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BACTERIAL DECONTAMINATION OF SOIL FROM OSTRAVA AIRPORT

1. Introduction

Biodegradation (biological decontamination) is grounded in the capacity of certain bacterial strains to make use of hydrocarbons as a source of carbon and energy for their growth and in this way, decomposition of contaminants occur all the way to harmless products — carbon dioxide and water. In short, biodegradation is a special case of degradation during which decomposition of polymers takes place due to the action of biological factors. It makes part of natural processes taking place in water and soil. For example, at contamination of soil by oil substances there is spontaneous degradation of biologically degradable oil substances. However, the process is slow and meanwhile contamination may spread into the surroundings. In the locality some resistant substances remain. In order to speed up the rate of degradation, it was necessary to make the process more intense and to remove resistant substances bacterial mixtures may be utilized.

The ability of microorganisms to degrade hydrocarbons has been known since 1895, when Miyoshi described growth of yeast on paraffin and shortly after the capacity of bacteria to make use of methane as a source of carbon was discovered. Gradually, it was demonstrated that they are able to decompose practically all components of crude oil and many other hydrocarbons. At present, over 200 types of microorganisms have been described that are able to degrade hydrocarbons. Some are able to make use of one hydrocarbon only (e.g. methane), but no microbial strain is known to degrade a whole range of hydrocarbons present in crude oil, for example. Therefore, these are rather microbial associations that participate in degradation [6].

The objective of the paper was examination of application of bacterial leaching in the decontamination of soil sampled from the Leoš Janáček Airport in Ostrava — these were samples taken from four sampling points.

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2. Leoš Janáček Airport in Ostrava

The first mention of air traffic at the territory of the present airport is from 1939 when German Luftwaffe built a field aerodrome to attack Poland [1, 2]. After the war the situation calmed down and the area was again used for agricultural purposes as in the past. The modern history began in 1956 when the current airport began to be constructed. The reason for the initiation of construction was the inconvenient state of the airport in Ostrava — Hrabůvka situated in urban development. The construction work finished on 17 October 1959. In that year the first airplane landed on the newly constructed airport and all air traffic from the airport in Ostrava — Hrabůvka was transferred there.

Before 1989, the airport was used mainly for the needs of the air force. Civil aviation was ensured by ČSA, namely for domestic flights, rarely for international ones. A significant turning point was the year of 1993 when the military traffic was terminated at the airport and Česká správa letišť s.p. became the operator.

On 1 July 2004 the Ostrava Airport was transferred from the ownership of Česká správa letišť, s.p. into the ownership of the Moravia-Silesian Region (Krajský úřad, 28. října 117, Ostrava 702 18). The operator is the company Letiště Ostrava, a.s.

On 13 December 2006 the airport was ceremonially christened after the composer of Leoš Janáček and a new departure hall was put into operation. At present, the ever developing airport of Leoš Janáček in Ostrava has been exposed to intense action of anthropogenic impacts, both due to an increasing proportion of traffic as well as in connection with the own operation of the airport. With regard to its excellent technical parameters, a pronounced development of this traffic junction is expected in the future. Figure 1 shows the new airport departure hall.

Fig. 1. New departure hall LEOŠ JANÁČEK airport

Several oil leaks have occurred at the airport and Figure 2 shows an oil interceptor Lapol D, which intercepts leaks of hazardous substances. Table 1 summarizes leaks of hazardous substances since 2005. At the same time, it gives substances that penetrated into the environment and the materials by means of which they were eliminated.

Fig. 2. Lapol D — leaks of oil products

TABLE 1
Leaks of oil substances at the airport

Date	Leak locality	Substance	Qty of leaked subst. [l]	Material used for disposal	Leak into sewer system
23.6.2005	Central passenger terminal	JET A – 1	200	Vapex, Cansorb	NO
21.6.2006	Central passenger terminal	JET A – 1	Not determ.	Cansorb	NO
28.7.2006	Central passenger terminal	Hydraulic oil	Not determ.	Cansorb	NO
12.9.2006	Central passenger terminal	JET A – 1	Not determ.	Cansorb	NO
18.9.2006	Taxiway	JET A – 1	50	Vapex, Cansorb, water, surface-active agent	NO
27.9.2006	Northern stand	JET A – 1	30	Cansorb	NO
29.3.2007	Central passenger terminal	JET A – 1	30	Cansorb	NO
28.3.2008	Bunkers of airport propellants	Oil products – closely unspecified	Not determ.	Vapex, sorption layer, absorption heaps, sewer seal	YES

It is apparent from the table that accidents with environmental impact prevail, accompanied by leaks of aviation turbine fuel JET A-1.

