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THE EFFECT OF THE FALL OF NICKEL LEACHING REST ON SELECTED GROUPS OF EDAPHIC ORGANISMS IN THE SURROUNDINGS OF NICKEL SMELTING WORKS IN SEREĎ (SOUTH SLOVAKIA)

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The influence of the fall of nickel leaching rest on selected groups of edaphic organisms (saprophytic bacteria, free living nematodes, free living mites and beetles) was studied in the surroundings of the nickel smelting works in Sereď in Slovakia. The majority of the groups studied exhibited a considerable degree of tolerance to the fall of nickel leaching rest. Its influence was detected only in the closest vicinity of the dump of the nickel leaching rest. Deeper changes in the populations or in the community structure were observed in *Coleoptera,* in which the changes in sex ratio were observed in the zone with the fall of 300—500 tkm^{-2} $year^{-1}$. The changes in the alpha diversity and in species number were observed inside the zone with the fall 800 tkm^{-2} $year^{-1}$. No changes were observed in secondary productivity also in *Coleoptera.*

Key words: nickel leaching rest, pollution, soil fauna *Bacteria, Nematoda, Acarina, Tardigrada, Carabidae, Staphylinidae,* sex ratio, alpha diversity, secondar productivity.

The nickel smelting works in Sereď (South Slovakia) produces annualy about 320 000 tons of nickel leaching rest which is stored in a big dump in ist vicinity. The nickel leaching rest represents extremly fine black dust, containing about 40 % of iron and a large spectrum of other metals (chromium, cobalt etc.). Due to its consistency the nickel leaching rest is easily dispersed by wind in considerable quantities into surroundings during dry periods. So the presence of nickel leaching rest dump is rather serious source of pollution in that area. The size of the pollution by nickel leaching rest was

the reason of an extensive research program aimed at investigation of posibilities and methods for the stabilization of dump surface by vegetation cover and of investigating effects of dispersion of the nickel leaching rest on the biota in the surroundings of the nickel smelting works (Paulech et al., 1983). The present paper represents a brief synthesis of the results of zoological and microbiological investigations on the influence of dispersion of nickel leaching rest on the soil fauna and microflora in the surroundings of the leaching rest dump.

Material and methods

Each group of soil fauna was studied by specific methods. The beetles were sampled into the pitfall traps installed in a 8.5 km long transect led in the direction of dominating winds. The mutual distances between the traps were 250 m. The glass jars of 95 mm in diameter served as a traps. The 6 % formol was used as killing and conserving solution. The mites were isolated from soil samples of 0.5 l taken in the same transect. The mutual distances of sampling sites for mites were 500 m. Besides, the soil samples were taken in closest vicinity of the dump in the distances of 5; 25 and 50 m respectively. The mites and beetles were sampled in one month intervals during the whole vegetation period. The nematodes were sampled in three sites, one of them situated directly on the dump, second on the margin of the surrounding field and third site was in the distance of 500 m from the dump. The tardigrades were sampled in the distances of 5; 30; 50; 100; 150 and 200 m from the dump margin respectively. The mosses from the surface of 25 cm^2 were sampled for isolation of the tardigrades. The nematodes and tradigrades were sampled three times during the vegetation period. All above methods are described in the papers of the individual authors (Šály, 1983; Kalúz, 1983, Šustek, 1983 in Paulech et al., 1983; Šály et al., 1985) in detail. All groups of the soil animals were sampled during the vegetation period of 1982.

The samples for the microbiological and chemical analyses were taken in the distances of 10 and 200 meters from the dump margin and in the margin proper and on its top. In each sampling site, the samples have been taken from the depth of 0—5 and 10—15 cm respectively. The actual cumulative microbial biomass in the samples was determined by a respirometric method modified by Anan'eva et al. (1985), bacteria number was determined by inoculation in agar substrate and finally, the respiration rate of bacteria (Co_2) followed by the gas chromatography (Makarov, 1977). The content of the metals in the soil was determined by the atomic adsorption spectrophotometry method proposed by Ivanov (1974). The results obtained should be considered semiquantitative.

