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Management Evaluate and Review Solutions to Reduce Soil Pollution

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Abstract

Crude oil is a complex natural mixture that is one of the main sources of energy for life. Oil pollution has unpleasant effects on the environment that can cause many problems for human beings, since the toxicity and carcinogenesis of oil compounds for living creatures and humans are obvious and proven. The oil-contaminated soils and waters are one of the most important environmental issues. Scientists have proved different ways to clean up oil pollution throughout history. In this research, ways to reduce and eliminate pollution of crude oil in the soil are going to be studied. The following methods are suggested : The use of electrochemical methods for reducing the aromatic contamination of crude oil, The use of biodegradable and synthetic detergents for the removal of oil hydrocarbons, bioremediation of soil contaminated with plants. Finally, by reviewing the results obtained, solutions can be found to clean up the pollution of crude oil from the soil, Because cleaning up crude from soil reduces environmental degradation.

Keywords: Crude Oil, Environment, Oil Purification, Pollution.

Abstrak

Minyak mentah adalah campuran alami kompleks yang merupakan salah satu sumber energi utama bagi kehidupan. Polusi minyak memiliki efek buruk pada lingkungan yang dapat menyebabkan banyak masalah bagi manusia, karena toksisitas dan karsinogenesis senyawa minyak untuk makhluk hidup dan manusia sudah terbukti. Tanah dan perairan yang terkontaminasi minyak adalah salah satu masalah lingkungan yang paling penting. Para ilmuwan telah membuktikan berbagai cara untuk membersihkan polusi minyak sepanjang sejarah. Dalam penelitian ini, cara-cara untuk mengurangi dan menghilangkan polusi minyak mentah di tanah akan dipelajari. Metode berikut disarankan: Penggunaan metode elektrokimia untuk mengurangi kontaminasi aromatik minyak mentah, Penggunaan deterjen yang dapat terurai secara biologis untuk menghilangkan hidrokarbon minyak, bioremediasi tanah yang terkontaminasi dengan tanaman. Akhirnya, dengan meninjau hasil yang diperoleh, solusi dapat ditemukan untuk membersihkan polusi minyak mentah dari tanah, Karena membersihkan minyak mentah dari tanah dapat mengurangi degradasi lingkungan.

Kata Kunci: Lingkungan, Minyak Mentah, Pemurnian Minyak, Polusi.

1. Introduction

Environmental pollution is increasing with a variety of pollutants, including heavy metals, radionuclides and hazardous organic compounds, which will eventually lead to serious health risks for humans, animals, and plants. Oil pollution has been one of the major concerns in the area of environmental pollution in recent centuries due to the dependence of petroleum products in all

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countries (Lu et al., 2010, and Xu and Lu, 2010). With increasing oil extraction and leakage from transportation tanks, the soil is polluted by oil hydrocarbons. According to the US Environmental Protection Agency's annual report for 2018, USEPA has 533,000 underground storage facilities in oil stores and hazardous materials in the United States that the leakage of underground storage reservoirs is the greatest risk for groundwater pollution and drinking water supply for half of the American people. Oil pollution also causes environmental pollution and endangers the lives of people in the United States and the world. Oil refinement and transfer are always associated with pollution and the presence of these pollutants undermines the balance of ecology that this balance may remain for many years, and these negative effects will endanger the life of living creatures and natural plants (Gogoi et al., 2003 and Singh, 2006). One of the causes of oil pollution is the multi-ring aromatic hydrocarbons such as anthracene, phenanthrene, benzopyrene and benzanthracene, which are potentially fierce, carcinogenic, and potent in the food chain (Neff et al., 1989). These compounds are in the waste water of many oil installations. A significant amount of aromatics remains in the waste water after oil refining. The release of these pollutants results in environmental pollution from hydrocarbon oil (Dastgheib et al., 2011) . For this reason, researchers have conducted several studies to find the most suitable and effective way to clean up environmentally friendly pollutants with increasing pollution over time on the environment (Chilingar et al., 1997).

