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Janina GOSPODAREK[1], Henryk KOŁOCZEK[2]
and Przemysław PETRYSZAK[3]

DYNAMICS OF ARACHNID OCCURRENCE IN SOIL CONTAMINATED WITH PETROL, DIESEL FUEL AND ENGINE OIL DURING BIOREMEDIATION PROCESS

DYNAMIKA WYSTĘPOWANIA PAJĘCZAKÓW W GLEBIE SKAŻONEJ BENZYNĄ, OLEJEM NAPĘDOWYM I OLEJEM SILNIKOWYM W TRAKCIE PROCESU BIOREMEDIACJI

Abstract: The research aimed at investigating the effect of oil derivatives during the process of their bioremediation on dynamics of arachnid (Arachnida) occurrence. The following objects were established in two series (with bioremediation and without bioremediation): control – unpolluted soil; soil polluted with petrol; soil polluted with diesel fuel and soil polluted with used engine oil (dose: 6 000 mg of fuel · kg^{-1}d.m. of soil). Epigeal fauna was trapped using Barber's traps. The traps were emptied once a week from June to October 2010. Moreover, once a month soil samples were collected from the 0–20 horizon and then examined for arachnid presence in a laboratory under a binocular.

Soil contamination with petrol, diesel fuel and used engine oil leads to drastic reduction of arachnid occurrence in the topsoil layer but is does not negatively affect soil surface penetration by these invertebrates. Some of the applied polluting substances, *eg* used engine oil, petrol even stimulated Arachnida occurrence on the soil surface. Bioremediation did not influence significantly total arachnid occurrence in soil for the period of 5 months since it was conducted. The marked decrease in the number of arachnids was observed in bioremediated topsoil layer while comparing with not bioremediated one during two months after petroleum contamination.

Keywords: oil derivatives, soil, bioremediation, Arachnida

Research conducted so far on the effect of pollutants on arachnid occurrence focused mainly on the influence of heavy metals [1–5], air pollution or chemical plant protec-

[1] Department of Agricultural Environment Protection, Agricultural University of Krakow, al. A. Mickiewicza 21, 31–120 Kraków, Poland, phone: +48 12 662 44 00, email: rrjgospo@cyf-kr.edu.pl

[2] Department of Biochemistry, University of Agriculture in Krakow, al. 29 Listopada 54, 31–425 Kraków, Poland, phone: +48 12 662 51 93, email: koloczek@ogr.ar.krakow.pl

[3] Department of Biochemistry, University of Agriculture in Krakow, al. 29 Listopada 54, 31–425 Kraków, Poland, phone: +48 12 662 51 94, email: przemek.petryszak@wp.pl

tion [6, 7]. Only few investigations concerned the effect of oil derivatives on this invertebrate group [8–11]. Results of these experiments point to a reduction of species richness and numbers, but also show a considerable diversification of the responses depending on the pollution level in the analyzed environment and the sampling method.

Applied bioremediation, using biopreparations containing specially selected groups of microorganisms, to the ground polluted with oil derivatives allows to accelerate considerably the process of oil derivatives decomposition. Subsequent stages of this process and intermediates which appear at that time may affect both epigeal and soil fauna.

The work aimed at investigating the effect of oil derivatives during the process of their bioremediation on dynamics of arachnid (Arachnida) occurrence.

Material and methods

The experiment was conducted at the Experimental Station of the University of Agriculture in Krakow situated in Mydlniki near Krakow, on agricultural land (covered by low herbaceous vegetation, mainly grass cut twice during vegetation season). The experiment was set up in autumn 2009 using randomised block method in four replications. The indigenous soil was placed in 1 m^3 (1 m × 1 m × 1 m) containers specially adapted for this purpose, and the natural soil layer arrangement was preserved. The containers were placed into the ground so that their upper ridges were level with the soil surface, so they did not pose a barrier for the analyzed invertebrates. Additionally the upper section of the container sides was perforated to allow the invertebrates a free penetration of polluted soil. Once the soil in the containers returned to its natural density and biological fitness, *ie* in June 2010, it was artificially polluted (by pouring onto the surface) with the following oil derivatives: petrol, diesel fuel and used engine oil in the amount corresponding to 6 000 mg of fuel · kg^{-1} d.m. of soil, which was a typical concentration of oil derivatives occurring in a medium polluted soils. A week after the soil contamination, half of the containers were subjected to bioremediation by means of ZB-01 biopreparation designed for biodegradation of oil derivatives, containing selected procaryotic microorganisms revealing high catabolic activity towards the oil derivatives. The following objects were established in each analyzed series: control – unpolluted soil; soil polluted with petrol; soil polluted with diesel fuel and soil polluted with used engine oil. Considering the pollutant content, the process of bioremediation was monitored using extraction-gravimetry on Soxhlet apparatus. Epigeal fauna was trapped using Barber's traps (a 0.9 dm^3 jar dug in level with the ground surface and covered against rainfall water by a plastic roof) placed in the central part of each container. The traps were emptied once a week from June to October 2010. Moreover, once a month soil samples were collected from the 0–20 horizon and then examined for arachnid presence in a laboratory under a binocular. Statistical computations were conducted using Statistica 9.0 PL programme. Means were differentiated using LSD Fisher test on significance level $\alpha = 0.05$.

