ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 16, No. 3 2009

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EFFECT OF OIL DERIVATIVE SPILL ON EPIGEAL INVERTEBRATES

ODDZIAŁYWANIE WYCIEKU ROPOPOCHODNYCH NA BEZKRĘGOWCE NAZIEMNE

Abstract: The investigations aimed to find the answer to the question how long since the moment of the environment contamination with oil derivatives the effect of these compounds on the epigeal and soil fauna may be assessed.

The experiment was conducted in 2006–2007 in Czyżów village at the No.4 national road section where a road accident of cistern truck carrying crude oil happened in 2004 resulting in a spill of 12 000 dm^3 of toxic substance into the ground. The reclamation of the contaminated area was conducted "in situ" using bioremediation method based on Trigger-2R fast liquidation of contamination technology, ie realized in the contaminated place by enzymes and bacteria specialized in oil-derivatives biodegradation to the required soil standards.

With time elapsing since the moment of soil contamination with oil derivatives their toxic effect on individual invertebrate groups diminished. Three years after the moment of pollution no negative effect on the occurrence of a majority of epigeal invertebrates was visible. However, a decrease in the numbers of beneficial *Bembidion* sp., *Pterostichus* sp. and *Harpalus* sp. may be notices seasonally. Two years after the moment of pollution a persistent decline in the numbers of caught *Oribatida* may be observed.

Keywords: oil derivative, soil pollution, *Carabidae*, *Staphylinidae*, *Formicidae*, *Oribatida*, biomarkers of environmental pollution

The effect of oil derivative pollution is one of the problems difficult to asses due to a complexity of these substances and their considerable mobility. The may cause acute and long lasting toxic effects [1]. The outcomes of this kind of pollution (mainly polycyclic aromatic hydrocarbons) were quite thoroughly researched for aquatic invertebrates. These substances may cause cell damage, lower immunity, they may lead to disturbances in the development and osmoregulation, etc. [2, 3].

Soil fauna is frequently used as an indicator of the extend of the environment degradation [4], however there is few data concerning the effect of oil derivatives on

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this animal group. A considerable diversification both in PAH metabolizing effectiveness and in their accumulation by various land invertebrate groups was revealed [5]. Usually, within a short period of time since the soil contamination either total damage of arthropod population or considerably limited occurrence may be observe. The length of time after which the polluted areas become re-settled depends on the kind of pollution, the speed of remediation process and on the invertebrate species.

The research aimed to answer the question whether any differences could be discernible in the species structure of the epigeal fauna between the polluted area and control (unpolluted area) after 2–3 years since the moment of the environment pollution by oil derivative substances.

Material and methods

The experiment was conducted in Czyżów village at the section of national road No. 4, where a road accident of a fuel cistern carrying crude oil happened in 2004. In result 12 000 dm^3 of toxic substance spilled into the ground. The event was classified to class 4, ie to the events posing a grave environmental emergency. In result of a major emergency response action carried out on 5–8 April 2004 about 6 Mg of water and oil emulsion was gathered. It was estimated that the total area in need of reclamation was 3980 m^2. This terrain was bioremediated "in situ" using Trigger – 2R technique for fast liquidation of pollution carried out on the spot by enzymes and bacteria specialized in oil derivative biodegradation to required soil standards.

The insects were trapped during the May–August 2006 and March–June 2007 periods. In order to determine the course of soil arthropod succession in time, 8 Barber traps were placed on the whole analyzed area (4 in the contaminated area and 4 in the control – unpolluted area). Because of group occurrence in a given area, which is characteristic for epigeal fauna, the control area was designed close to the polluted area and comparability of the environmental elements (kind of vegetation, distance from the road, etc.) was maintained. The trap was a glass jar dug into the ground so that its upper edge was even with the soil surface. The traps were protected against rainwater by plastic roofs. They were emptied between every 7 and 10 days. The obtained fauna material was classified to orders and families and in case of *Col*., *Carabidae* beetles to species or gender according to Freude, Harde and Lohse [6]. Collected data were subjected to one factor ANOVA and the means were verified by Duncan's test at $p = 0.05$.