Results

Soil microorganisms

Some microbiological indices of the soil on the dump and in its surroundings and the content of the most important pollutant are presented in tab. 1. The large content of all toxic metals was detected in the sample taken on the top of the dump. The following are other metals present in the samples: Mn (730—2500 mg kg^{-1}), Cu (20—40 mg kg^{-1}, Zu (18—260 mg kg^{-1}) Pb (2—17 mg kg^{-1}, Hg (0.006—0.065 μg g^{-1}) and Fe (2.9—52.8 %). The mutal ratio of

Table 1

Content of metals, soil microorganisms biomass, respiration rate and number of saprophytic bacteria in individual sampling points on the dump of nickel leaching rest and in its surroundings

Site number	Distance from dump margin in meters	pH water	Depth in cm	Content of metals mg/kg dry soil				Biomass of soil micro-organisms μg C/g	Respiration rate of soil μg CO_2/ /100 g in hours	Number of saprophytic bacteria 1000 cells/g
				Cr	Co	Ni	Σ Me			
1	top	5.0	0—5	14000	650	3400	18050	69.87	12.65	2.59
2	margin	6.5	0—5	2800	210	<20	3030	281.30	52.43	378.74
2	margin	6.5	10—15	900	75	235	1210	129.30	83.39	41.47
3	10 m	6.0	0—5	210	50	135	395	228.08	26.20	252.01
3	10 m	6.0	10—15	210	40	135	385	266.06	42.64	350.34
4	200 m	6.5	0—5	135	50	170	355	260.70	40.46	229.91
4	200 m	6.5	10—15	165	50	155	370	309.77	101.0	446.39

the main toxic elements in the leaching rest on the surface of the dump slope is Cr:Co:Ni = 140:10:1, but in the depth of 10—15 cm the ratio corresponds to 45:4:12, respectively (20 mg kg^{-1} Ni being 1, cf. tab. 1).

The biomass and respiration rates of the microorganisms are rather low in the sample from the dump top. It is evident that there exist rather un favourable conditions for the soil organisms. However, already on the dump margin, the values of the microbiological indices move within the variation limits of the values from more distant sampling sites. The samples taken in the depth of 10—15 cm show higher respiration rate, biomass and number of saprophytic bacteria than the samples from the dump surface. In the distances of 10—200 m from the dump margin respectively, the influence of metals on the microbiological indicens is insignificant. The concentration of nickel and chromium in the samples from both distances are considerably higher than those in the normal conditions (A n a n'e v a, O r e s h k i n, T y u r i u k a n o v a).

Free living nematodes

Only 4 and 10 species and 151 and 92 individuals respectively were found in the two samples taken on the dump margin. The average weight of one individuum was 0.207 μg. In the close vicinity of the dump, 15 and 18 species and 183 and 212 individuals respectively occurred in the samples. The average of one individual was 0.2495 μg. There 22 and 27 individuals and 248 and 204 individuals respectively were found in the samples of 100 m distance from the dump margin. In these samples the average weight of one individual was 0.3355 μg. The control samples taken in the distance of 500 m from the dump margin contained less species and less individuals than the samples from the 200 m distance (21 species and 149 individuals), but the average weight of one individual was 0.5190 μg in this sample. The species *Aphelenchoides*

parietinus, Aphelenchus avenae and *Acrobeloides buetschli* seem to be most tolerant. They were present also in the samples from the rhizosphere of *Carduus acanthoides* on the dump margin. The above analyses show the surprising tolerance of free living nematodes against the nickel leaching rest and a possibility for using nematodes to produce conditions for a gradual development of plant cover on the dump surface and, consequently, to stabilize it (Šály, 1983, Šály, 1983 in Paulech, 1983).

Tardigrada

Only one species, *Macrobiotus harmsworthi,* was present in 72.2 % of moss samples. The number of individuals varied within the limits of 13—102 individuals per sample. No dependence of individuals number from the distance of the dump margin was observed. It seems that the local topic conditions exhibit much more influence on the populations of *Macrobiotus harmsworthi* than the fall of nickel leaching rest (Guoth, 1983 in Paulech et al., 1983).

Free living mites

An obvious decrease in abundance of mites was visible up to the distance of 50 m from dump margin. In distances extending over 50 m, the abundance of mites varied in close limits around the average abundance in the whole transsect. In the distance of 5 m from the dump margin, the abundance of mites amounts only about 40 % of their average abundance in the whole transsect, and immediately on the dump margin the abundance of mites drops to 20 % of average abundance. There, the representatives of 17 mites families (besides Oribatei) were checked on the dump margin. In the dump itself, the representatives of three families of phytophagous mites occurred in the poor nickel leaching rest. These were represented only few individuals in each sample. Changes in the qualitative composition of mite faunula were observed up to the distance of 200—500 m from the dump margin (Kalúz, 1983 in Paulech et al. 1983).