Results and discussion

Soil contamination with oil derivatives contributed to a drastic reduction of arachnid representative occurrence in the analyzed soil samples (Fig. 1). Only after 3–4 months single Arachnida were spotted in the object contaminated with petrol (both in the bioremediated series and without bioremediation) and used engine oil. Early result of used pollutants towards the tested invertebrates was undoubtedly connected with their lethal effect. In a longer perspective also the effect of oil derivatives on vegetation as a source of food for the investigated mezofauna might have been also important. In the initial period, applied oil derivatives caused almost total destruction of vegetal cover in the studied area. In the course of time (several months later) plant started to reappear, first on petrol polluted soil (both subjected to bioremediation and non-remediated). Cebron et al [9] emphasize the effect of vegetation on the occurrence of soil Arachnida. In the research of these authors on the use of various kinds of bioindicators for the assessment of biological activity in both PAH-polluted and thermal desorption treated soils, the presence of vegetation was the basic factor modifying the number of soil Arachnida. Considerably reduced occurrence of arachnids in soil samples collected from seasonally flooded stream banks polluted with oil derivatives were registered by Couceiro et al [8].

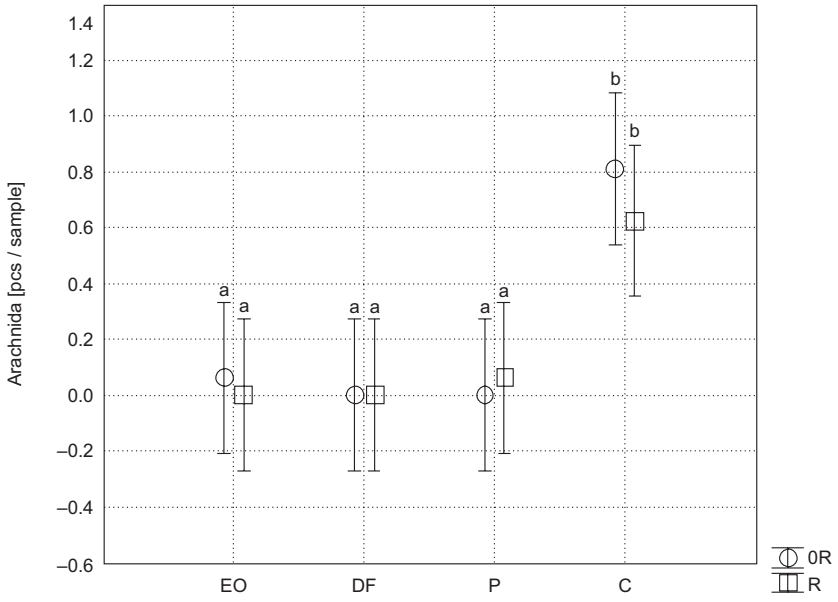

Fig. 1. Occurrence of arachnids in soil samples, average for the investigated period. EO – soil contaminated with used engine oil, DF – soil contaminated with diesel fuel, P – soil contaminated with petrol, C – unpolluted soil, 0R – series without bioremediation, R – series with bioremediation. Means marked with the same letters do not differ significantly according to LSD test at $\alpha = 0.05$; factors contamination x remediation. ⌶ Mean ± 0.95 confidence interval

Among the fauna caught using Barber's traps, arachnids occurred in greatest numbers in the initial period of the experiment, *ie* at the turn of June and July (Fig. 2).