2. Methods

2.1. Oil Pollution Removal From The Environment

The study aimed to evaluate the advantages and disadvantages of three basic methods of reducing oil pollution in soil. These methods are: 1.) The use of electrochemical methods to reducing the aromatic pollution of crude oil, which is due to the high efficiency of removal of pollutants (especially high removal efficiency of heavy metals), comprehensiveness, simplicity and low cost and cost-effective simply because it is widely used be (Darmawan and Wada, 2020 and Mattson et al., 2002). 2.) Use of biodegradable and synthetic detergents to remove petroleum hydrocarbons, which have the advantages of using this method: Ease of preparation from renewable natural resources; Less toxicity than synthetic types; Biodegradable; Compatibility with the environment after disposal of effluent from the soil washed into the environment; Introduces excellent surface activity than synthetic detergents (Urum et al., 2003), and 3.) Bioremediation of soil contaminated with plants, plants are able to stimulate and increase the activity of destructive microbial oil-producing populations by releasing nutrients and secreting various compounds, including organic acids and sugars in the soil, as well as transferring oxygen to their root zone, the main recommendation on the main use of this short method for refining (6 months to 2 years depending on the existing pollution conditions), very low cost compared to other refining methods, accelerating the degradation of refining organic compounds in areas with low biodegradation rate, the need for minimum features and equipment and additives and minimal side effects on the environment (Li et al., 2002 and Marin et al., 2005).

3. Result and discussion

3.1. The Use of Electrochemical Methods for Reducing the Traumatic Contamination of Crude Oil

One of the methods for soil treatment is the electrochemical method, which is a useful tool in the removal of many pollutants, especially contaminants from soil and sediments. In this method, a low-current electricity passes through the octres in the soil, and pollutants are removed from the soil through electrophoretic, electroshock, and ion migration phenomena. This method is used in other methods where soil clearing is not working, and is more applicable (Acar and Alshawabkeh, 1993 and Reddy and Cameselle, 2009). Pollutants can be classified into: Absorbed to the surface of soil particles; Species absorbed to colloidal particles in soil penetrating liquid; Soluble species in soil penetrating liquid; Solid species like sediment. Only pollutants that are soluble in the permeate liquid of the soil or colloidal particles suspended in the soil porous liquid can be removed by electro-kinetics. So, some methods have been used by the researchers to increase the dissolution of pollutants and their mobility (Yeung, 2006). Electro-osmotic flow is the most important transmission mechanism for eliminating organic pollutants by electrokinetic method. On the other hand, due to the low solubility of

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organic pollutants in water, the electrokinetic method is usually combined with other methods, including flushing or soil washing. These compounds exist both in artificial and natural forms (Fan et al., 2014). Surfactants include materials used in soil washing. These surfactants include amphiphilic compounds that have two hydrophilic and hydrophobic subgroups. Surfactants improve the removal of oil compounds in water through two main mechanisms: moving oil particles (stimulation) and dissolution (solubility) of the oil compounds in the water. In the stimulation mechanism, phenomena like surface tension reduction, interface tension, reduced capillary strength and hygroscopicity and increased contact angles are created. While in the solubility, due to the distribution and transfer of contaminated particles into the hydrophobic section, surfactant micelles is done. Many researchers used a variety of surfactants for washing soils contaminated with organic materials. In 2012, Saponin surfactant (Figure 1) was used to wash soil contaminated with crude oil and the removal efficiency reached 72% (Seyed Razavi et al., 2012). In another study, with the investigation of the efficacy of Brig 35 and Tween 80 surfactants in the removal of gasoline, the removal percentage of 60-65% and 70-80% was reported (Mehrasebi et al., 2013). In 2009, the removal efficiency became 97% while washing soil contaminated with Sodium Dodecyl Sulfate with a density of 8mM (Khalladi et al., 2009). The combination of using surfactants with the electrokinetic method was used in other studies, for example, in 2014, to improve the removal of PCBs from contaminated soils by Electrokinetic method, Igepal CA-720 the removal efficiency reached 38% (Fan et al., 2014).