Carabidae, Silphidae and Staphylinidae

The negative influence of the fall of nickel leaching rest on the community structure of *Carabidae, Silphidae* and *Staphylinidae* can be observed in the area subjected to the fall intensity amounting 300—500 tkm^{-2} $year^{-1}$. In this area the fall influence reflects in a sudden change of sexual index of dominant species *Harpalus rufipes, Dolichus halensis* and *Agonum dorsale.* Inside this area the dominance of males increases in each species in direction towards the dump where the fall is stronger, while outside this area the females dominate in all above species. In the immediate vicinity of the dump (ca 100 m north, west and east and about 200 m south) and in the area with the fall intensity amounting 800 tkm^{-2} $year^{-1}$ respectively, the

influence is so strong that the changes in sex ratio of the only autodominant species, *Harpalus rufipes* (about 97 % individuals and 99 % biomass), become extremly striking and they are acompanied by a deep drop in the alpha diversity and in species number. The above striking dominance of males in this area indicates the starting extinction of these species populations. This extinction is, under the present size of this zone (more than 800 tkm^{-2} $year^{-1}$) compensated still by an imigration from less affected surroundings. Due to this, the fall of nickel leaching rest has had no tangible effect on the cumulative abundance and on the biomass of the above there groups of beetles untill present. This conclusion is supported by the laboratory tests of the toxicity of nickel leaching rest tor caterpillars of *Scotia segetum (Lepidoptera, Noctuidae,* Švataráková, 1983 in Paulech et al. 1983). The samples size from the entire transect varied between 1000 and 2000 individuals respectively. Its variation depended on the ecoclimate in the surrounding cultures, of maize and cereals, on their time caincidence with the development cycle of carabids, and on close competitive relations between *Silpha carinata, Silpha obscura* on one hand and *Harpalus rufipes, Calathus fuscipes* and *Dolichus halensis* on other hand.

The pitfall trapping on the dump surface, on its margin and along the ways in its interior as well, showed an intensive imigration of Carabids and Staphylinids on the dump. The size of the individual samples of *Carabidae* and *Staphylinidae* from the dump interior never exceeded 100—120 individuals. It was strongly subjected to the presence, size and density of patches *Salsola cali.* The more moveable species mostly hygrophilous species, were dominant among the imigrants. The presence of carabid larvae *(Harpalus rufipes* and *Amara aulica),* and the clusters of tipulid larvae in the small islands of ruderal vegetation of the dump interior confirm relatively good conditions of regeneration of soil fauna after the possible recultivation of the dump. However, due to the extremly low biomass of all arthropods imigrating on the dump, they can not be expected to play a more important role in inrechement of the upper layers of the dump by organic matter and, consequently, in a spontaneous arize of a soil on the dump surface. The recultivation of the dump and a stabilization of its surface by means of vegetation cover can, however, result only from extensive agritechnical and/or silvitechnical measures. The determination of the zone extent with noxious influence by the fall of nickel leaching rest is, however, strongly biased by the sensitivity of the above bioindicative criteria and hardly controlable environmental factors (Šustek, 1983 in Paulech et al., 1983).

Discussion and conclusions

The nickel leaching rest containing higher quantity of several metals (e. g. chromium, nickel, cobalt) has apparently no significant influence on the microbiological indices of the soil. The literary data on this problem are ambiguous. According to Haanstra and Doelman (1984) the nickel and zinc have strong inhibitive effects on the activity of invertase und urease, while a high concentration of nickel in the soil with pH close to neutral reaction has no effect on vitality of soil microorganisms according to Babich and Stotzky (1982). The chromium concentration higher than 500 mg kg^{-1} surpresses

the number of bacteria and the ATP contents (Zibliske, Wagner, 1982; Capone, Reese, Kieme 1983). Earlier, it has been shown that the normal biomass of soil microorganisms in the chernozem of South Slovakia is 200—300 $\mu g\ C\ g^{-1}$ (Šály, Anan'eva, Kalúz, 1986).

