EX SITU BIOREMEDIATION AS CIRCULAR ECONOMY: MICROBIAL MINERALIZATION OF WASTE HEAVY REZIDUAL OIL FUEL (MAZUT) FROM BELGRADE (SERBIA) POWER PLANTS AND ITS REUSE FOR LANDFILL STABILIZATION

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Abstract

In our work we have studied the process of bioremediation of waste heavy residual oil fuel (mazut) from the site of the Belgrade heating plants. Bioremediation is performed on the projected biopile adding microbial consortium that was isolated from the polluted site. We added nutrients (biostimulation) at biopile, and aeration is provided by periodic mixing.

Biostimulation and inoculation of biopile for 150 days resulted in a decrease of total petroleum hydrocarbons (TPH) for about 80 times and increased content of humic acids that indicate the beginning of Soilification.

This "primitive" soil was used as an overlay for the stabilization of municipal waste landfill after bioremediation.

Introduction

One of the technology that has been increasingly used for the remediation of contaminated habitats, primarily soil, is bioremediation. Bioremediation is especially effective in the remediation of habitats polluted by oil and oil products., but is also used for the treatment of waste which has not yet entered the environment, and are increasingly being used for habitat polluted by heavy metals. One of the most effective types of bioremediation is the use of non-pathogenic microorganisms isolated from pollutants. Microorganisms that are naturally present on the contaminated site translate toxic substances in products that are non-toxic to humans and the environment. Although the bioremediation can be used by microorganisms that have been transferred from another contaminated or even unpolluted habitat, the best effect show those who are isolated at the site of contamination. Many components of pollutants can be decomposed only by joint operation of multiple strains of microorganisms - consortium.

Experimental

Preparation of bioremediation pile (biopile) and ex-situ bioremediation

Biopile was made on a watertight asphalt surface of about 1500 m² with a slope of 1%. Biopile was consisted of a mixture containing the waste fuel oil, sawdust (as an additional source of carbon and as a filler) and river sand, which was added due to increased porosity. In order to ensure homogeneity the biopile was stirred with a bulldozer and is aligned at the end of the tractor. Biopile final volume was 600 m^3. [1].

Determination of the Total Petroleum hydrocarbons (TPH)

Total Petroleum hydrocarbons (TPH) were extracted according to Beškoski et al. [1] and by ISO 16703 (2004) [2] and gravimetric determined by DIN EN 14354 (2004) [3]. Also, TPH was determined by a gas chromatograph.

Microbiological methods

A consortium of microorganisms was obtained from soil contaminated with mazut by enrichment in 200 mL volumes of mineral medium (10 vol.%) [4] containing mazut (2 g L^{-1}) as the only energy and carbon source in Erlenmeyer flasks (1 L).

Microbial populations of the flasks was used to inoculate the bioreactor (approximately 1% by volume), volume was 1000 L.

The number of micro-organisms was determined by serial dilution [5,6].

Bioremediation of waste heavy residual oil fuel (mazut) from the site of the Belgrade heating plants

Conclusion

Bioremediation proved to be a successful technology for circular economy, since microorganisms origin from waste degraded waste heavy rezidual oil fuel into non-hazardous and inert material. At the same time, the content of humic acid, which are indicatiors for fertile land, were increased. At the end this land was used as an overlay for the stabilization of municipal waste landfill.

Acknowledgement

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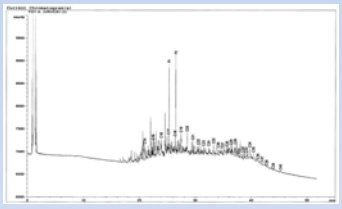
Results

The main parameters for determining the performance of the bioremediation was reduction of TPH, increasing of humic acid content and changes the number of microorganisms that as the main source of carbon use oil hydrocarbons.

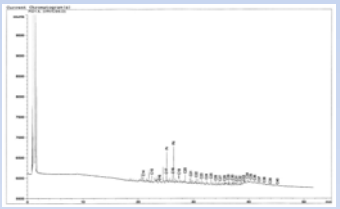
Basic parameters to monitor the process of bioremediation

Parameter	Unit	S-0	S-50	S-100	S-150
Humidity	%	15,4 ± 0,5	13,0 ± 0,7	14,5 ± 0,2	13,4 ± 1,5
pH		7,3 – 7,5	7,3 – 7,5	7,2 – 7,6	7,1 – 7,3
Loss on ignition	%	9,9 ± 1,1	6,9 ± 1,6	6,7 ± 0,2	6,1 ± 0,7
Organic carbon	%	2,46 ± 0,04	1,87 ± 0,08	1,19 ± 0,06	1,08 ± 0,05
Inorganic carbon	%	0,65 ± 0,03	0,66 ± 0,04	0,60 ± 0,03	0,56 ± 0,03
Total nitrogen	%	0,25 ± 0,03	0,23 ± 0,04	0,22 ± 0,02	0,25 ± 0,01
Humic acid content	%	1,92	2,30	2,72	2,83
TPH	g / kg	39,9	15,21	5,3	< 0,5
Biopile					
Total chemoorganoheteroprophs	CFU / g	2,0 x 10^6	2,2 x 10^6	1,3 x 10^7	8,0 x 10^6
Microorganisms which decompose hydrocarbons	CFU / g	7,2 x 10^4	1,5 x 10^6	9,9 x 10^6	2,0 x 10^6
	%	4	68	76	25
Control					
Total chemoorganoheteroprophs	CFU / g	9,7 x 10^5	2,2 x 10^5	3,2 x 10^5	4,8 x 10^5
Microorganisms which decompose hydrocarbons	CFU / g	5,6 x 10^4	1,8 x 10^4	2,2 x 10^4	4,3 x 10^4
	%	6	8	7	9

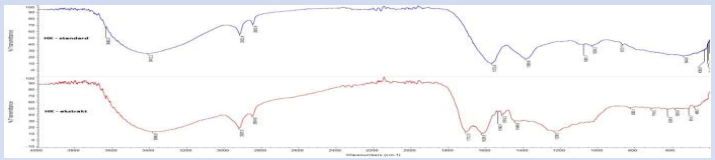
The content of TPH



At the beginning of bioremediation



At the end of bioremediation



FTIR spectra of comparative display standard and extracted humic acid

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