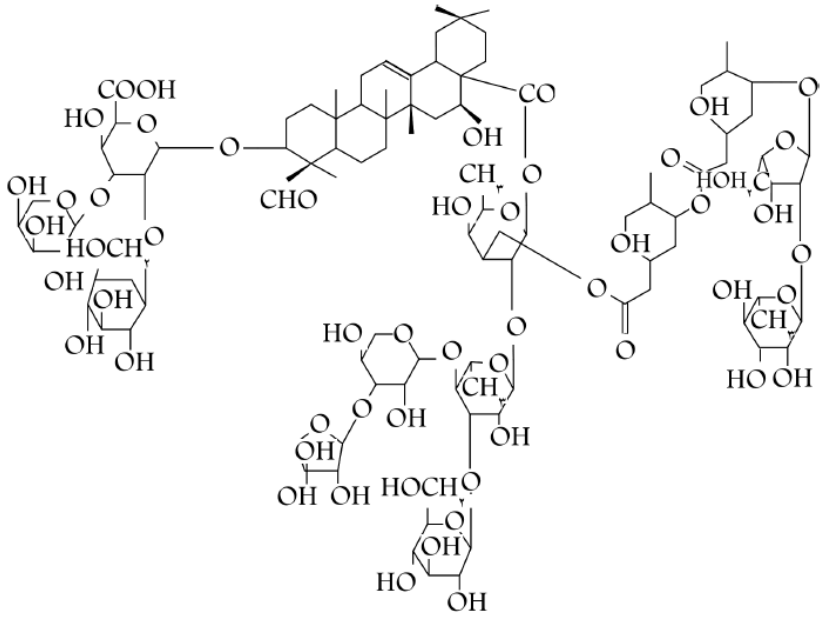

Figure 1: Chemical Structure of Saponin
Source: Mulligan et al, 2001

3.2. The Use of Biodegradable and Synthetic Detergents for the Removal of Oil Hydrocarbon

Detergents are dual-bonded compounds that increase the energy of the system by replacing high-energy molecules at high levels. Detergents are used for soil contamination due to their high ability to rinse dirt. The detergent acts on the boundary between the pollutant and the solution, where each molecule of detergent has a hydrophobic and a hydrophilic section. Currently, detergents has been widely used in the industry by classification based on the solubility in water with neutral pH. This category includes anionic, cationic, non-ionic, and amphoteric detergents (Elvers et al., 1994 and Holmberg, 2002). The detergent acts in the boundary layer between the solvent and the pollutant. The hydrophobic part tends towards the pollutant, and the hydrophilic part is formed by hydrogen bonding water, and this mechanism removes pollutants from the soil pollution levels and eliminates contamination (Mulligan et al., 2001). Of course, the detergent also depends on factors such as temperature, time and concentration, and the main use of detergents is the solubility of the oil compounds of water-soluble liquid. This is done by reducing surface tension and interface tension. By

reducing the surface tension and increasing the concentration of detergents, the string monomers are formed. The concentration of detergents in which the first monomer strings are formed is the Critical Micelle Concentration (CMC). In fact it is a point at which the lowest level of surface tension occurs for the first time. CMC is one of the most important attributes of detergents. Many of the physical properties of detergents, such as the formation of emulsions, the dissolution of oil and gasoline compounds, foaming, surface tension and interface tension depend on it. These properties are very important for determining the proper detergents in soil washing process. For CMC, the amount of detergent, length of hydrocarbon and type of detergent affects it. Anionic and non-ionic detergents are less absorbed by the soil than cationic detergents. Ionic detergents may also precipitate. Combination of ionic and non-ionic detergents can reduce the amount of sedimentation, but there are still some concerns about this, for example, researchers have reported problems such as cavity obstruction and reduced permeability, which are major causes of soil remediation. Figure 2 shows the effects of detergent concentration on surface tension and interface tension and solubility (Mulligan, 2005). Artificial detergents have a significant effect on biological activities, ecosystems and our environment. Although the effect of different detergents are different but the negative and toxic effect of it on living cells is obvious. Because these substances are toxic to the body, the absorption of these materials by body may cause harmful damages, the excessive use of these detergents will cause their extensive spread in the environment and contaminating the river and sea. The presence of these detergents in the environment and the excessive growth of mosses absorb the oxygen in the water and cause the death of aquatic organisms. Bio-detergents are a suitable alternative to artificial ones because they have less negative effects, they can be easily prepared from renewable sources, have better performance in surface activity, have better compatibility with the environment after wastewater discharging, and in the end have the ability to tolerate high concentrations of water-soluble salt.

