World Applied Sciences Journal 3 (3): 365-368, 2008
ISSN 1818-4952

Bioremediation of Oil Based Drilling Cuttings in a Slurry Bioreactor

[1]N. Alavi, [1]A.R. Mesdaghinia, [1]K. Naddafi, [2]N. Jafarzadeh,
[1]R. Nebizadeh, [3]G. Mohebal and [1]A. Mahvi

[1]Department of Environmental Health Engineering,
Tehran University of Medical Sciences, Tehran, Iran
[2]Department of Environmental Health Engineering,
Ahvaz Jundishapur, University of Medical Sciences, Ahvaz, Iran
[3]Department of Petroleum Biotechnology, Research Institute of Petroleum Industry, Tehran, Iran

Abstract: Oil and gas extraction generates a substantial volume of by products and wastes that must be managed. One of the most attractive methods is bioremediation. In this research first indigenous bacteria were isolated from polluted soil by drilling cuttings and then adopted to drilling mud concentrations up to 20 %(v/v).In all of adaptation stages, the number of bacteria was higher than 10^8.Adopted bacteria inoculate to drilling cutting in a slurry bioreactor. C/N/P 100/5/1, 100/10/2,100/20/1 ratios were examined. The removal efficiency was 53.8, 55.2 and 52 percent respectively. The result didn't show significant difference between seeded and blank reactors. Effect of temperature in 20°C and 40°C were evaluated. Removal TPH in 20 and 40°C was 53.9 and 61%.The number of bacteria were not increased with increasing temperature. therefore TPH reduction may relate to volatilization and adsorption in solids.

Key words: Oil based drilling cuttings · bioremediation · total petroleum hydrocarbon

INTRODUCTION

Oil and gas extraction generates a substantial volume of by products and wastes that must be managed. There are a number of possible environmental impacts from wastes generated during the well drilling and completion/stimulation processes. It is investigated extensively [1-3]. It has been estimated that between 0.2 barrels and 2 barrels(8.4 and 84 gallons) of total drilling waste are produced for each vertical foot drilled [4].

One of the most important wastes in oil extraction is oil based drilling cuttings. Although a large amount of oil based mud is recycled during drilling, however, it is remained in cuttings in different percent. There are many ways for treatment of cuttings. One of the most attractive methods is bioremediation. Advantages of this method is simplicity and less cost.

Biodegraded bacteria of oil based drilling cuttings was isolated from drilling mud cuttings in a new oilfield in Nigeria [5, 6]. At the same time aerobic and anaerobic degradation of drilling cuttings in situation similar to seabed of north sea in laboratory scale was don by Rogaland Research Institute [7].

Microbial degradation of hydrocarbons in soils polluted by oil based drilling cuttings has been investigated in some limited research [8-11]. All of this research used composting or biopiling.

The aim of this work was 1-Isolation and adaptation of indigenous bacteria from abandoned drilling sites 2-Capability of hydrocarbon in drilling cuttings and effects of temperature and nutrients on it.

MATERIALS AND METHODS

Isolation and adaptation indigenous bacteria: Indigenous bacteria at suitable condition could degrade petroleum hydrocarbon better than augmented bacteria [12]. Indigenous bacteria are isolated from different abandoned drilling pits and around soils. Samples were screened by 0.1mm mesh and then soil solution was prepared by adding 90 ml distilled water containing 2 drops of Tween 80 to 10 g screened soil and mixed 25 min in 150 rpm. 1ml oil based drilling mud was used as carbon source. 2.5ml of soil solution in addition to 96.5ml Mineral Salt Medium (MSM) (KH_2PO_4, 1.52g, Na_2HPO_4, 2.44g,

Corresponding Author: Dr. A.R. Mesdaghinia, Department of Environmental Health Engineering, Tehran University of Medical Sciences, Tehran, Iran

$CaCl_2$. $2H_2O$, 0.5 g, $MgSO_4$.7H2O, 0.2g, $(NH_4)_2SO_4$, 0.50g, trace element 10ml) were added to every carbon sources. After every two week, 2.5 ml of the bacteria were transferred to new media and gradually, concentration of carbon is increased, in every passage 1 ml. Flasks were shaken at 25°C in a shaking incubator [13]. After five month adaptation to common concentration in drilling cuttings, 25 ml of this solution was used as seed in bioreactors.

