RESEARCH ARTICLE OPEN ACCESS

Efficiency of Bioremediation based on Microbial Kinetics

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ABSTRACT: Petroleum hydrocarbons are the main source of Energy, causing pollution of soil and water allover the globe. In this study an attempt has been made to to evaluate efficiancy of removal of Total petroleum hydrocarbons with varied % by weight at optimal C:N:P ratio with soil as media under Bioremedition process.with the microbial kinetic studies. Study reveals that at 10% of TPH by weight, the efficiency of TPH removalwas 70.2%, with decay rate 0.01/d, maximum growth rate of 0.09/d and yield coefficient 0.22/d.
Keywords: Bioremediation, Hydrocarbons, Microbial kinetics. Biosurfactants.

Date Of Submission: 05-06-2019 Date Of Acceptance: 20-06-2019

I. INTRODUCTION:

Petroleum hydrocarbon continues to be used as the principal source of energy and hence an important global environmental pollutant. Apart from accidental contamination of the ecosystem, the vast amounts of oil sludge generated in refineries from water oil separation systems and accumulation of waste oily materials at the bottom of crude oil storage tanks pose great problems because of the expensive disposal methods. Despite decades of research, successful bioremediation of petroleum hydrocarbon contaminated soil remains a challenge. Petroleum is a complex mixture of non-aqueous and hydrophobic components like n-alkane, aromatics, resins and asphaltenes. Bioavailability might be the limiting factor in the biodegradation of such compounds(Wei ouyong,2005).

Pollution caused by petroleum and its derivatives is the most prevalent problem in the environment. The release of crude oil into the environment by oil spills is receiving worldwide attention. Many accidents can cause soil pollution, for this reason, many techniques are being developed to clean up petroleum contaminated soil. The biological treatments are more efficient and cheaper than chemical and physical ones. In relation to biological treatment, the bioremediation technology is being employed for the degradation of crude oil in soil matrix through microorganisms to transform petroleum hydrocarbons in less toxic compounds. However, the low solubility and adsorption are two major properties of high molecular weight hydrocarbons that limit their availability to microorganisms. In this case, the addition of biosurfactant enhances the solubility and removal of these contaminants, improving oil biodegradations rates(Anushree malik,2006, M. Vidali,2001)

Biosurfactants possess better properties than many chemical surfactants, they stand out by having properties as tolerance to temperature and pH changes, high hydrocarbon emulsification, low toxicity, and high biodegradability(Karanth N G K et.al 1999, Lu J R 2007). Soil is a key-component of the environment and, depending on the type of mineral, organic matter, pH, redox potential, humidity and soil handling, the pollutants can be adsorbed or released, causing different poisonous effects. The need for biosurfactants is due to the advantages of easy production from renewable resources and possible reuse by regeneration, high specificity and less toxicity, biodegradability. Biosurfactants display excellent surface activity in comparison to synthetic ones despite their bulky molecular structures. They show greater environmental compatibility and also high activity at extreme temperatures, pH and salinity conditions(Anushree Malik,2007, Michael D Lagrega,2001).

Thus, they are expected to be more effective than synthetic surfactants and can be blended with other (bio and/or synthetic) surfactants to offer desired performance characteristics. Due to their physiochemical characteristics, biosurfactants are thus better suited to environmental applications than synthetic ones. Thus the use of biosurfactants would enhance the biodegradation rate of petroleum contaminated soil (Banat I M et.al, 2000, Cameotra S S et.al.,2004).

At many contaminated sites, microorganisms naturally exist that have developed the capability of degrading the contaminants. However, not all sites have competent microbes and typically lack environmental conditions (such as sufficient electron acceptor levels and/or bioavailability restraints) conducive for rapid degradation of the contaminants. Engineered Bioremediation, Therefore typically involves use of biosurfactants so that the naturally existing microorganisms stimulated to degrade the contaminants. For the degradation to occur it has to be ensured that C:N:P ratio of 100:10:1, moisture content of 20 to 80 % of the field capacity of the soil is to be maintained .(Lu J R 2007, Desai T D et.al. 1997)

It is estimated that approximately 1% of the total oil processed in refineries is discharged as oily sludge, usually after being accumulated in storage tanks for several days/years. Incineration of this sludge is not recommended due to its high energy costs involved, the potential risk of air pollution and the persistence of TPH. Similarly, the inadequate disposal of such a very toxic residue in landfills encourages the search for alternatives. Composting, landfarming and bio-piles are examples of biotreatment techniques which are reported to be effective in many cases, but with the main drawback being exploiting soil biodiversity and requiring long treatment time and hence is the risk of contaminating air and aquifers by leaching.(Wei ouyong, 2005, M Vidali,2001) They also use up large areas and are affected by the climate. An interesting alternative to these problems is the use of bioreactors, since optimum process conditions can be more easily controlled.(Singh P et.al 2004)

II. METHODOLOGY:

The kinetics of petroleum hydrocarbons degradation was evaluated for the simulated contaminated soil prepared using petroleum oily sludge from VRL logistics Ltd, situated at Kengeri, Bangalore .Soil rich in native microorganisms was collected from Bangalore University campus and the same was used to prepare simulated contaminated soil. The study was conducted with the use of ten bioreactors. Each reactor was filled with a mixture of 4 Kg(fresh soil) and 1Kg(contaminated soil) thus making up simulated contaminated soil of 5 Kg . Each bioreactor has a total volume of 7 litres and a working volume of 5 litres. In each reactor simulated contaminated soil was filled up to a depth of 0.15 m for efficient degradation of contaminated soil. Oily sludge was mixed in varying percentages so as to have TPH varying as 2,4,6,8,10,11,12,13,14,& 15% by weight of dry soil.