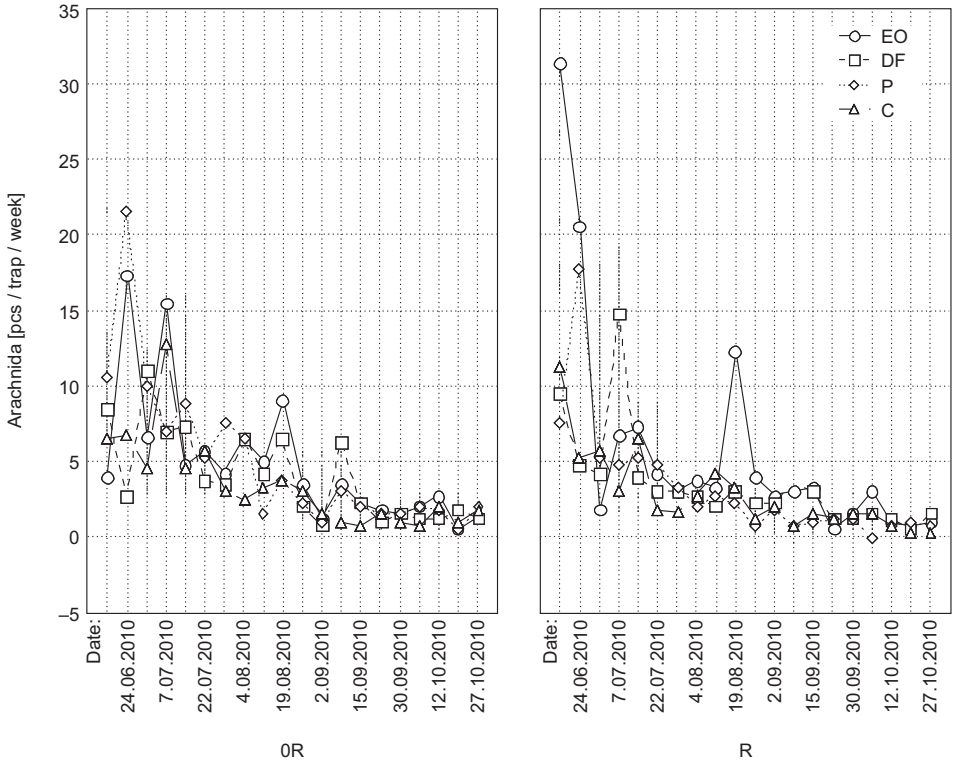

Fig. 2. Course of dynamics of Arachnida occurrence trapped using Barber's traps. The symbols as in Fig. 1

Later their number was several times lower. No such distinct differences in the course of their occurrence dynamics depending on soil contamination were noticed, as in case of arachnids observed in soil samples (Fig. 3). Statistical analysis of data from the subsequent months passing from the moment of soil pollution did not reveal any negative effect of the applied substances on Arachnida presence on soil surface. In some months greater numbers of these invertebrates were even trapped in the contaminated than in the control soil. Also the applied bioremediation did not significantly affect Arachnida occurrence for most of the investigated period. Only during the second month after contamination a marked decline in the number of trapped arachnids was registered in conditions of soil contaminated with petrol in the series with bioremediation. At that time it was similar as noted in the control. During that period a decrease from 4288 to 2841 mg of fuel · kg^{-1} d.m. was observed in the compounds extracted by petroleum spirit. It might have been connected with the stage of intensive bioremediation of soil polluted with petrol, during which short chained intermediates appear, toxic for Arachnida. During a later period of bioremediation a decline in toxic