The soil animals exhibited, aparently, rather different grade of tolerance to the fall of nickel leaching rest. The striking degradation of nematode fauna (Šály, 1983 in Paulech et al., 1983), as organisms concentrated in the soil or, frequently, in the tissues of plant roots or in decaying plant rests, was observed only on the dump. slopes. It was manifested in a poorer species spectrum (only four more tolerant species present), and in low average weight of individuals. The number of individuals in more distant sites was even larger than those in normal soils in the fields with applied to fertilizers or pesticides. The quantitative changes in representation of free living mites manifested themselves up to distances of 50 m from the dump margin, the qualitative changes could be observed up to distances of 5 m from the dump margin (Kalúz, 1983 in Paulech et al., 1983). The tardigrades were represented only by one species which did not exhibit any reaction on the fall of nickel leaching rest (Guoth, 1983 in Paulech et al., 1983). The indication of noxious effects of the fall of nickel leaching rest on *Coleoptera* were strongly dependent from the sensitivity of the bioindicative criteria used. The fall of 300—500 $tkm^{-2}\ year^{-1}$ caused changes of sex ratio in the dominant species, the fall of more than 800 $tkm^{-2}\ year^{-1}$ provoked also striking decrease in alpha diversity and in species number. The abundance and biomass of all three coleopterous groups remained unchanged even in a close vicinity of the dump*. The imigration of *Coleoptera* on the dump was rather extensive, an essential however extensive agritechnical and silvitechnical measures are a precondition for succesfull collonization of the dump surface by beetles being. Because of the accumulation of nickel leaching rest in the soil of the dump surroundings, the prognosis of its influence on the edaphon is pessimistic (Šustek, 1983 in Paulech et al., 1983). Even the present content of chromium, cobalt and nickel in the soils around the dump amounts approximately three times more metals than under normal conditions. The microbiological analyses indicate that the most noxious metal appeares to be the chromium.

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* Similarly as in other groups. This fact should be considered by the interpretation of the results obtained in other groups studied.

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VPLYV SPADU NIKLOVÉHO LUŽENCA NA VYBRANÉ SKUPINY EDAFICKÝCH ORGANIZMOV V OKOLÍ NIKLOVEJ HUTY V SEREDI (JUŽNÉ SLOVENSKO)

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Vplyv spadu niklového lúženca na vybrané skupiny edafických organizmov v okolí niklovej huty v Seredi sa študoval na príklade saprofytických baktérií voľne žijúcich nematód, pomaliek, roztočov a chrobákov. Väčšina študovaných skupín vykazovala vysoký stupeň tolerancie k spadu niklového lúženca. Jeho vplyv sa zistil len v najbližšej blízkosti haldy. Hlbšie zmeny v štruktúre populácií a spoločenstva sa pozorovali u chrobákov, kde sa v zóne so spadom 300—300 t km^{-2} rok^{-1} prejavovali zmeny v pohlavnom indexe bystruškovitých a v zóne so spadom viac ako 800 t km^{-2} rok^{-1} boli nápadné zmeny v alfa-diverzite a počte druhov bystruškovitých a drobčíkovitých. Ani u chrobákov sa nezistili zmeny v sekundárnej produktivite spoločenstva.

Došlo 27. 1. 1986

ВЛИЯНИЕ ВЫПАДЕНИЯ НИКЕЛЕВОЙ ЩЕЛОЧИ НА ИЗБРАННЫЕ ГРУППЫ ЭДАФИЧЕСКИХ ОРГАНИЗМОВ В ОКРЕСТНОСТИ НИКЕЛЬПЛАВИЛЬНОГО ЗАВОДА В ГОРОДЕ СЕРЕДИ (SEREĎ) ЮЖНАЯ СЛОВАКИЯ (JUŽNÉ SLOVENSKO)

Збышек Шустек, Станислав Калуз, Антон Шалы, Надежда Д. Ананьева, Галина К. Тюрюканова, Валентин Н. Орешкин

Влияние выпадения никелевой щелочи на избранные группы эдафических организмов в окрестности никельплавильного завода в городе Середи (Sereď) изучалось на примере сапрофитических бактерий свободно живущих нематод, тихоходок, клещей и жуков. Большинство изучаемых групп обладали высокой степенью устойчивости к выпадению никелевой щелочи. Ее влияние было обнаружено только в непосредственной близости отвала. Более глубокие изменения в структуре популяций и сообществ были отмечены у жуков, где в зоне с выпадением 300—500 т /$км^{-2}год^{-1}$ появились изменения в половом индексе жужелиц и в зоне с выпадением более чем 800 т $км^{-2}год^{-1}$ были заметные изменения в альфа разнообразии и количестве видов жужелиц и коротконадкрылых. Даже у жуков не были обнаружены изменения во вторичной продуктивности сообщества.