BIO-TREATMENT OF SOIL FROM INTERNATIONAL AIRPORT IN OSTRAVA

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Abstract: The paper deals with an examination of possible application of biodegradation in the decontamination of soil samples from international airport in Ostrava. The laboratory biodegradation tests were carried out with a pure bacterial culture of *Pseudomonas putida*, a pure laboratory culture of *Rhodococcus sp*, their mixture and a mixture prepared combining their media free of bacteria. The results of the paper imply that for biodegradation of airport pollutants is most suitable to apply a mixed bacterial culture of *Pseudomonas putida* and *Rhodococcus sp*. The results show that the biodegradation method is applicable for the pollution.

Keywords: *biodegradation, Pseudomonas putida, Rhodococcus sp., mixed culture*

1. Introduction

Biodegradation (biological decontamination) is grounded in the capacity of certain bacterial strains to use 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, there is spontaneous degradation of biologically degradable oil substances at contamination of soil by 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 (NOVOTNÝ, 2005).

The objective of the paper was to examine the application of bacterial leaching to the decontamination of soil samples from the Leos Janacek Airport in Ostrava – these samples were taken from two sampling points.

2. Materials and methods

2.1 Leos Janacek 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. The modern history began in 1956 when the current airport began to be constructed. Before 1989, the airport was used mainly for the needs of the air force. Civil aviation was ensured by CSA, 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. On 13 December 2006 the airport was ceremonially christened after the composer of Leos Janacek and a new departure hall was put into operation. With regard to its excellent technical parameters, a pronounced development of this traffic junction is expected in the future (see references).

Several oil leaks have occurred at the airport and Figure 1 and Figure 2 show an oil interceptor Lapol D and Lapol 2, 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 used for their elimination.

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, wa ter, 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.

Fig. 1. Lapol D – leaks of oil products.

Fig. 2. Lapol 2.

2.2 Characteristics of drawn samples

The soil samples were taken directly from the airfield of the Leos Janacek Airport in Ostrava – Mosnov - see Figure 3.

Fig. 3. View of the sampling point.

The mineralogical analyses were implemented in the laboratories of the Institute of Geological Engineering at Mining College - Technical University of Ostrava by means of an X-ray diffraction. The results of the mineralogical analyses of sample 1 (Figure 4) imply that the samples contain about 18 % of amorphous phase, majority of quartz - about 57 % and followed by calcite, chlorite, muscovite, orthoclase and albite.

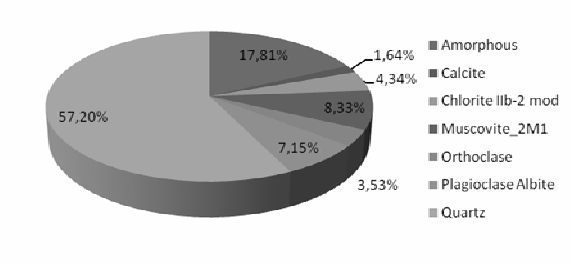

Fig. 4. Mineralogical analysis of the sample No.1.

The results of the mineralogical analyses of sample 2 (Figure 5) imply that the samples contain about 30 % of amorphous phase, majority of quartz - about 42 %. .

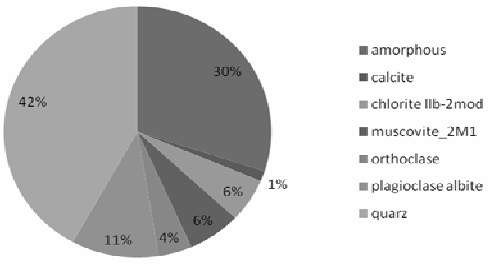

Fig. 5. Mineralogical analysis of the sample No.2.

2.3 Characteristics of bacterial cultures and the method of laboratory tests

For biodegradation of the samples, pure bacterial cultures of *Pseudomonas putida* and *Rhodococcus sp* were used. The bacterial cultures are shown in Figures 6 A, B (FEČKO *et al.*, 2004).

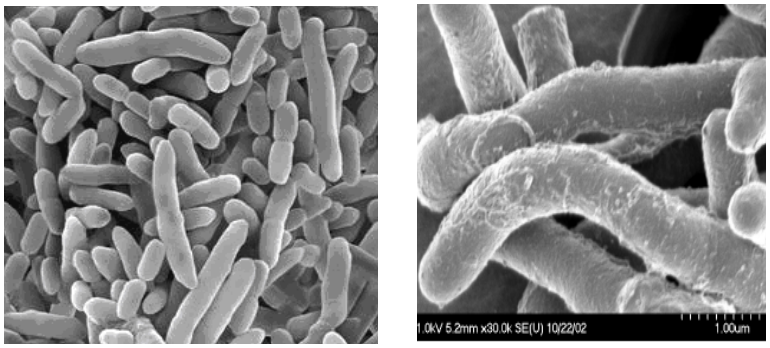

Fig. 6. *Pseudomonas putida (A)* and *Rhodococcus sp.* RHA1 (B) (FEČKO *et al.,* 2004).

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

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 VSB-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.

