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ENVIRONMENTAL LEAD VERMIDEGRADATION FROM TOTAL PETROLEUM HYDROCARBONS (TPH) IMPACTED SOIL

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ABSTRACT

Total petroleum hydrocarbons (TPHs) contaminated water sample with 104762.42 mg/L was impacted on an organically rich humus soil of 1000 g and the TPHs-impacted soil gave environmental lead (Pb) concentration of 54.00 ± 0.01 mg/kg. However, Pb vermiextraction from the TPHs contaminated soil by *Esiena fetida* showed

Introduction

Environmental lead (Pb) is a natural constituent of the environment, but indiscriminate use for human purposes has altered their geochemical cycles and biochemical balance. This results in excess release of the heavy metal into natural resources like the soil and aquatic environments (Alloway & Ayres, 1998; Zhang et al., 2012). Prolonged exposure and higher accumulation of Pb can have deleterious health effects on human life and aquatic biota (Khan et al., 2005). Moreover, there is an increasing trend of Pb accumulating in soils due to a number of deliberate or wrong practices such as mining and milling, metal or coal mining, road transport such as gasoline combustion, component wear, fluid leakage and corrosion of metals (Brown et al., 2000). Environmental-lead is one of the major metal pollutants of the environments and is released from fuel burning, wear out of tyres, leakage of oils, and corrosion of batteries (Onder et al., 2007; Brown et al., 2000). The secondary sources of anthropogenic pollution are more

39.83 mg/kg which gave vermidegraded value of 9.17 mg/kg of Pb in the soil with treatment efficiency of 83.02%. In the control group, Pb concentration without TPHs soil impact was 5.10 ± 0.00 mg/kg while *E. fetida* extracted 2.47 ± 0.01 mg/kg with vermidegraded Pb soil concentration of 0.31 ± 0.02 mg/kg. The results were analytically obtained using Gas chromatography mass spectrometry detection (GC-MSD) Agilent Technologies 7890A for the TPH value and Atomic Absorption Spectrophotometer (AAS) (Buck Scientific Model 210 VGP) for Pb concentration; instruments were set in accordance with manufacturers' operational specifications.

Keywords: Environmental lead (Pb), TPH-impacted soil, Vermidegraded, *Esiena fetida*, GC-MSD, AAS.

dominant, localized and causing higher magnitude soil pollution. Use of contaminated water for agricultural purpose has affected the soil health and reduced the crop productivity in the long run as a consequence; there would be a risk for ecosystems and agro-systems (Denti et al., 1998; Dolan et al., 2006). Children are at particularly high risk for adverse effects of lead exposure; even at low concentrations, lead can affect physical, mental, and behavioural development. Children living near lead-zinc mines are at high risk for environmental lead poisoning, especially the contaminated soil (Wilson et al., 2005). Vermidegradation is an innovative and promising technology available for removal of heavy metals and recovery of the heavy metals in polluted water and lands (Blouin et al., 2013; Contreras-Ramos et al., 2006). Since earthworms have developed various strategies for their survival in organic and inorganic polluted habitats, these organisms are known to develop and adopt different detoxifying mechanisms such as vermidegradation, vermifiltration, vermiextraction, vermitransformation and vermimineralisation, which can be exploited for bioremediation either *ex situ* or *in situ* (Contreras-Ramos et al., 2008). Remediation or cleanup of Pb contaminated soil is a necessity in order to have a safe and healthier environment, which will sustain our life on the beautiful earth planet. This study aims to degrade elevated environmental toxic lead from TPHs impacted soil using an eco-friendly and cost effective vermidegradation technique.

Materials and Methods

Soil Sampling/Vermiculture

Organically rich humus soil of 1000g was weighed into a clean plastic vessel (20, 000 cm^3) with a suitable dimension (length [28.30 cm], width [25.50 cm] and height [33.60 cm]) while earthworm bed consist of old newspapers was made at the pit of the container. The moisture content (45-50%), pH (6.5-7.0), humidity (40-45%) and temperature (20-30°C) of the humus soil samples were observed at green house. *Eisenia fetida* squirms were introduced and covered with old newspapers to reduce or prevent illumination (earthworms are sensitive to light) and maintain the vermiculture's condition.

Soil from the vermiculture was collected (after the detention period of 5 weeks) and dried at room temperature to constant weight, ground homogenously with clean mortar, sieved through a 2 mm sieve to remove debris and stones and stored in transparent polythene bags at room temperature for characterisation of TPHs and Pb.

