial consortium had a lead (Pb) concentration decline from 13.27 to 11.02 mg/kg. The set up amended with consortia of the bacteria and fungi had reduced from 13.2 to 9.18 mg/kg while the control set up was observed to have a fairly constant concentration of lead.

Furthermore, Bioremoval of Arsenic (As) was monitored during the remediation study as presented in Figure 5. The soil samples amended with bacterial consortia was observed to be removed from 5.36 mg/kg to 4.91mg/kg. The experimental control of arsenic remained constant.

Bioremoval of chromium was presented in Fig. 6, here the concentration of chromium was significantly reduced from 9.7 mg/kg to 3.62 mg/kg between 0-28 day was observed for the sample amended with bacterial and fungal consortia. In addition to that the sample amended with bacterial consortia alone reduced from 9.43 mg/kg to 5.7 mg/kg. The control experiment does not have any changes in concentration in chromium. Similarly result was observed for the response of the result were presented in figure 6.

4 .0 Discussion

During the remediation of diesel polluted soil, the samples treated with bacterial consortia was observed to have a reduction in heavy metal concentration Lead (Pb) reduced from 13.27mg/kg to 11.85mg/kg for bacteria consortia while bacterial and fungi consortia reduced from 13.2mg/kg to 9.18 mg/kg. Arsenic (As) 5.36mg/kg to 4.91 mg/kg. Chromium (Cr) was reduced from 9.7 mg/kg to 3.62mg/kg and bacteria consortia above reduced from 9.43mg/kg to 5.7mg/kg. Ezemonye et al, (2006) reported that biostimulation can lead to uptake of metals. In their study vermidegradation coupled with effective biostimulation led to reduction in metals. Metal–binding protons could be attributed for the success of the degradation.

The result revealed 8.04±0.001% of sample P_1 was sandy while 65.35%±0.007% of P_2 was sandy while 31.9±0.13% of P_3 was sandy. The soil sandy quality increased with increase of distance away of pollutant. P_1 was adjudged to have a clay content of 53.67% and P_2 was 23.87% and samples obtained from the 100m mark P_1 was also adjudged to have a high silt content of 68.14±0.04%. However, Patil et al. (2012) reported a particulate quality of clay 0.24%, sand 12.83 and silt quality of 86.42% and water holding capacity of 10.5% , pH of [12] 6.74 and 7.54 for P_2, Whereas in this study a pH of 6.19±0.009 was reported during the study. The pH reported could impact the bacterial diversity and degradation of pollutant

Risk is estimated on the basis of receptor i.e. the adult and children and several variables as described in table 5. The Hazard quotient 0.013 was reported for children while for adults were 0.014. Furthermore, cadmium with Average Daily Intake (ADI) of $1.7x10^{-6}$mg/kg/day on day zero then reduced to $1.9x10^{-6}$ for children while adult recorded a reduction of 6.6x10-7 mg/kg/day to 6.05 $x10^{-7}$ mg/kg/day. Risk Average Daily Intake (ADI dermal contact) revealed Lead (Pb) reduced from $5.2x10^{-6}$ mg/kg/day to $4.7x10^{-6}$ mg/kg/day with a Hazard Quotient (HQ) of 2.06 x 10^{5} and $1.7x10^{5}$. However the average daily intake of Chromium by children was observed to reduce from 7.5 $x10^{-6}$ mg/kg/day to $1.06x10^{5}$ mg/kg/day and had a hazard quotient of 0.138 to 0.187. This was similar to the finding by Kamunda et al. (2016) who reported $1.96x10^{-4}$ mg/kg/day for chromium. According to USEPA (2004) $1.0x10^{-6}$ mg/kg/day to $1.0x10^{-4}$ mg/kg/day was acceptable for cancer risk. The cancer risk for this study was higher [14] than regulatory limit for countries like South Africa. The opinion of Kamunda et al. (2016) suggests that hazard quotient (HQ) and hazard index (HI) greater than 1.0 suggests cause for risk and carcinogenic effect.