Polluted and control soils were also analyzed with respect to their concentrations of nonpolar aliphatic hydrocarbons, heavy metals and basic elements, and also considering soil pH and texture. The samples were collected on 10.07.2006 and the analyses were conducted in the laboratory of the Regional Chemical-Agricultural Station in Krakow and in the laboratory of the Malopolskie Provincial Inspectorate for Environmental Protection in Krakow. The results were presented in Tables 1–3.

Table1

Contents of basic elements and heavy metals in contaminated and control soils

Area of sample collection	Soil mechanic group	pH in KCl	Content per mg/100 g of soil			Content per mg/kg d.m. soil				
			P_2O_5	K_2O	Mg	Pb	Cd	Zn	Cu	Ni
Polluted soil	IV	7.24	4.3	7.7	> 15.0	31.84	0.78	103.20	18.67	17.22
Control soil	IV	6.43	2.7	3.7	> 15.0	32.07	1.17	123.26	18.23	17.67

Table 2

Percent content of fractions in the analyzed soil

Percent fraction content			
< 2 μm	2–20 μm	20–50 μm	50–2000 μm
4.87	35.18	33.60	26.34

Table 3

Content of nonpolar aliphatic hydrocarbons

Analyzed indicator	Polluted soil	Control
Nonpolar aliphatic hydrocarbons [mg/kg d.m.]	589.9	246.9

Higher content of aliphatic hydrocarbons in the polluted soil indicates that the terrains has not been completely cleared. However, the level of these substances two years after the event was already over 200 times lower than on the day of the accident (data MPIEP). Heavy metal contents in the soils from both analyzed areas were similar.

Results and discussion

A total of 1807 invertebrate specimens were trapped in 2006, of which 905 in the polluted area. 3496 specimens were caught in 2007 (1603 in the control area and 1893 in the polluted area). One of the most numerous invertebrate groups of fauna were arachnids. Two years after the catastrophe no significant differences were observed in total numbers of arachnids between the polluted and control areas, whereas a year later significantly more arachnids were trapped in the polluted area (Table 4). Former investigations did not register any negative effect of oil derivative substances, such as petrol or diesel oil (dosed 2 dm^3/m^2) on arachnid population numbers. Seasonally even larger numbers of these invertebrates were trapped in the petrol polluted area than on the control [7]. On the other hand, a negative effect was noted for diesel oil [8]. *Acari, Oribatida* are one of dominant groups among the soil mezofauna. Due to their species

Table 4

Representatives of epigeal fauna in control soil and in soil polluted with oil derivatives

Anthropoda	Mean number of caught invertebrates specimens/trap/week			
	Control		Polluted area	
	2006	2007	2006	2007
Carabidae – total	1.00 a	3.86 a	1.10 a	3.00 a
Bembidion sp.	—	1.20 a	—	1.02 a
Pterostichus sp.	0.38 a	0.80 a	0.52 a	0.40 a
Harpalus sp.	—	0.93 a	—	0.94 a
Amara sp.	—	0.31 a	—	0.30 a
Agonum sexpunctatum (L.)	0.10 a	0.18 a	0.08 a	0.21 a
Carabus cancellatus (Illig)	0.25 a	0.20 a	0.15 a	0.09 a
Ophonus pubescens (Mull.)	0.07 a	0.09 a	0.05 a	0.04 a
Carabidae larvae	0.18 a	0.42 a	0.05 a	0.26 a
Staphylinidae	0.13 a	1.62 a	0.18 a	1.09 a
Formicidae	0.60 a	1.96 a	0.50 a	4.02 a
Collembola	1.98 a	8.06 a	3.28 a	9.30 a
Arachnida – total	7.07 a	8.51 a	6.82 a	13.68 b
Oribatida	2.67 b	1.58 a	1.05 a	0.47 a

