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Treating of Oil-Based Drill Cuttings by Earthworms.

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ABSTRACT

This study assessed the advantage of using earthworms in combination with punch waste and nutrients in remediating drill cuttings contaminated with hydrocarbons. Analyses were performed on day 0, 7, 14, 21, and 28 of the experiment. Two hydrocarbon concentrations were used (20000 mg/kg and 40000 mg/kg) for three groups of earthworms number which were five, ten and twenty earthworms. After 28 days, the total petroleum hydrocarbon (TPH) concentration (20000 mg/kg) was reduced to 13200 mg/kg, 9800 mg/kg, and 6300 mg/kg in treatments with five, ten and twenty earthworms respectively. Also, TPH concentration (40000 mg/kg) was reduced to 22000 mg/kg, 10100 mg/kg, and 4200 mg/kg in treatments with the above number of earthworms respectively. The present study revealed that the trend of degradation was observed to increase significantly with an increase in Earthworms number and with an increase in number of tested days. The results of this study have shown that TPH with certain concentrations can be reduced to acceptable levels by using the selected earthworms named Allolobophora. Also the study results revealed that the present bioremediation can be considered an additional option to deal with the local petroleum contaminated sites.

Keywords: Earthworms, drill cutting, Environmental Protection, bio treatment

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INTRODUCTION

Drilling and oil well can generate different types of wastes. These wastes require specialized treatment prior to responsible disposal. When discharged untreated into the surrounding environment, drilling mud and cuttings may be capable of interfering with normal function of organisms such as antioxidant levels [1].

In addition to land treatment, there are many ways to deal with invert mud laden cuttings in onshore drilling operations [2].

Among of these ways, bioremediation can be considered as a well-proven and environmentally acceptable technology that uses microorganisms (bacteria and fungi) or earthworms to biologically degrade hydrocarbon contaminated waste in to nontoxic residues and reduce contaminant concentrations to acceptable levels.

Vermiculture or worms farming is a well-established method for treating organic wastes and decompose them into a material capable of receiving necessary nutrients to increase plant growth [3].

This process has been found successful in treating certain synthetic-based drilling wastes since it provides a good application in reducing the hydrocarbon concentration to acceptable levels [4].

It was found that the best oil based or synthetic based drilling fluid formulation for vermiculture operations would be based on linear paraffin with an internal brine phase of potassium acceptable [5].

Earthworms have been used as biomarkers for assessing chemical environmental pollution and earthworms contribute to the aeration of the soil [6]. In soils, earth worms constitute 60-80 % of the animal biomass and can accumulate drilling mud in their body from soil [7].

The aim of this study is to test the selected earthworms called allobophara in treating hydrocarbon contaminated waste (drilling wastes) in to nontoxic residues.

The bio-degradability of different petroleum products from more degradable products to less degradable one according to the United States Environmental Protection Agency (USEPA) which can be treated through birremedation using petroleum products [8]. A number of important studies have highlighted the activity of earthworm use to promote hydrocarbon contaminant loss from soil [9-11].Nutrients are very important for build –up the cellular biomass of both microorgansims and plant [12].

The survival of earthworms (Eudrilus eugeniae) with engine oil contaminated soil was tested and it was found that engine oil concentration level acceptable to earthworms was dependent on the source of the used engine oil [13].A laboratory study was shown that Eudrilus eugeniae could be applied as a possible bioremediation in diesel polluted soil [14].

MATERIALS AND METHODS

Drill cutting contaminated with hydrocarbons (oil based drill cutting) were collected from an Iraqi oil field and crushed to be at 5-10 mm in diameter and mixed with soil (50% w/w). Then it blended and mixed with paunch waste (undigested grass) from a slaughterhouse earth at a 20% w/w ratio of total weight. An earthworms called Allolobophora was collected from a single source, i.e., from an agricultural soil. Two hydrocarbon concentrations of 20000 mg/kg, and 40000 mg/kg were tested for 28 days to know the hydrocarbon degradation within the present bio treatment. The total mixture of drill cuttings, soil and paunch wastes was performed on a plastic container that have the dimensions of 0.4 m*0.10 m * 0.15 m. There where two replicate container per treatment for five, ten and twenty earthworms per container of mixture. The test containers were covered with a net of very small mesh size to allow aeration which is very important to maintain this treatment and to prevent the earthworms form elude out of the containers.It is important to know that the nutrients (nitrogen and phosphorus) with nitrogen ratio (25:1) were added to the total mixture at a 10% w/w.

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Also, an irrigation and watering procedure was periodically used to maintain the correct moisture content. The compost mixtures were maintained at temperatures of 30-35 ^{0}C.

50-cc Grab samples were taken at time zero and then at approximately seven days intervals. Samples were analyzed for total petroleum hydrocarbon (TPH) concentration using high pressure liquid chromatography (HPLC).

