THE REMEDIATION OF LAND CONTAMINATED WITH PETROLEUM HYDROCARBONS RELEASED FROM INDUSTRIAL OPERATIONS BY IN-SITU BIOREMEDIATION PROCESSES USING COMPOST TECHNOLOGY

INTRODUCTION

BACKGROUND

Petroleum is made up of hundreds and thousands of aliphatic branched and aromatic hydrocarbons (Prince, 1993; Wang et al, 1998; Yuniati, 2018), and other organic compounds. This fuel plays a vital role in various industrial developments, transportation, the agricultural sector, (Shahid and Jamal, 2008; Brunet et al., 2012), and our daily lives. The main petroleum products sold in South Africa are petrol, diesel, jet fuel, illuminating paraffin, fuel oil, bitumen, and liquefied petroleum gas (LPG) (SAPIA, 2021). Although South Africa does not have its crude oil reserves, there are companies such as BPSA, PetroSA, and Engen Petroleum, amongst others, that play a major role in the South African oil industry, and they operate storage terminals and distribution facilities throughout the country (SAPIA, 2021).

Bioremediation of land polluted with petroleum hydrocarbons

Land pollution caused by petroleum hydrocarbons is one of the biggest concerns of the recent world as it has catastrophic and disastrous consequences on human health and the general biological ecosystem (Ahmed and Fakhruddin, 2018). To solve this problem a remediation technique is needed to treat the contaminated lands. Traditional land remediation methods are often expensive, environmentally risky, and unsustainable as they involve the removal and excavation of soil, application of chemicals such as solvents and surfactants, and application of hot water or air at high pressures (Balseiro-Romero et al., 2017), amongst others. These drawbacks encouraged the development of more sustainable remediation technologies that are inexpensive and have lower impacts on the land (Balseiro-Romero et al., 2017). Bioremediation is a clean-up strategy (Balseiro-Romero et al., 2017) that uses biological organisms, mainly microorganisms to degrade environmental pollutants into less toxic forms (Heerden et al., n.d). These microorganisms can either be indigenous or non-indigenous added to the polluted land (Sharma, 2020). They consume the contaminants and use them as a food and energy source by usually altering them into small amounts of water, harmless gases like carbon dioxide, and fatty acids (Ahmed and Fakhruddin, 2018). The process of bioremediation has widely been used to treat petroleum hydrocarbon polluted lands (Yuniati, 2018), and it can be carried out in-situ and ex-situ (Sharma, 2020).

Different methods that can be used to develop bioremediation

Bioremediation technologies came into extensive usage and continue growing at an exponential rate to date (Sharma, 2020). Various bioremediation techniques have been developed and modeled by researchers to restore land contaminated with petroleum hydrocarbons (Sharma, 2020). These methods include both physicochemical and biological treatments (Yuniati, 2018). Due to the nature and type of pollutant, there is no single bioremediation technique that serves as the main method to restore contaminated lands (Maitra, 2018). Physicochemical techniques are usually carried out ex-situ and are often expensive as they involve digging and transportation of large quantities of pollutants for treatment at a different place (Yuniati, 2018). There are several ways that a contaminated land can be remediated in-situ namely natural attenuation, bioventing, and composting (Maitra, 2018), amongst others. The above-listed methods follow one or three of the in-situ bioremediation strategies that are bioattenuation, biostimulation, and bioaugmentation (Maitra, 2018). The type of bioremediation technique to be applied is chosen based on the nature of the pollutant, depth and amount of pollution, type of environment, location, cost, and environmental policies (Sharma, 2020). This study focuses on composting in-situ bioremediation technique because of its multiple advantages such as cost effective, and environmental sustainability.

Compost technology as an in-situ bioremediation strategy

Compost technology, also known as compost bioremediation, is one of the techniques that are currently being used to restore contaminated lands. This technology is classified as an enhanced in-situ bioremediation technique (Maitra, 2018). In the last few decades, compost or farmyard manure addition as well as composting with various organic supplements were found to be very effective in soil bioremediation (Sharma, 2020). With this technique, a biological system of microorganisms in manure, or cured compost is applied to break down contaminants in the soil (EPA, 1997). Due to the huge metabolic diversity of microorganisms developing during the composting processes, a highly complex metabolic diversity is established as a ‘metabolic memory’ within developing and mature compost materials (Sharma, 2020). The parameters important for composting depend on the type of pollutants and waste materials to be used for composting (Maitra, 2018). The addition of compost can therefore be considered as a ‘super-bioaugmentation’ with a complex natural mixture of degrading microorganisms, combined with a ‘biostimulation’ by nutrient containing readily to hardly degradable organic substrates (Sharma, 2020).

Evaluation of compost bioremediation efficiency or capacity in a polluted land

Compost bioremediation has proven effective in degrading or altering many types of contaminants such as petroleum hydrocarbons (EPA, 1997). In addition to reducing the contaminant levels, compost bioremediation facilitates plant growth (EPA, 1997), improves soil structure, nutrients, and microbial activity (Maitra, 2018). The composting efficiency generally depends on the temperature and soil-waste amendment ratio as the two important operating parameters for bioremediation (Antizar-Ladislao et al., 2005; Maitra, 2018). Furthermore, during composting bioremediation, the efficiency of biodegradation is determined by the pollutant bioavailability and biodegradability, operating conditions, and waste amendment (Maitra, 2018). Increasing the bulking agents such as peat moss, pine wood shavings, bran flakes, or a mixture of these agents from 6-12% lead to an increase of 4-5% in the biodegradation of the total petroleum hydrocarbons (Baheri and Meysami, 2002; Maitra, 2018). Therefore, composting can be considered a sustainable way to decontaminate land polluted with petroleum hydrocarbons.

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