* means in lines for individual year marked with different letter are statistically different at p = 0.05

abundance they are considered as potentially good bioindicators of habitat quality and human impacts upon the environment [9]. Among the soil invertebrates they are considered as one of the most sensitive to the presence of eg heavy metals, which at high concentrations cause a decrease in density and diversity of these mites [10]. Almost twice greater amounts of these arachnids were caught on the control than in the polluted area in 2006. A year later larger numbers of these invertebrates were found on the control (differences ranged within an experimental error). No statistically significant differences in mean seasonal numbers of trappings between the control and polluted areas were assessed for other numerously present groups of invertebrates, such as *Col*., *Carabidae*, *Col.*, *Staphylinidae* beetles, *Hym.*, *Formicidae* or *Collembola* (Table 4). Visibly higher numbers of these representatives of epigeal fauna were trapped in 2007. Former investigations on the influence of oil derivatives on the occurrence of beneficial *Col.*, *Carabidae* beetles revealed that a negative effect of soil contamination with oil derivatives, such as petrol, diesel oil and used engine oil (applied in a dose of 2 dm^3/m^2) persisted for the period of at least 4 months since the moment of contamination. The response of individual *Carabidae* species was also diversified. Repellent effect of oil derivative substances was longer lasting in case of species with smaller bodies (*Amara*

sp., *Bembidion* sp.) [11]. The same investigations determined that *Formicidae* may be sensitive biomarkers of the environmental pollution with oil derivatives. Their negative reaction to pollutant presence was observed in all years when the research was conducted [12]. Obviously negative quantitative reaction under conditions of oil derivative pollution was registered also for *Collembola* [7].

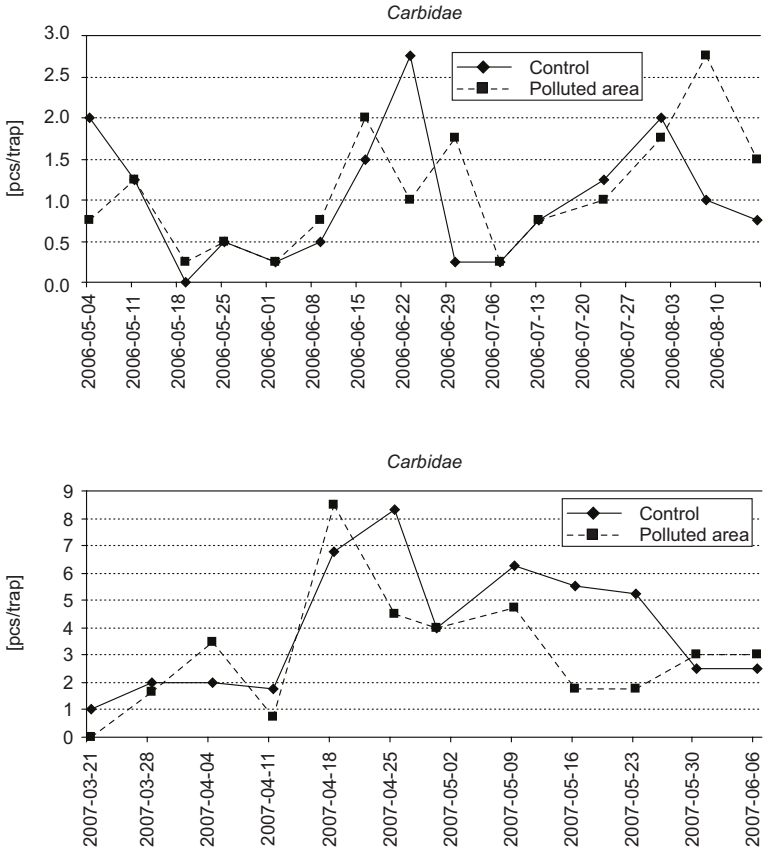

Fig. 1. Dynamics of *Col., Carabidae* beetles occurrence under conditions of control (unpolluted) soil and in soil polluted with oil derivatives. Means for respective dates marked with different letters are statistically different at p = 0.05. Marking was used only if statistical differentiation existed, on the other observation dates differences were insignificant