The selected earthworms are Allolobophora ,figure(1) which have the following bio classification:Phylum: Annelida, Class: Oligochaeta ,Order: Opisthopora

Fig. 1: picture represents the selected earthworm (Allolobophora)

RESULTS AND DISCUSSION

One hundred and forty Allolobophora (mean weight 2.5 gm.) were collected from an agricultural soil. The annelids were kept under specific condition in the laboratory for seven days until used. The Carbone chain length distribution of the C12-C17 linear paraffin blend has been found in hydrocarbon contaminated drill cuttings.

At the end of the exposure, bioaccumulation total hydrocarbons increased with increase drilling cuttings concentration with hydrocarbons (Figures 2 and 3 and 4). The abbreviations E5, E10, E20 means treatment with five earthworms, ten earthworms, and twenty earthworms respectively. It can be seen from the results that the highest bio accumulation of heavy metals and total hydrocarbons occurred at 40000 mg/kg and least at 20000 mg/kg. Figure 4 shows that the hydrocarbon concentration in case of treatment with twenty earthworms decreased from 40000 mg/kg (dry wt.) to less than 4200 mg/kg (dry wt.) in under 28 days with less than 15000 mg/kg (dry wt.) remaining after 10 days in what appears to be a fairly typical exponential type degradations curve.

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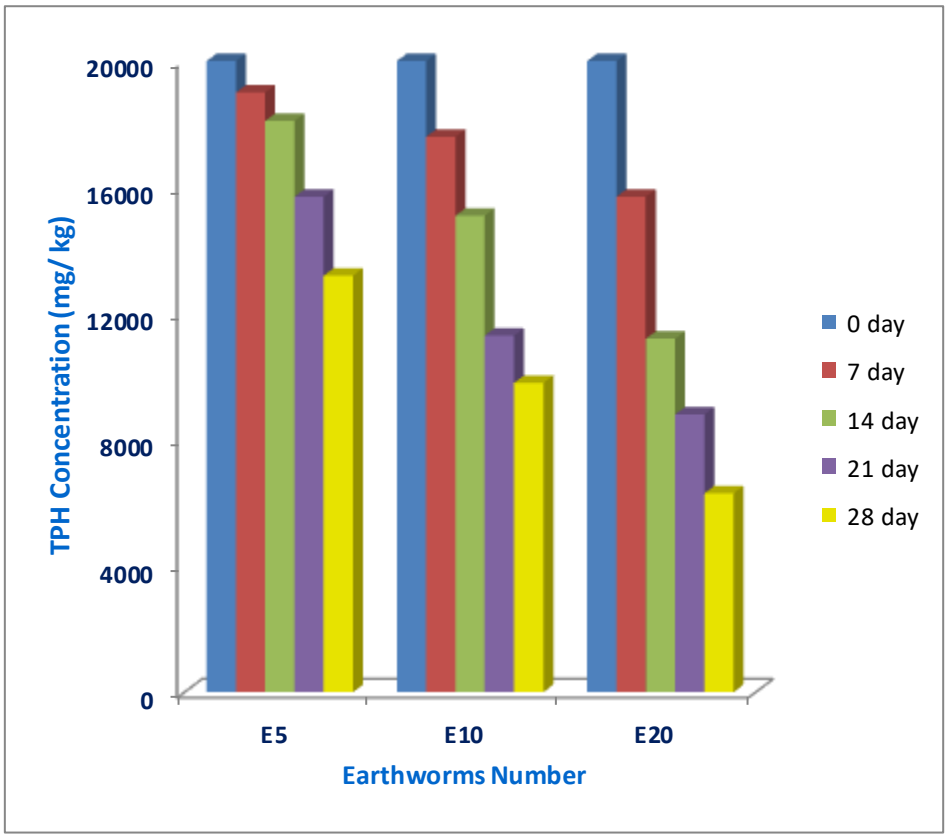

Fig.2: Total petroleum hydrocarbon (TPH) concentration degradation in samples among 28 days (with basic TPH concentration 20000 mg/kg).