Cuttings: Oil based drilling cuttings were gotten from point of discharging to environment in south oil fields of Iran. All drillings has been done in Asemari formation. All oil based mud used in this formation is free of barite (Baso4). It is gotten from National Iranian South Oil Company.

Nutrients: Different ratio C/N/P, 100/10/1, 100/20/1,100/5/1 used.NH4No3 (MERCK) used as nitrogen source, KH2Po4 (MERCK) used as phosphorous source. Amount of carbon in cuttings analyzed by method ISO-TIC [14].

TPH analysis: TPH analyzed according to method 1005 Texas Natural Resource Conversation Commission (TNRCC). All samples extracted by pentane in diluted 1/10 to 1/100 ratios [15].

Enumeration of microorganisms: Enumeration of heterotrophic bacteria was performed by plate-count method according to Alef (1995) and expressed as colony-forming per gram of dry matter (CFU/g).The plates were incubated at 35°C and counted on day 3 for heterotrophic bacteria [16].

Experiment set up: A 5 L Pyrex cylindered reactor was used as slurry bioreactor. It completely mixed by mechanical mixer. Air, after passing through an activated carbon, was injected from bottom of reactor by a perforated curved pipe. In every run 2 kg cuttings used. A reactor used as blank and it is not seeded by bacteria. TPH and CFU are measured at 0, 3, 7, 14, 21 days.

RESULTS

Adaptation indigenous bacteria: In all of adaptation stages, the number of bacteria was higher than 10^8.This is showed that with gradual increasing substrate concentration, bacteria can adopt to mud as carbon source. In any stage, 2 ml from flask in the last stage was used as seed for next stage. Base on these results, bacteria can tolerate to 20% of mud and diesel in aquatic environment.

Nutrients effects: C/N/P 100/5/1, 100/10/2,100/20/1 ratios were examined. The removal efficiency was 53.8, 55.2 and 52 percent respectively.

Temperature effects: Effect of temperature in 20°C and 40°C were evaluated. Removal TPH in 20 and 40°C was 53.9 and 61%.The bacteria were not increased with increasing temperature.

DISCUSSION

Adaptation indigenous bacteria: In all of adaptation stages, the number of bacteria was higher than 10^8. Although microbial count is not a direct measure of activity in soils and semisolids, However It is an indicative of microbial viability or biodegradation potential in a polluted soil [17]. This is showed that with gradual increasing substrate concentration, bacteria can adopt to mud as carbon source. Base on these results, bacteria can tolerate to 20% of mud and diesel in aquatic environment. Generally the percent of oil in oil based drilling cuttings is less than 20%.

Nutrients effects: C/N/P 100/5/1, 100/10/2,100/20/1 ratios were examined. The result didn't show significant difference. The removal efficiency was 53.8, 55.2, 52 percent respectively. The bacteria numeration didn't show significant relationship with TPH decreasing trend. The addition of different ratios of C/N/P did not stimulate aerobic degradation of the hydrocarbons. Some other researches showed these result too [8-11].

Temperature effects: Effect of temperature in 20°C and 40°C were evaluated. Like other biochemical reactions removal efficiency is increased when temperature is increased. Removal TPH in 20 and 40°C was 53.9 and 61%. The bacteria were not increased with increasing temperature therefore TPH reduction may relate to volatilization and adsorption in solids. There is no significant relationship between CFU and TPH results.

In all of runs we had a high variance in TPH results. It may relate to heterogeneous matrix of drilling cuttings slurry [7].