3. Results and discussion

The results of laboratory biodegradation tests after one-month biodegradation with applied pure bacterial cultures and mixed culture are stated in Tables 2, 3. The tables imply 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.*

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 1									
Parameter	**Input**	**R**	**Removal degree**	**PP**	**Removal degree**	**PP+R**	**Removal degree**	**Check test - K**	**Removal degree**
	mg/kg	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%
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
Fenantrene	208.8	32.03	84.66	22.69	89.13	46.36	77.8	114.38	45.22
fluoranthene	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-d)pyrene	18.7	0.1	99.47	11.98	35.94	4.44	76.26	18.67	0.16
naftalene	12.3	1.35	89.02	0.95	92.28	2.14	82.6	3.71	69.84
pyrene	230.9	4.08	98.23	12.45	94.61	25.16	89.1	64.17	72.21
Σ PAH	**1188.7**	**289.15**	**75.68**	**95.04**	**92**	**183.94**	**84.53**	**473.38**	**60.18**
PCB 28	0.01	0.01	0	0.01	0	0.01	0	0.01	0
PCB 52	0.01	0.01	0	0.01	0	0.01	0	0.01	0
PCB 101	0.01	0.01	0	0.01	0	0.01	0	0.01	0
PCB 118	0.02	0.01	50	0.01	50	0.01	50	0.02	0
PCB 138	0.02	0.02	25	0.02	25	0.01	45	0.02	0
PCB 153	0.06	0.02	57.89	0.04	36.84	0.02	59.65	0.04	24.56
PCB 180	0.02	0.01	50	0.02	15	0.01	50	0.01	50
Σ PCB	**0.15**	**0.09**	**39.46**	**0.11**	**26.53**	**0,08**	**42.86**	**0.12**	**16.33**

*) NEL – hydrocarbons $C_{10} – C_{40}$

It is apparent from the results of four-week biodegradation test that the most suitable application for the sample 1 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 is visible from the following removed quantities: 63.3 % of NEL, 84.50 % of PAH and 42.9 % of PCB.

Table 3. 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 2									
Parameter	**Input**	**R**	**Removal degree**	**PP**	**Removal degree**	**PP+R**	**Removal degree**	**Check test - K**	**Removal degree**
	mg/kg	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%
NEL	**150**	**100**	**33.3**	**60**	**60**	**35**	**76.6**	**120**	**20**
antracene	0.7	0.49	30	0.07	90	0.1	85.71	0.12	82.86
benzo(a) antracene	2.36	1.89	19.92	0.33	86.02	0.44	81.36	0.48	79.66
benzo(b) fluoranthene	5.2	4.95	4.81	0.6	88.46	0.69	86.73	0.71	86.35
benzo(k) fluoranthene	3.1	2.99	3.55	0.43	86.13	0.54	82.58	0.59	80.97
benzo(a) pyrene	5.31	4,67	12.05	0.53	90.02	0.59	88.89	0.74	86.06
benzo(ghi) perylene	3.5	1.16	66.86	0.21	94	0.27	92.29	0.28	92
fenantrene	2.65	2.45	7.55	0.86	67.55	0.14	94.72	1.45	45.28
fluoranthene	5.7	0.27	95.26	0.19	96.67	0.41	92.81	0.58	89.82
chrysene	2.7	0.13	95,19	0.25	90.74	0.02	99.26	0.02	99.26
indeno(1,2,3-cd) pyrene	6.99	6.66	4.72	2.39	65.81	0.11	98.43	0.56	91.99
naftalene	0.09	0.07	22.22	0.07	22.22	0.07	22.22	0.07	22.22
pyrene	4.75	2.69	43.37	0.6	87.37	0.17	96.42	1.3	72.63
Σ PAH	**43.05**	**28.42**	**33.98**	**6.53**	**84.83**	**3.55**	**91.75**	**6.9**	**83.97**
PCB 28	<0.01	<0.01	-	<0.01	-	<0.01	-	<0.01	-
PCB 52	<0.01	<0.01	-	<0.01	-	<0.01	-	<0.01	-
PCB 101	<0.01	<0.01	-	<0.01	-	<0.01	-	<0.01	-
PCB 118	<0.01	<0.01	-	<0.01	-	<0.01	-	<0.01	-
PCB 138	<0.01	<0.01	-	<0.01	-	<0.01	-	<0.01	-
PCB 153	<0.01	<0.01	-	<0.01	-	<0.01	-	<0.01	-
PCB 180	<0.01	<0.01	-	<0.01	-	<0.01	-	<0.01	-
Σ 7 PCB	**<0.07**	**<0.07**	**-**	**<0.07**	**-**	**<0.07**	**-**	**<0.07**	**-**

*) NEL – hydrocarbons C_{10} – C_{40}

It is apparent from the results of four-week biodegradation test that the most suitable application for the sample 2 is that of mixed bacterial cultures of *Pseudomonas putida* and *Rhodococcus*, where the degradation of contaminants of PAH was 91.75 %. The amount of PCB was lower as detection limit.

In this case, the efficiency of the mixed bacterial culture was very positive as is visible from the following removed quantities: 76.6 % of NEL, 84.83 % of PAH and 0 % of PCB.

4. Conclusions

The objective of the paper was to examine the application of biodegradation in the decontamination of soil sample from the Leos Janacek Airport in Ostrava.

For the laboratory biodegradation tests soil samples from the airport of the Leos Janacek in Ostrava – Mosnov 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 of sample 1 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 efficiency of the biodegradation of sample 2 after one-month leaching with pure bacterial culture of *Pseudomonas putida* (PP) was 60 % for NEL, 84.5% for PAH, 0 % for PCB, by means of pure bacterial culture of *Rhodococcus sp.* (R) was 33.3 % for NEL, 28.5 % for PAH, <0.07 % for PCB, by means of mixed bacterial culture it was 76.6 % for NEL, 91.8 % for PAH and 0 % for PCB.

The paper results imply that the laboratory sample 1 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 paper results imply that the biodegradation efficiency of laboratory sample 2 with the selected contaminants ranged from 33.3 – 76.6 % for NEL, 33.98 – 91.75 % for PAH. The amount of PCB was lower as detection limit.

The best efficiency was obtained in the laboratory biodegradation of PAH. Intermediate efficiency was reached with biodegradation of NEL and PCB. The highest amount of NEL and PCB were removed by 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.

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