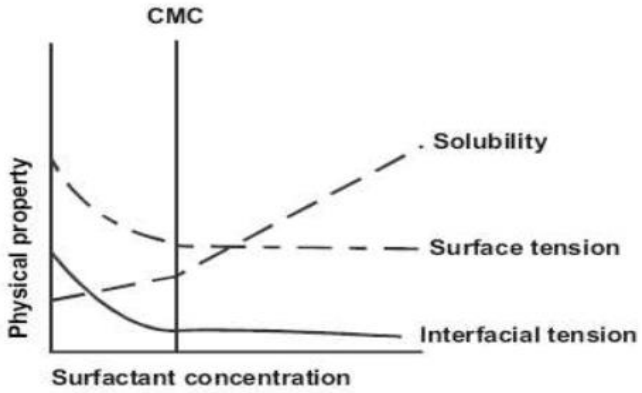

Figure 2: Effect of Detergent Concentrations on Physical Properties
Source: Rahman et al., 2002

Studies carried out by Rahman et al. (2002) and Urum et al. (2003) on the reinforcement of the biological recovery of gas-contaminated soils, which was surveyed for 90 years by bio-detergent showed that up to 80% of hydrocarbons were omitted during the first 60 days and the most omission was related to this model that Rhamnolipid was added to it at a concentration of 1%. In conducted research, Mulligan et al. (2003) shows that sandy soil with 1000 ppm up to 20 times of empty volume was washed with an anionic detergent JBR425 and a purification efficiency of up to 67% of the detergent was reported (Urum et al., 2003). Wide research investigated the optimal conditions of washing soil contaminated with crude oil by biological detergent solutions. In the experiments carried out by them, various features and items such as temperature, dilute solution concentration, volume of detergent solution, mixing speed and washing time were investigated. The results of the experiments at 50° C and 10-minute washing showed that synthetic detergents Sodium Dodecyl Sulfate (SDS) (Figure 3), Rhamnolipid Microbial Washing Solution and Saponin Bio-detergent had an elimination efficiency over 80%. The results from the research (Calvo et al., 2004) suggest that biological detergents have a very effective efficiency in the process of soil pollution modification from crude oil.

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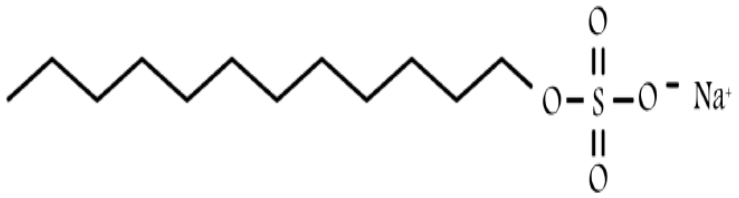

