Treatment of a mud pit by bioremediation

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Aim

The aim of our study was to analyze the process of bioremediation treatment of a mud pit located at TUS 69 (near Zrenjanin, Serbia), which is the property of the Petroleum Industry of Serbia.

Introduction

Drilling mud is used during drilling of boreholes in the process of petroleum and natural gas exploration and exploitation. Drilling mud consists of a liquid base (water, diesel or mineral oil or a synthetic compound) (Fink, 2012), a weighting agent (usually barium sulphate barite or calcium sulphate), bentonite clay, which helps the elimination of drilled out material and forms a filter cake on the borehole walls (Boussen et al., 2015), lignosulphonates and chrome lignite, which keep the drilling mud liquid, and various additives used to adjust specific properties (Caenn et al., 2011; Harto, 2016). The mud waste formed during the works are a waste product that is temporarily deposited in so-called mud pits, until it is collected and stored at the nearest disposal site where waste is collected (Kisic et al., 2009; Kokal, 2006; Veil, 1998). Mud pits formed during the construction of oil wells have not been treated since the very beginning of petroleum exploitation in Serbia. The average volume of a mud pit in Serbia is about 1000 m^3. Bioremediation, a process that makes use of the ability of microorganisms to decompose toxic waste, is a prevailing trend in the decontamination of polluted soil and groundwater (Beškoski et al., 2011). The bioremediation technology used in this case was based on the use of microorganisms isolated from the contaminated site, which are capable of using contaminating substances as nutrients (Gojgić-Cvijović et al., 2012). Bioremediation procedures are economically advantageous, are categorized as "environmentally friendly" technologies, do not form waste and the treated soil can recover its natural biological activity.

Material and methods

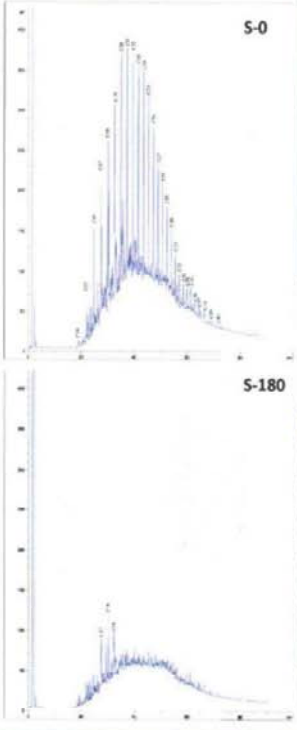
Composite samples for monitoring and analyses were taken at the beginning and every 60 days during the bioremediation process, which lasted for 180 days. Composite samples were analysed for moisture, water holding capacity (WHC), and loss on ignition. The content of total petroleum hydrocarbon (TPH) in the composite samples was extracted as per method ISO 16703 (ISO 16703, 2004) and determined gravimetrically in accordance with DIN (DIN EN 14345, 2004). The gas chromatographic analyses were conducted on an Agilent 7890A gas chromatograph with a flame ionization detector (FID). The number of microorganisms in the composite samples was determined by plating appropriate serial dilutions on agar plates incubated at 28°C. The media used were nutrient agar for total chemoorganoheterotrophs (TCs), while a mineral base medium containing 2 g of standard D2 diesel fuel in 1 dm^3 of medium was used for microorganisms that decompose hydrocarbons (HDs).

Results and Discussion

Table 1. Changes in mud pit soil parameters during the 180 days bioremediation process.

Parameters	S-0[a]	S-60	S-120	S-180
Time of bioremediation (days)	0	60	120	180
Moisture (%)	22.5±1.2	23.9±1.1	20.6±1.2	19.6±1.3
WHC (%)	74.0±2.8	73.0±3.1	75.0±2.7	76.0±2.8
Loss on ignition (%)	15.5±0.7	15.2±0.7	14.2±0.8	13.5±0.7
TPH (g/kg)	**32.2±1.5**	**17.15±0.9**	**8.3±0.4**	**1.5±0.1**
TC (CFU/g)	1.1×10^6	7.5×10^6	7.7×10^6	3.6×10^6
HD (CFU/g)	8.8×10^4	4.2×10^6	4.7×10^6	8.2×10^5
HD (%)[b]	8	56	61	23

WHC: water holding capacity; TPH: total petroleum hydrocarbon; TC: total chemoorganoheterotroph; HD: hydrocarbon.
[a]After mixing, watering, biostimulation and reinoculation; [b]Share of HD within the TC.
In all standard results: ± deviation for six measurements.



On day 0 the level of TPH was 32.2 g/kg of bioremediation substrate. After application of the bacterial consortium, nutrients and aeration and during the bioremediation process, the TPH level was reduced to 17.5, 8.3 and 1.5 g/kg of soil after 60, 120 and 180 days, respectively (Table 1), meaning 45.6 %, 74.2 % and 95.3 % of the TPH was degraded, respectively.

Figure 1. Gas chromatography analysis of mud pit soil on 0 and 180 days of bioremediation treatment (S-0 and S-180).

Figure 2. a) mud pit soil before and b) after bioremediation treatment.

Conclusion

This research monitored the effects of bioremediation of mud pit soil over a period of 180 days. Levels of TPH reduced from the initial 32.2 to 1.5 g/kg of remediated mud soil. The final level of TPH achieved after bioremediation treatment of mud pit soil was lower than the level required by Serbian regulation (5 g/kg), and indicates that the process of bioremediation was performed successfully. The high degree of biodegradation of TPH in this study was likely a consequence of the activity of the zymogenous microbial consortia, which were derived from microorganisms that had naturally flourished in the contaminated soil at the site. The results show that the method described is emerging as a promising technology for the treatment of mud pit soils contaminated with petroleum HDs.

References

Beškoski VP, Gojgić-Cvijović G, Milić J, et al. (2011) *Chemosphere 83*: 34–40.
Boussen S, Sghaier D, Chaabani F, et al. (2015) *Applied Clay Science 118*: 344–353.
Caenn R, Darley HCH and Gray GR (2011) *Composition and Properties of Drilling and Completion Fluids. 6th ed. Waltham, MA: Gulf Professional* Publishing, pp.535–616.
Fink JK (2012) *Petroleum Engineer's Guide to Oil Field Chemicals and Fluids. Oxford: Elsevier, pp.1–59.*
Gojgić-Cvijović GD, Milić JS, Solević TM, et al. (2012) *Biodegradation 23*: 1–14.
Harto C (2016) Drilling waste management information system, fact sheet. Available at: http://web.ead.anl.gov/dwm/techdesc/index.cfm
Kisic I, Mesic S, Basic F, et al. (2009) *Geoderma 149*:209–216.
Kokal SL (2006) Crude oil emulsions. In: Fanchi JR (ed) *Petroleum Engineering Handbook, Vol. I. Richardson, TX: Society of Petroleum* Engineers, pp.533–570.
Veil AJ (1998) Summary of offshore drilling waste disposal practices. US EPA, US Department of Energy.

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