3. Characteristics of drawn samples and the method of laboratory tests

The soil samples from 4 sampling points were taken directly from the airfield of the Leoš Janáček Airport in Ostrava — Mošnov — see Figure 3.

Fig. 3. View of the sampling point

For biodegradation of the samples, pure bacterial cultures of Pseudomonas putida and Rhodococcus sp were used. The bacterial cultures are shown in Figures 4 and 5 [3, 5].

The culture media were the liquid medium of M1 for Pseudomonas putida and medium of M96 for Rhodococcus sp.

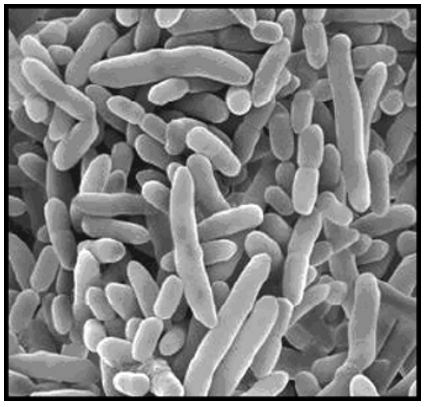

Fig. 4. Pseudomonas putida

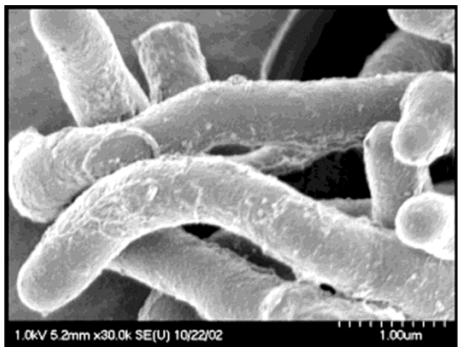

Fig. 5. Rhodococcus sp. RHA1

The laboratory experiments were carried out with pure bacterial cultures of Psedomonas putida and Rhodococcus sp., mixed culture and bacterial medium made of 50% MI medium and 50% of M96 medium. The experiments were carried out in the laboratories of the Institute of Environmental Engineering at VŠB-TU Ostrava, where 28-day bacterial degradation took place. Each sample was placed into a 2 l glass beaker. Aeration was secured by means of aquarium pumps placed into the beakers. The necks of the beakers were sealed with a foil and then the beakers were moved into the chemical hood. In the course of 4-week degradation the volume in the beakers was regularly filled with distilled water as gradual evaporation occurred. Having finished the experiment, the samples were filtered, dried and sent to further chemical analyses into the Brown Coal Research Institute in Most.

4. Sample characteristics

The mineralogical analyses were implemented in the laboratories of the Institute of Geological Engineering at Mining College — Technical University Ostrava by means of an X-ray diffraction. The results of the mineralogical analyses (Fig. 6) imply that the sample contains about 18% of amorphous phase, majority of quartz — about 57% and followed by calcite, chlorite, muscovite, orthoclase and albite.

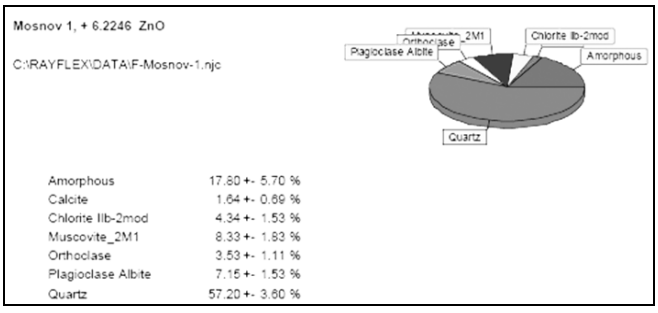

Fig. 6. Mineralogical analysis of the sample

5. Biodegradation test results

The results of laboratory biodegradation tests after one-month biodegradation with applied pure bacterial cultures and mixed culture are stated in Table 2. The table implies that in the course of biodegradation tests, gradual degradation of harmful substances content from the sample occurred. For biodegradation the following pure bacterial cultures were used: Pseudomonas putida — *PP*, Rhodococcus sp. — *R*, mixed culture Rhodococcus sp. and Pseudomonas putida — *R* + *PP*, and a check sample from media mixtures — *K*.

It is apparent from the results of four-week biodegradation test that the most suitable application for the sample is that of the pure bacterial cultures of Pseudomonas putida, where the degradation of contaminants of *PAH* was 92%.