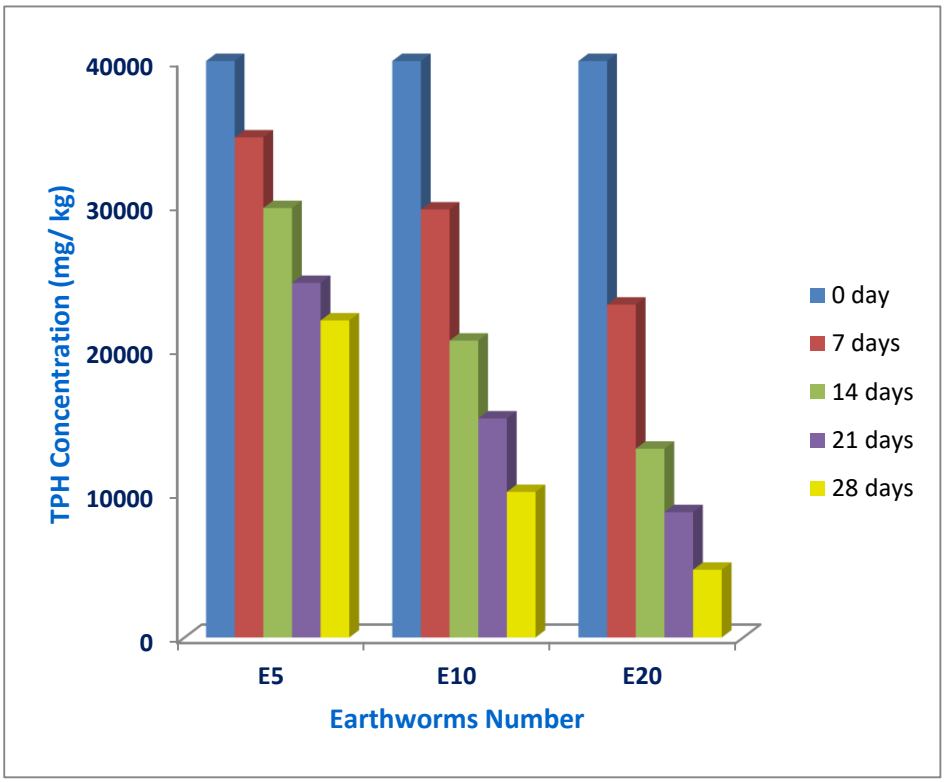

Fig. 3: Total petroleum hydrocarbon (TPH) concentration degradation in samples among 28 days (with basic TPH concentration 40000 mg/kg).

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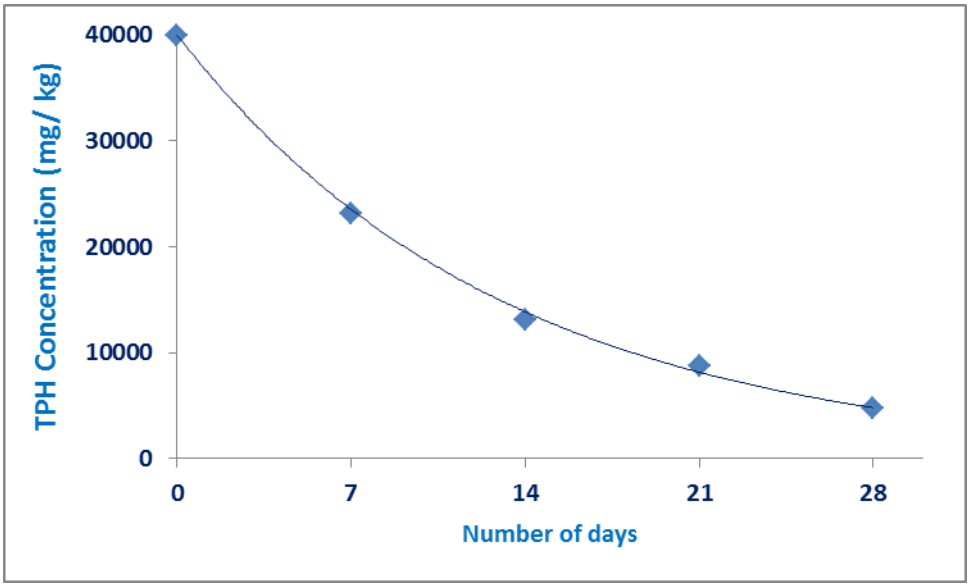

Fig. 4: Degradation of hydrocarbons in sample of TPH concentration=20000 mg/kg by twenty earthworm.

It can be seen that bio accumulation of the heavy metals increased with increase drilling cuttings concentration with hydrocarbons**,** Fig (5).