As it is showed in Figs. 1-3, TPH results have a high variances and correlation between CFU and TPH was not significant. It may be related to low moisture in

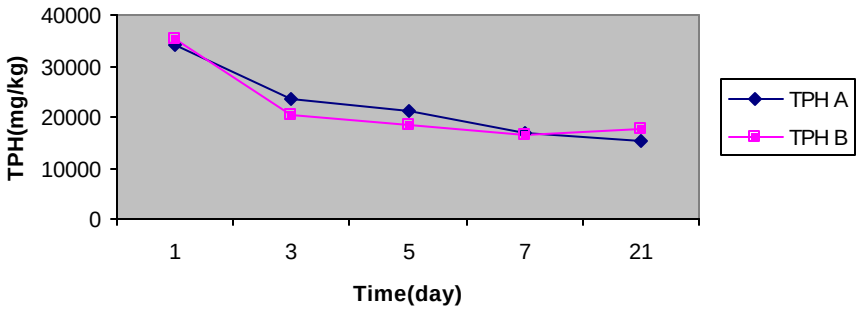

Fig. 1: TPH removal in C/N/P ratio 100/5/1

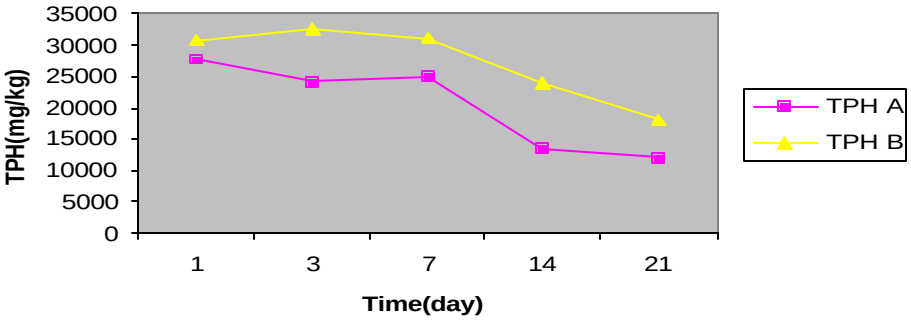

Fig. 2: TPH removal in C/N/P ratio 100/10/1

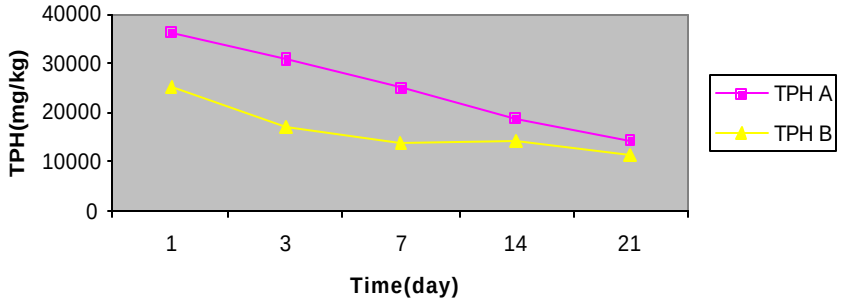

Fig. 3: TPH removal at 40°C

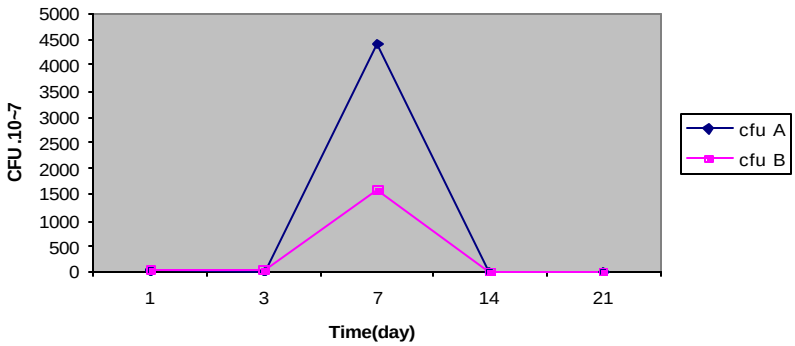

Fig. 4: Bacteria enumeration at 40°C

cuttings, average 30% and compacting and heterogeneous matrix in drilling cuttings. In MSM medium the bacteria had sustainable stability during a long time adaptation. Therefore for bioremediation of oil-based drilling cuttings we have to dilute it by other solid or liquid matrix such as soil, water and biosurfactants.