TPHs Water

Homogenized 500 cm^3 petroleum hydrocarbons contaminated water sample was subjected for a liquid-liquid extraction in 1000cm^3 glass separatory funnels fitted with a glass stopper. Acetone and n-hexane (1:1, v/v) of 125 cm^3 was added and was shaken on a reciprocating mechanical shaker at 120 oscillations per minute for 4hours. The mixture of sample was poured into separatory funnel and allowed to stand for a couple of minutes for the organic layer to separate clearly from the aqueous phase. The organic (extract) layer sample was collected and stored in an amber bottle with Teflon lined cap and refrigerated at 4°C until needed.

TPHs Soil

Petroleum hydrocarbons contaminated water sample of 250 cm^3 was impacted with the constructed vermiculture and mixed homogenously while 5 weeks detention period was observed.

TPH Analysis

Total petroleum hydrocarbons of petroleum contaminated water was carried out using the refrigerated organic extracted sample. The TPHs value was quantified by Gas chromatography mass spectrometry detection (GC-MSD) Agilent Technologies 7890A in accordance to the specifications and operational conditions of the manufacturer.

Digestion of Soil for the Determination of Pb

The soil sample of 1g was digested with mixtures of 12 cm^3 of freshly prepared aqua regia (3cm^3 HNO_3 and 9cm^3 HCl) separately in 100 cm^3 standard Pyrex breakers. The sample was heated on steam bath for 30mins until cleared solutions were obtained in the laboratory fume hood and then cooled. The digest was filtered independently with Whatman number 41 filter papers and the filtrates were made up to 50cm^3 standard volumetric flasks with deionised water. The different solutions were transferred into their properly labelled plastics bottles and refrigerated at 4°C.

Preparation of Lead (Pb) Stock Solution

A stock solution of 1000 mg/L Pb was prepared by dissolving 1.60g of Pb $(NO_3)_2$ into 100cm^3 deionised water in a litre volumetric flask. This was subsequently filled up to the mark. Further dilution (5, 10, 15 and 20 mg/L) were made. The solutions were stored in air tight Teflon sample bottles kept in a cool, dark room until needed.

Pb Analysis

The digested soil sample was characterised for concentration of Pb using Atomic Absorption Spectrophotometer (AAS, Buck Scientific Model 210 VGP) at the wavelengths of 217.0 nm. The instrument's setting and operational conditions were done in accordance with the manufacturer's specifications. The prepared calibration curve of the element was used to infer its concentration.

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Result: Table 1

Environmental Lead (Pb) Vermidegradation

Lead (Pb) Concentration (mg/Kg)						TPHs Water (mg/L)	Environmental Pb Soil Treatment Efficiency (%)	WHO/FAO (2001) MPL
Control Group			Experimental Group					
Soil without Petroleum Hydrocarbons Water Impact	*Eisenia fetida* (Pb vermiextraction)	Pb Soil after vermiextraction	Soil with Petroleum Hydrocarbons Water Impact (TPHs Soil)[a]	*Eisenia fetida* (Pb vermiextraction)	Pb Soil after vermiextraction[b]			
5.10 ± 0.00	2.47 ± 0.01	0.31 ± 0.02	54.00 ± 0.00	39.86 ± 0.01	9.17 ± 0.01	10476 2.42	83.02	50.00

MPL =Maximum permissible limits, n =4, TE = (a-b)/a X 100%

Discussion

In this study (Table 1) the environmental lead soil concentration after TPHs impact showed elevated mean value above the maximum permissible limit of World Health Organisation/Food Agriculture Organisation (WHO/FAO). The high concentration of contaminated Pb soil from the experimental group as compared to the control resulted in the dramatic consequence of TPHs impact on the organically rich humus soil. The use of *E. fetida* for soil rehabilitation and clean up tool degraded the toxic environmental Pb by the bio-technique of vermidegradation process with treatment performance of 83.02% that is significantly below the WHO/FAO maximum permissible limit of 50.00 mg/Kg.

Conclusion

The contamination and elevated concentration of environmental lead from TPH impacted soil was an indication of how agricultural ecosystem and food chain is polluted by human activities, such as fossil fuel exploration and usage. People living in such polluted areas area exposed to Pb toxicity; however Pb

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exposures have severe adverse health impacts. From the present study, soil rehabilitation from heavy metal like Pb and organic (TPHs) contaminants require adaptive biological and sustainable system that can resuscitate biotic component of the soil of which vermidegradation technique was viable. However, the simultaneous clean up of multiple contaminants using conventional chemical and thermal methods is both technically difficult and expensive. These methods also have the potentials in destroying the biotic component of soils.

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