Treatability studies on TPH contaminated soil was conducted in all ten reactors for a period of sixteen weeks. The reactors were maintained at room temperature within the Environmental laboratory of Civil Engineering Department, UVCE, Bangalore.All reactors were maintained at moisture content of 60% field capacity, and pH within the range of 7-8. Nutrient concentration was maintained at a C:N:P ratio of 100:10:1.These conditions are considered favourable for microbial growth .Weekly measurements of pH,temperature ,moisture content ,TPH concentrations ,biomass growth and C,N,P levels were done for all the ten reactors. From the study it was concluded that Maximum percentage TPH removal of 70.2 % was observed at TPH concentration of 10% (99780mg/Kg) of weight of soil. At TPH concentrations above 10%, it was observed that the percentage removal reduces considerably. The specific growth rate increases initially with substrate concentration reaching a maximum value of 0.09(d^{-1}) at 10% TPH concentration, but at concentrations of substrate greater than 10 % there appears to be a decrease in specific growth rate. The maximum degradation rate is 0.01 d^{-1} was observed in bioreactor B5 having TPH concentration of 10%. The highest coefficient of yield of 0.22 was also in reactor B5 with substrate concentration of 10% TPH (99780mg/Kg).This indicates that biological activity is greatly influenced by substrate concentration .This in turn affects the degradation of petroleum hydrocarbons.

Table. 1. showing TPH Reduction in various Bioreactors

Sl.No	Bioreactor	Initial TPH (mg/Kg)	Final TPH (mg/Kg)	TPH Reduction (mg/Kg)	% Reduction
1.	B1	19670	9364	10306	52.4%
2.	B2	38890	14140	24750	63.6%
3.	B3	60010	18464	41546	69.2%
4.	B4	78450	24100	54350	69.3%
5.	B5	99780	29650	70130	70.2%
6.	B6	109890	36896	72994	66.4%
7.	B7	118960	50472	68488	57.6%
8.	B8	129600	58601	70999	54.7%
9.	B9	138900	71515	67385	48.5%
10.	B10	149840	94020	55820	37.2%

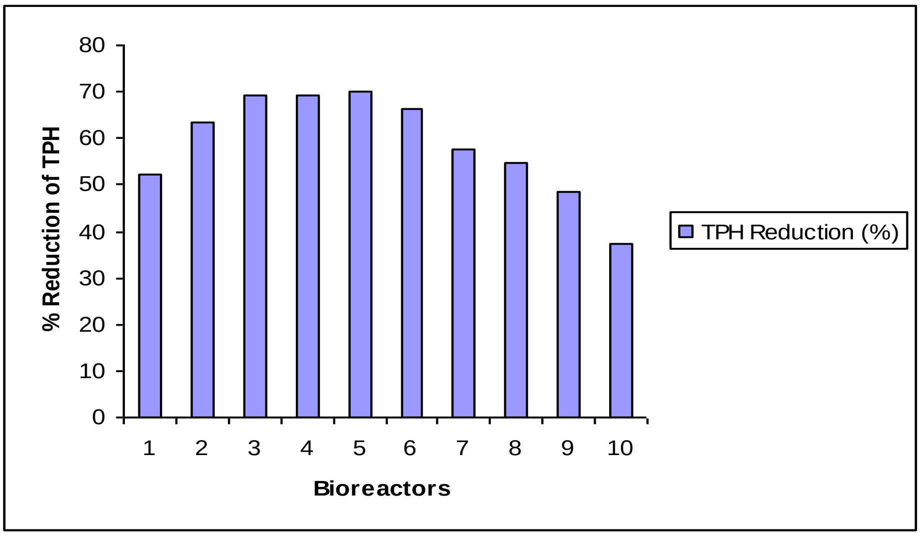

Figure 1. Showing variation TPH Reduction in various reactors.

Further, Kinetic coefficients for the Monod's Equation are evaluated, and the same are presented in the following table.

Table 2. Showing values of Kinetic coefficients for various bioreactors.

SL No	Bioreactors	Substrate Concentration(mg/Kg)	$(k)d^{-1}$	Ks (mg/Kg)	μmax (d^{-1})	Y(g/g)
1	B1	19670	0.007	10060	0.04	0.21
2	B2	38890	0.0086	18440	0.053	0.14
3	B3	60010	0.0094	29480	0.08	0.19
4	B4	78450	0.0094	35410	0.082	0.15
5	B5	99780	0.010	45198	0.09	0.22
6	B6	109890	0.0091	48077	0.088	0.19
7	B7	118960	0.0076	62000	0.066	0.18
8	B8	129600	0.0072	64125	0.06	0.12
9	B9	138900	0.0065	75183	0.06	0.09
10	B10	149840	0.0048	94412	0.04	0.06

III. CONCLUSION:

Based on the study it can be concluded that at 10% of TPH by weight, the efficiency of TPH removalwas 70.2%, with decay rate 0.01/d, maximum growth rate of 0.09/d and yield coefficient 0.22/d.

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B G Mahendra" Efficiency of Bioremediation based on Microbial Kinetics" International Journal of Engineering Research and Applications (IJERA), Vol. 09, No.06, 2019, pp. 11-14