REFERENCES

1. Holdway, D.A., 2002. The acute and chronic effects of wastes associated with offshore oil and gas production on temperate and tropical marine ecological processes. Marine Pollution Bulletin, 44: 185-203.
2. Dirce, P., E.C. Lima, S.M. Mia and J.M.G. Fachel, 2005. Heavy metals contribution of non-aqueous fluids used in offshore oil drilling. Fuel, 84: 53-61.
3. Alastair, G. and A.D. Briggs, 2002.Toxicity of sediments from around a North Sea oil platform: Are metals or hydrocarbons responsible for ecological impacts. Marine Environmental Research, 53: 95-116.
4. EPA 2000. Office of Compliance, Profile of the Oil and Gas Extraction Industry, US Environmental Protection Agency.
5. Nunbia, C. and G.C. Okpokwasili, 1993. The microbiology of drill mud cuttings from a new off-shore oilfield in Nigeria. Environmental pollution, 82: 153-156.
6. Benka-Coker, M.O. and A. Olumagin, 1995. Waste drilling-fluid utilizing microorganisms in a tropical mangrove swamp oilfield location. Bioresource Technology, 53: 211-215.
7. Kjeilen, G. and S. Torgrimsen, 2001. UKOOA phase ï Task 3: Aerobic and anaerobic degradation of drill cuttings-results from small scale laboratory experiments. Rogaland Research Institute, Report RF-200/217.
8. Rebekka, R.E., T. Semple and K. Killham, 2002. The potential for anaerobic mineralization of hydrocarbon constituents of oily drill cuttings from the North Sea seabed. J. Environ. Monitoring, 4: 553-557.
9. Rojas-Avelizapa, N.G. and T. Roldan-Carrillo, 2007. A field trial for an *ex situ* bioremediation of a drilling mud-polluted site. Chemosphere, 66: 1595-1600.
10. Chaillan, F., C.H. Chaineau, V. Point, A. Saliot and J. Oudot, 2006. Factors inhibiting bioremediation of soil contaminated with weathered oils and drill cuttings. Environ. Pollu., 144: 255-265.
11. MacDonald, J. and R. Portier, 2003. Feasibility studies on in-situ biological treatment of drilling muds at abandoned site in Sicily. Chem. Technol. Biotechnol., 78: 709-716.
12. Xia, W.X. and X.L. Zheng, 2006. Enhanced biodegredation of disel oil in seawater supplemented with nutrients. Eng. Life. Sci., 6(1): 80-85.
13. Margeisne *et al*. 2001. Bioremediation of Diesel Oil Contaminated Soil in an Alpin Glacier Area. Applied and Environ. Microbiol., 67: 3127-3133.
14. ISO/TC190/SCS, 1994. Soil quality general aspects, Chemical and physical Methods of Analysis, Biological Method of Analysis. ISO Standard Compendium, Geneva, CH.
15. TNRCC Method 1005, Total Petroleum Hydrocarbons, Texas Natural Resources Conversation Commission, 2001.
16. Alef, K., 1995. Methods in Applied Soil Microbiology and Biochemistry. Harcourt, Brace and Company Publishers, Academic Press.
17. Bossert, L.D. and D.S. Kosson, 1997. Methods for measuring hydrocarbon biodegradation in soils. Manual of Environmental Microbiology. ASM Press, Washington, DC., pp: 738-745.