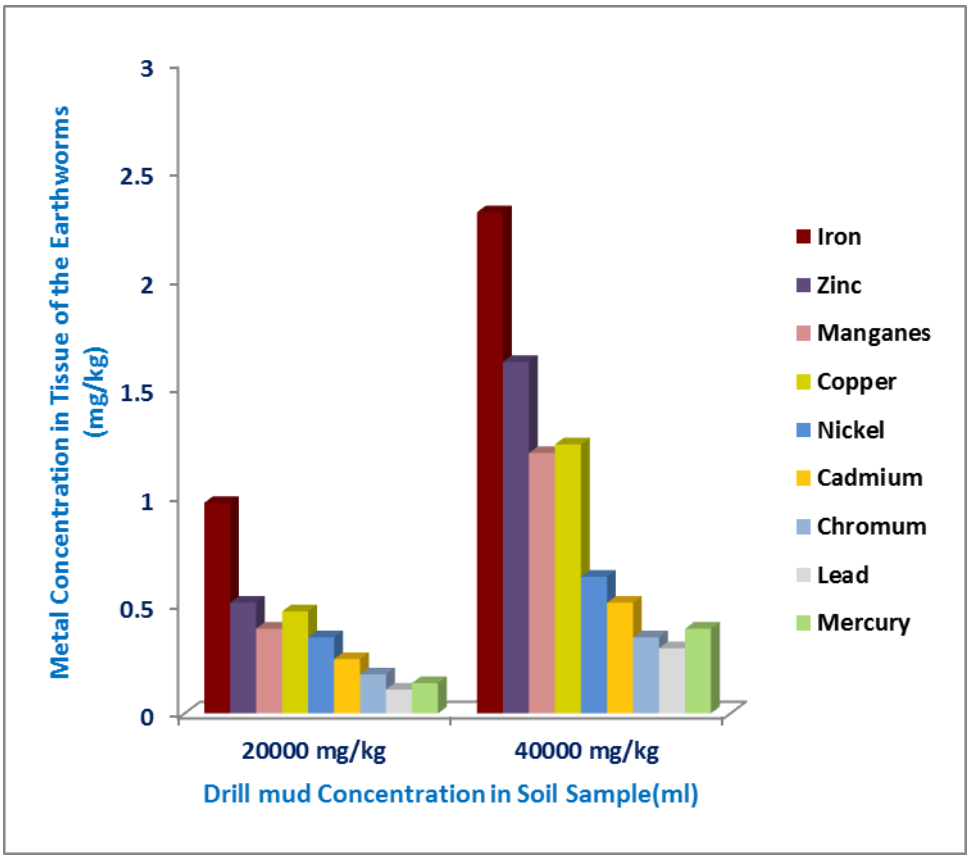

Fig.5: Bioaccumulation of some heavy metals in earthworms exposed to contaminated drill cuttings.

There was an identical significant decreased in the heavy metals concentration with Allolobophora after 7, 14, 21, and 21 days of the study. The uptake of zinc, copper and nickel revealed the same trend while the chromium had the lowest uptake and the mercury showed the highest uptake.

The level of trace element demand or requirement and the rate of bioremediation process may explain the rate of uptake of heavy metals by the present earthworms. Also it is important to mention that the longer duration had resulted in the higher reduction in TPH.

As a part of this study, bioaccumulation factor (BAF) was evaluated as the concentration of the heavy metals in the earthworms in relation to the concentration in polluted soil after 28 days of the experiments [14]:

$$BAF_{\text{heavy metal}} = HM_E / HM_S$$

Where:

$BAF_{\text{heavy metal}}$ =bioaccumulation factor for heavy metals
HM_E = heavy metal concentration in the earthworms (mg/kg)
HM_S = heavy metal concentration in the soil (mg/kg)

The BAF for heavy metals in the contaminated sample showed that zinc, copper, and nickel had a BAF_S of 1.51, while manganese, cadmium, chromium, lead, mercury and iron has a BAF_S of 1.56,1.54,1.52,1.59,1.3 and 4.33 respectively.

This study revealed that earthworms (Allolobophora) enhanced oil degradation in soil. Also the results indicated the semi complete degradation of the cuttings and no detectable mortality among the selected worms. Spent drilling mud and cuttings with high TPH concentrations should not be discharged onshore where earthworms present because of their toxicity. An important issue in such treatment is the use of certain drilling fluid designed for bioremediation or vermiculture process but this option is technically and practically difficult. The trend of degradation was observed to increase with number of earthworms and with number of tested days. It is important to say that these results agree with that obtained by many researchers.

CONCLUSIONS

The earthworm Allolobophora highly bio accumulated the constituents of the contaminated drill cuttings at the end of 35 days experimental period.

In general, spent drilling mud and contaminated drill cuttings should be treated before the final disposal or dumping in terrestrial ecosystems.

Local legislations should be made to regulated and control the disposal of drilling wastes especially in cases of using oil based drilling fluids.

The most interesting feature of the present process is its tendency to generate no real waste at all and the end product can utilize to enhance the soil or plant growth.

Successful biodegradation using earthworms is dependent upon many conditions such as hydrocarbon concentration, nutrients ratio and temperature.

Obviously, the specific biological mechanism responsible for hydrocarbon degradation using this type of earthworms is not known. Many hypotheses concerning with this biotreatment include microbial degradation with the worm beds, favorable aerobic conditions available during the experimental periods, and metabolic consumption of the hydrocarbons by the selected worms.

The study has shown that the selected earthworms could be applied as a possible bioremediation in drill cuttings polluted soil.

The effect of increased heavy metal concentrations in the worm cast would require further study using alternative weighting materials.

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