Figure 3: Chemical Structure of SDS
Source: Calvo et al., 2004

3.3. Bioremediation of Soil Contaminated with Plants

Many physical and chemical methods are used to remove contamination from zones with low areas with fairly coarse aggregate size and are very costly for large areas such as contaminated soils, industrial materials, petroleum products, mines and the like (Khan, 2005). Another way of remediation is when the amount of clay in the soil is high, the lay particles usually comprise between 20% and 50% of the contaminated soils, and it's not easy to clean up these soils with physical and chemical methods, because when the soil has a large percentage of clay, it needs more process to be clean. Therefore, the bioremediation method is recommended for these soils (Robertson et al., 1999). Bioremediation is based on the combination of plant activity and the microbial community associated with the decomposition, transfer, deactivation, and settling of soil and groundwater contaminants (Cunningham et al., 1996). Figure 4 shown processes involved in the stabilization and sequestration of contaminants in soil. In technology, bioremediation of plant root has a stimulatory effect on microbial activity, which makes the conditions and the environment suitable for the growth and proliferation of microbial populations, and thereby reducing oil pollution from the soil (Gunther et al., 1996). Meanwhile, selection of plant type is very important. Merkl et al. (2005) have shown that nitrogen instability can cause oil pollution damage to plants because infected soils can reduce the ability of roots to absorb nutrients. In order to solve this problem, they have used plant fertilizers to stabilize nitrogen, and thus improves soil fertility. A study by Akaninwor et al. (2007) showed that the maize plant was able to grow and germinate at a concentration of 5%. But at higher concentrations, the amount of proteins, lipids and plant carbohydrates were broken and the plant has not been able to grow and germinate, and also in another comprehensive study by Lorestani et al. (2016) on four plants (Lathyrus sativus, Lens Culinaris, Trigonella Foenum, Glycycrrhiza Glabr) from Fabaceae family at a temperature of 70° C for 48 days, which obtained the dry weight of plant and began to purify with volumetric concentration 1, 2, 3 and 4% of the oil in the soil, the results shows that increasing the amount of pollution decreases the percentage of soil refining, so that most reduction in the elimination of contamination of oil compounds was in the 1% contamination model for Lathyrus sativus with 73.3% and the lowest amount of oil pollution reduction in the 4% contamination model for Trigonella Foenum with a value of 38.6%. It has also been observed that increasing the dry weight of the soil increases the amount of removal of the oil compound pollution from the soil. Due to the efficiency of the samples used to purify oil pollution and the economic saving of plant purification, it is recommended to use this method for contaminated soils than other methods.

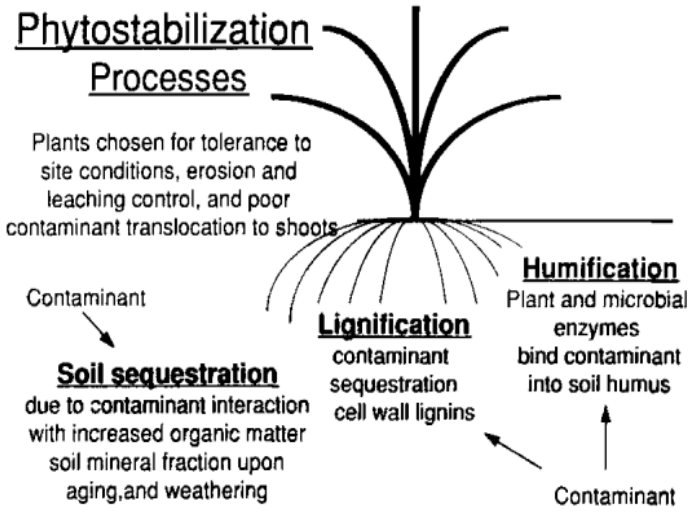

Figure 4: Naturally Occurring Processes Involved in Phytostabilization
Source: Cunningham et al., 1996

4. Conclusion

When washing with electrocynthetic method, adding a certain amount of synthetic detergent SDS, the voltage and the concentration of surfactant affects the efficiency of removal of oil pollution from the soil and improves the removal. Adding a Saponin bio-detergent adds more power to the removal efficiency, but with the addition of detergent and increasing surfactant concentration, the efficiency of the removal is not significantly changed and even slightly reduced. The use of organic detergents (natural) in reducing oil pollution from soil is better and has less biodegradable than artificial detergents. The efficiency of eliminating oil pollution from soil with water is lower than the yield of extra additives and sulfur oxides and polymers.

The results obtained from the bioremediation in eliminating oil compounds indicate that the higher vegetation in soil will cause more removal of oil pollution from the soil and higher efficiency. This shows the importance of vegetation in contaminated soils.
Increasing dry weight of the plant has increased the removal of organic pollutants. Therefore, reduction of oil hydrocarbons was associated with a decrease in dry weight, because the reason is that reducing the amount of nitrogen in the form of a nutrient causes the containment of the organic pollutant activity of the soil.

Although the Trigonella Foenum plant has relatively good germination resistance against organic contamination, the two Lathyrus sativus and Lens Culinaris is very effective in the removal of light crude oil from contamination, the Glycycrrhiza Glabr plant does not have a good resistance to bulbing against contamination, and it does not show the efficiency of removing crude oil.

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