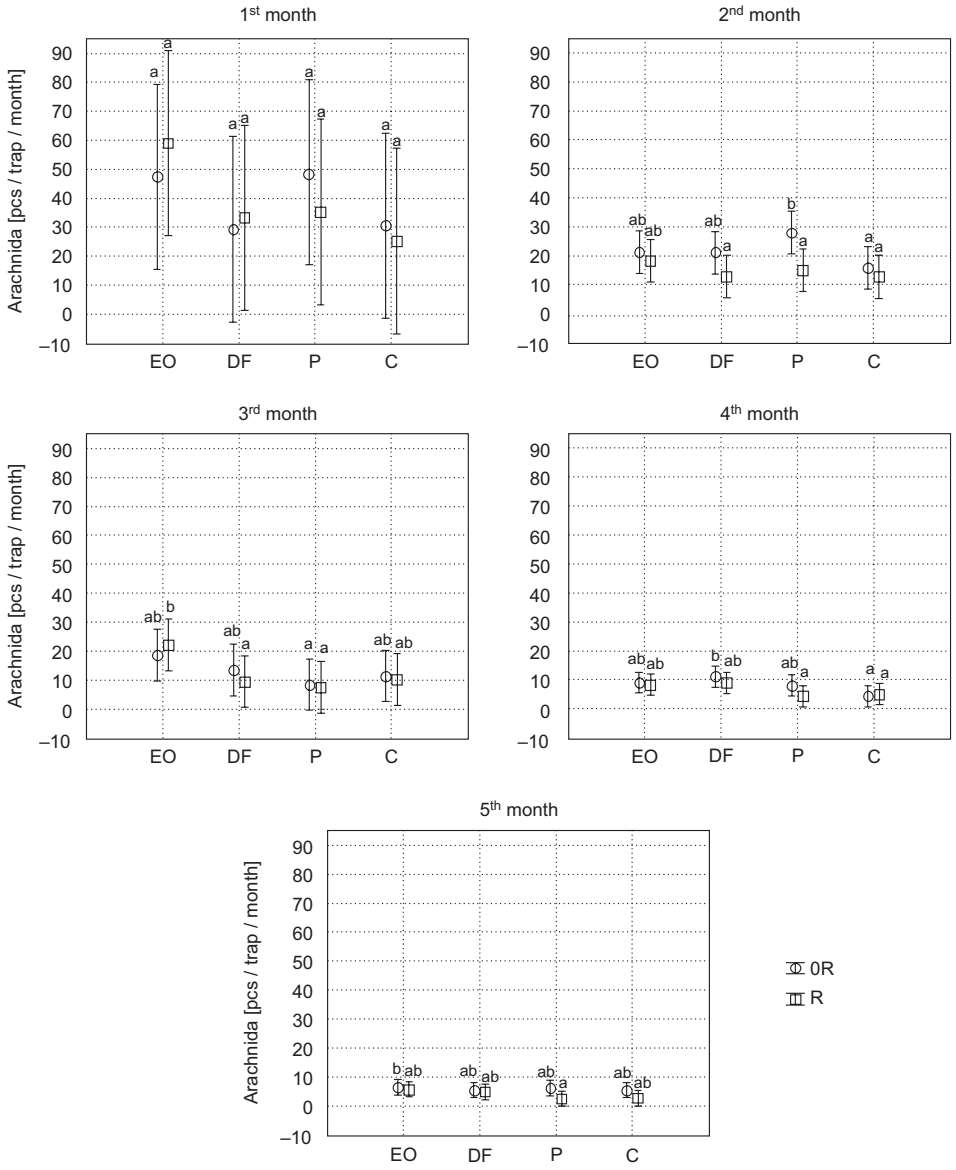

Fig. 3. Occurrence of Arachnida trapped using Barber's traps in individual months after soil contamination. The symbols as in Fig. 1. Means marked with the same letters do not differ significantly according to LSD test at $\alpha = 0.05$; factors contamination x remediation. ⊥ Mean ±0.95 confidence interval

compounds in soil contaminated with petrol and engine oil and increase in the concentrations of emulsifying compounds and bacteria number were the factors causing an increase in the number of trapped Arachnida. On average during the period of the experiment a significantly higher number of trapped arachnids were noted in the object

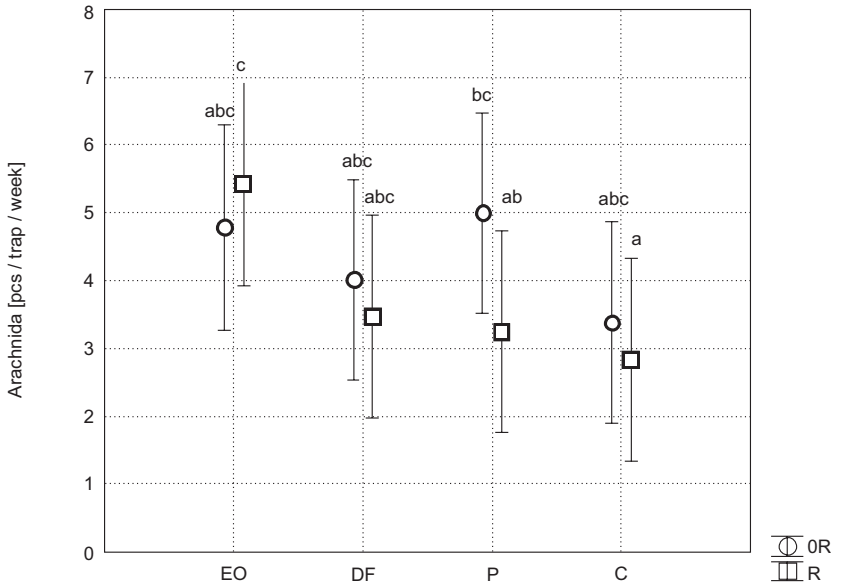

Fig. 4. Occurrence of Arachnida trapped using Barber's traps mean during experiment. The symbols as in Fig. 1. Means marked with the same letters do not differ significantly according to LSD test at $\alpha = 0.05$; factors contamination x remediation. ⌶ Mean ±0.95 confidence interval