The course of dynamics of *Carabidae* occurrence in both analyzed areas was similar. No statistically significant differences in the numbers of trappings on individual dates were registered between the control and oil polluted area (Fig. 1). However, if we follow the dynamics of occurrence of most numerously represented genera of beetles from this family, a seasonal decrease in the numbers of trappings in the polluted area is visible even in 2007. It refers to beetles of *Pterostichus* sp., *Bembidion* sp. and *Harpalus* sp. genera (Fig. 2–4).

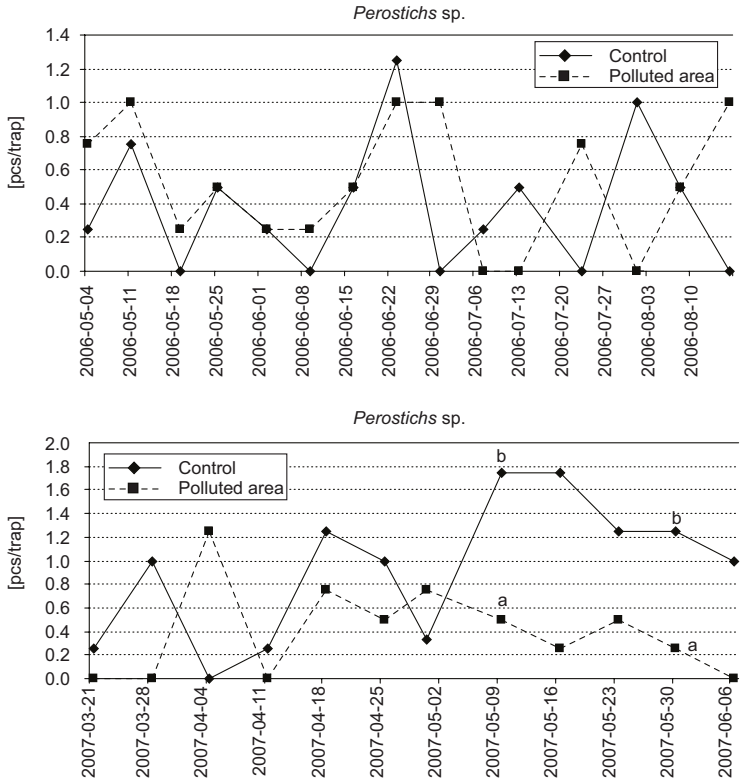

Fig. 2. Dynamics of *Pterostichus* sp. (*Col.*, *Carabidae*) beetles occurrence under conditions of control (unpolluted) soil and in soil polluted with oil derivatives. Means for respective dates marked with different letters are statistically different at p = 0.05. Marking was used only if statistical differentiation existed, on the other observation dates differences were insignificant

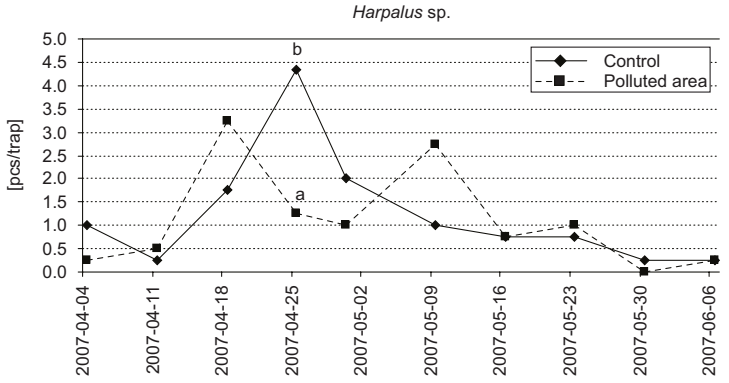

Fig. 3. Dynamics of *Harpalus* sp. (*Col.*, *Carabidae*) beetles occurrence under conditions of control (unpolluted) soil and in soil polluted with oil derivatives. Means for respective dates marked with different letters are statistically different at p = 0.05. Marking was used only if statistical differentiation existed, on the other observation dates differences were insignificant