In terms of degradation of *PCB* the best was the application of mixed culture, i.e. 42.9%. In this case, the efficiency of the mixed bacterial culture was very positive as applying it the following quantities were removed: 63.3% of *NEL*, 84.50% of *PAH* and 42.9% of *PCB*.

6. Conclusion

The objective of the paper was examination of application of biodegradation in the decontamination of soil sample from the Leoš Janáček Airport in Ostrava.

For the laboratory biodegradation tests a soil sample from the airport of the Leoš Janáček in Ostrava — Mošnova was used. The laboratory biodegradation tests were implemented with pure bacterial culture of Pseudomonas putida, pure bacterial culture of Rhodococcus sp, their mixture and mixture made combining their media free of bacteria.

The efficiency of the biodegradation after one-month leaching with pure bacterial culture of Pseudomonas putida (*PP*) was 38.8% for *NEL*, 92% for *PAH*, 26.5% for *PCB*, by means of pure bacterial culture of Rhodococcus sp. (*R*) was 35.2% for NEL, 75.7% for *PAH*, 39.5% for *PCB*, by means of mixed bacterial culture it was 63.3% for *NEL*, 84.5% for *PAH*, and 42.9% for *PCB*.

The paper results imply that the laboratory sample biodegradation efficiency with the selected contaminants ranged from 35.2÷63.3% for *NEL*, 60.2÷92% for *PAH* and 16.3÷42.9% for *PCB*. The best efficiency was obtained in the laboratory biodegradation of *PAH*. Intermediate efficiency was reached with biodegradation of *NEL* and *PCB*. Best removed *NEL* and *PCB* were by means of mixed bacterial culture (*PP* + *R*). For soil biodegradation, it is thus the most suitable to apply the mixed bacterial culture of Pseudomonas putida and Rhodococcus sp.

The results demonstrate that for the given type of contamination the method of biodegradation is suitable.

TABLE 2

Course of degradation the selected contaminants by means of Rhodococcus — *R*, Pseudomonas putida — *PP* and mixed culture *PP* + *R*, check test – *K*

Evaluation of the biodegradation test of sample									
Parameter	Input, mg/kg	*R*, mg/kg	Removal degree, %	*PP*, mg/kg	Removal degree, %	*PP* + *R*, mg/kg	Removal degree, %	Check test – *K*, mg/kg	Removal degree, %
NEL	196	127	35.2	120	38.78	72	63.27	89	54.59
anthracene	11.4	1.3	88.6	1.03	90.96	2.22	80.53	4.28	62.46
benzo(a)anthracene	65.8	8.2	87.54	5.83	91.14	12.88	80.43	29.09	55.79
benzo(b)fluoranthene	67.2	11.51	82.87	7.74	88.48	14.61	78.26	40.22	40.15
benzo(k)fluoranthene	61.2	54.16	11.5	5.97	90.25	11.81	80.7	27.36	55.29
benzo(a)pyrene	105	102.29	2.58	3.71	96.47	5.78	94.5	17.66	83.18
benzo(ghi)perylene	56.5	49.76	11.93	3.09	94.53	6.13	89.15	14.31	74.67
Fenantren	208.8	32.03	84.66	22.69	89.13	46.36	77.8	114.38	45.22
fluoranthen	264	24.05	90.89	18.88	92.85	36	86.36	96.96	63.27
chrysene	86.9	0.32	99.63	0.72	99.17	16.41	81.12	42.57	51.01
indeno(1,2,3-cd)pyren	18.7	0.1	99.47	11.98	35.94	4.44	76.26	18.67	0.16
naftalen	12.3	1.35	89.02	0.95	92.28	2.14	82.6	3.71	69.84
pyren	230.9	4.08	98.23	12.45	94.61	25.16	89.1	64.17	72.21
Σ PAU	1188.7	289.15	75.68	95.04	92	183.94	84.53	473.38	60.18
PCB č. 28	0.01	0.01	0	0.01	0	0.01	0	0.01	0
PCB č. 52	0.01	0.01	0	0.01	0	0.01	0	0.01	0
PCB č. 101	0.01	0.01	0	0.01	0	0.01	0	0.01	0
PCB č. 118	0.02	0.01	50	0.01	50	0.01	50	0.02	0
PCB č. 138	0.02	0.02	25	0.02	25	0.01	45	0.02	0
PCB č. 153	0.06	0.02	57.89	0.04	36.84	0.02	59.65	0.04	24.56
PCB č. 180	0.02	0.01	50	0.02	15	0.01	50	0.01	50
Σ 7 kongenerů PCB	0.15	0.09	39.46	0.11	26.53	0.08	42.86	0.12	16.33

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