where soil was polluted with engine oil and subjected to bioremediation and in the object with petrol contaminated soil than in conditions of clean soil where the biopreparation was applied (Fig. 4). In the Author's previous research [11] on the effect of environmental pollution with oil derivatives in result of a serious road accident on epigeal fauna, no negative effect of them on representatives of Arachnida phylum was noticed, either. Periodically greater number of these invertebrates were trapped in the polluted area. No negative effect of petrol or engine oil applied in a dose of 2 dm^3/m^2 on the number of trapped arachnids penetrating the earth surface was noted [12]. It is interesting to observe, that the area of soil polluted with used engine oil was penetrated by Arachnida irrespectively of the bioremediation, but also their occurrence was more numerous in comparison with the control. These results suggest that composition of engine oil contains attractants for these organisms. The period of time for bioremediation of soil polluted with engine oil was relatively short and pollution level in the topsoil decreased from 36417 to 20608 mg · kg^{-1} d.m. in the investigated period. The result mentioned above stimulates further research on the identification of the substances contained in the oil as stimulants for settling soil surface by this group of organisms.

Conclusions

1. Soil contamination with petrol, diesel fuel and used engine oil leads to drastic reduction of arachnid occurrence in the topsoil layer but is does not negatively affect soil surface penetration by these invertebrates.

2. Some of the applied polluting substances (used engine oil, petrol) even stimulated Arachnida occurrence on the soil surface.

3. Applied bioremediation did not influence significantly total arachnid occurrence in soil for the period of 5 months since it was conducted.

4. Bioremediation of soil polluted with petrol two months after it was conducted contributed to limited presence of Arachnida on the soil surface to the level similar as in the conditions of unpolluted soil.

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DYNAMIKA WYSTĘPOWANIA PAJĘCZAKÓW W GLEBIE SKAŻONEJ BENZYNĄ, OLEJEM NAPĘDOWYM I OLEJEM SILNIKOWYM W TRAKCIE PROCESU BIOREMEDIACJI

[1] Katedra Ochrony Środowiska Rolniczego
[2, 3] Katedra Biochemii
Uniwersytet Rolniczy im. Hugona Kołłątaja w Krakowie

Abstrakt: Celem pracy było zbadanie oddziaływania substancji ropopochodnych w trakcie procesu bioremediacji gleby na dynamikę występowania pajęczaków (Arachnida). W każdej z dwóch serii badawczych (z bioremediacją i bez bioremediacji) utworzono następujące obiekty: 1. kontrola – gleba niezanieczyszczona. 2. gleba sztucznie zanieczyszczona benzyną, 3. gleba sztucznie zanieczyszczona olejem napędowym, 4. gleba sztucznie zanieczyszczona zużytym olejem silnikowym (dawka 6 000 mg paliwa · kg^{-1} s.m. gleby). Odłowy fauny naziemnej prowadzono z wykorzystaniem pułapek Barbera. Pułapki opróżniano raz w tygodniu w okresie od czerwca do października 2010 roku. Ponadto raz w miesiącu pobierano próbki gleby z poziomu 0–20 cm, które następnie przeglądano w laboratorium pod binokularem, pod kątem obecności pajęczaków.

Skażenie gleby benzyną, olejem napędowym i zużytym olejem silnikowym powoduje drastyczne ograniczenie występowania pajęczaków w powierzchniowej warstwie gleby, natomiast nie wpływa negatywnie na penetrację powierzchni gleby przez te bezkręgowce. Niektóre z zastosowanych substancji zanieczyszczających (zużyty olej silnikowy, benzyna) odziaływały wręcz stymulująco na występowanie pajęczaków na powierzchni gleby. Zastosowana bioremediacja, przez okres 5 miesięcy od momentu jej przeprowadzenia, nie wpłynęła istotnie na występowanie pajęczaków ogółem w glebie. Bioremediacja gleby zanieczyszczonej benzyną po upływie dwóch miesięcy od jej przeprowadzenia przyczyniła się do ograniczenia występowania pajęczaków na powierzchni gleby do poziomu podobnego jak w warunkach gleby niezanieczyszczonej.

Słowa kluczowe: ropopochodne, gleba, bioremediacja, Arachnida