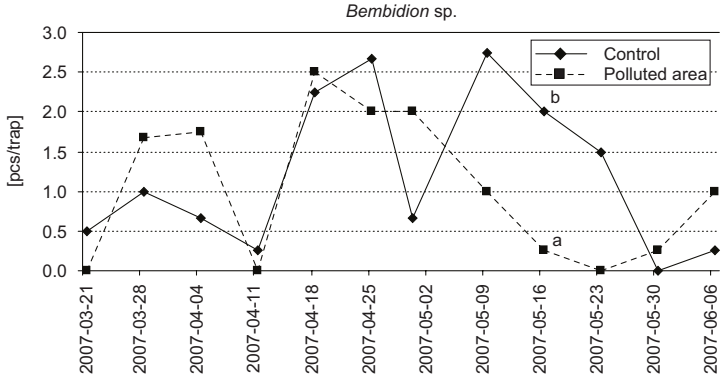

Fig. 4. Dynamics of *Bembidion* sp. (*Col.*, *Carabidae*) beetles occurrence under conditions of control (unpolluted) soil and in soil polluted with oil derivatives. Means for respective dates marked with different letters are statistically different at p = 0.05. Marking was used only if statistical differentiation existed, on the other observation dates differences were insignificant

Conclusions

1. Three years after the moment of pollution no negative effect on the occurrence of a majority of epigeal invertebrates was visible. However, a decrease in the numbers of beneficial *Bembidion* sp., *Pterostichus* sp. and *Harpalus* sp. may be notices seasonally.

2. Two years after the moment of pollution a persistent decline in the numbers of caught *Oribatida* may be observed.

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ODDZIAŁYWANIE WYCIEKU ROPOPOCHODNYCH NA BEZKRĘGOWCE NAZIEMNE

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Abstrakt: Celem badań było uzyskanie odpowiedzi na pytanie, jak długo od momentu zanieczyszczenia środowiska substancjami ropopochodnymi można mieć do czynienia z oddziaływaniem tych związków na faunę naziemną i glebową.

Doświadczenie zostało przeprowadzone w latach 2006–2007 w miejscowości Czyżów przy odcinku drogi krajowej nr 4, gdzie w 2004 r. miał miejsce wypadek cysterny przewożącej surową ropę naftową, czego efektem był wyciek do gruntu 12 000 dm^3 substancji toksycznej. Przeprowadzono rekultywację zanieczyszczonego obszaru metodą bioremediacji "In situ" w technologii szybkiej likwidacji skażeń Trigger-2R, tj. realizowaną na miejscu skażenia przez wyspecjalizowane w biodegradacji substancji ropopochodnych enzymy i bakterie, do wymaganych standardów jakości gleby.

Wraz z upływem czasu od momentu skażenia gleby ropopochodnymi zmniejsza się ich toksyczne działanie na poszczególne grupy bezkręgowców. Po upływie 3 lat od momentu zanieczyszczenia można stwierdzić brak negatywnego wpływu na występowanie większości grup bezkręgowców naziemnych. Okresowo można jednak zaobserwować zmniejszenie liczebności pożytecznych chrząszczy z rodzajów *Bembidion* sp., *Pterostichus* sp. i *Harpalus* sp. Po upływie 2 lat od momentu zanieczyszczenia można zaobserwować nadal utrzymujące się zmniejszenie liczebności odłowów mechowców.

Słowa kluczowe: ropopochodne, zanieczyszczenie gleby, *Carabidae*, *Staphylinidae*, *Formicidae*, *Oribatida*, biomarkery zanieczyszczenia środowiska