Journal of Environmental Protection and Ecology 2, No 3, 637–641 (2001)

THE HEAVY METALS IMPACT ON SOIL MEZOBIOTA

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Abstract. The impact of the heavy metals on the soil invertebrates has been investigated in some European countries. This gives a basis to investigate further those issues in Bulgaria because of the problem importance. Till now, there has been no similar investigations performed. The aim of the present study was to determine the soil taxons biodiversity and the basic ecological characteristics of the soil mezo-fauna on the polluted by heavy metals soils. A standard field methodology of Giliarov was used for sampling. The following parameters were investigated: density on 1 m^3, diversity and number of one mezobiota group compared to the total number observed in single soil sample as well as this number as percentage of the total. The results show that all investigated ecological parameters of the soil mezobiota have been influenced negatively by the presence of heavy metals in the soil. On the basis of this research, a taxonomic group is proposed as bio-indicators to be used in the monitoring systems for heavy metals detection in the soil.

Keywords: heavy metals, industrial pollution, soil mezobiota.

AIMS AND BACKGROUND

The pollution caused by the human activities, in particular by the heavy industry, has considerable negative impact on environment. It also has a disturbing effect on the natural processes in the ecosystems.

One of the primary aims in the environmental protection programmes in Bulgaria is the quantity assessment of the soil pollution and prognosis of the soil changes, in cases they are placed near zones with developed industry.

The heavy metals belong to the group of the most important polluters. They represent a considerable research interest because of the fact that their excessive quantities in the soil bring also non-reversible effects, namely disturbance of the natural nutrients cycle, the normal development of the soil bio-cenoses and the mechanisms for interactions of the living organisms with the environment.

The problem of soil pollution with heavy metals and their influence on the soil invertebrate fauna has been investigated by many researchers[1-4]. In Bulgaria, this type of investigations are very scarce[5-7].

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The aim of this investigation was to monitor the influence of heavy metals such as copper, lead, arsenic and cadmium on the soil mezobiota and its basic characteristics. During the investigation the following research aims have been achieved:

- the taxonomic diversity of soil mezobiota in polluted with heavy metals plots in the town Pirdop region and non-polluted soils has been observed;
- the basic ecological characteristics of the soil mezobiota have been determined – soil mezobiota population density, abundance, frequency, the index of diversity of Simpson, and the index of equality of Simpson;
- the main soil parameters have been detected – pH, humus content, soil moisture;
- the heavy metal content has been detected of the above mentioned groups and the comparison was made with the ultimate levels/norms according to Bulgarian Standard.

EXPERIMENTAL

The investigations were performed in Pirdop region (South Bulgaria) and the controlled plot of the same soil type in the region of Grebna baza – Plovdiv. A standard field methodology of Giliarov[2] was used for sampling. Three plots with of 1 m^2 and 15 cm depth were sampled. The plots were at 250 m and 500 m from the pollution source – the Heavy Metal Plant Asarel Medet.

The following ecological parameters were detected[8]:

1. soil mezobiota population density – number of individuals per taxonomic group on 1 m^2 ;
2. abundance – ratio between the number of individuals from a taxonomic group and the total number of individuals in the entire sample;
3. frequency – ratio between the number of individuals from a taxonomic group and the total number of individuals in the entire sample expressed in %;
4. the index of diversity of Simpson – this is treatment of abundance of every species to abundance of everyone species in sample, calculated by the formula:

$$D = \frac{1}{\sum_{i=1}^{s} Pi^2}$$

where $\sum_{i=1}^{s} Pi^2$ is the sum of abundances of all taxones in the sample which describes the role of the individuals of every taxon in the total density of the sample.

Index of diversity increases with increasing biodiversity.

5. The index of equality of Simpson – it is the maximum index of diversity, calculated by the formula

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$$E = \frac{1}{S\sum_{i=1}^{s} Pi^2}$$

The heavy metals quantity in the soil was determined by the method of adsorption spectrophotometric analysis.

RESULTS AND DISCUSSION

During the investigations, the following soil characteristics were detected as it is shown in Table 1. The heavy metals content in the sample and control plots expressed in mg/dm^3 are given in Table 2.

Table 1. Soil characteristics

Characteristics	Sample plots	Control plots
pH	6.1	6.4
Soil moisture	18.5	17.7
Temperature	21.5°C	21.8°C
Air humidity	81%	80%

Table 2. Heavy metal content in soil (mg/dm^3)

Type of metal	250 m from the Metal Plant	Times above norms	500 m from the Metal Plant	Times above norms
Copper	1137	74.8	340	7.5
Lead	330	15.5	47.5	0.175
Arsenium	85	2.4	18.9	under threshold levels
Cadmium	4.1	0.366	traces	under threshold levels

The heavy metals quantity in the soil is decreasing when the distance from the source of pollution increases. For copper and lead there have been several times higher quantities detected as compared with the threshold levels (norms) for Bulgaria. The soils in the region are heavily polluted with heavy metals.

Seven taxonomic groups of soil mezobiota have been detected during the investigation. The density, the abundance and the frequency of the samples from the investigated and the controlled plots are presented in Table 3.

The analysis of the results shows that all the three investigated ecological characteristics of the soil mezobiota have lower values in the samples taken from the fields polluted with heavy metals as compared to the control plots. This is especially valid for the parameter density. The representatives of the family *Lumbricidae* have almost two times lower density in the polluted soils. Similar situation can be observed with the population of classes *Miriapoda* and *Arachnidae*. The above mentioned three taxonomic groups are most significantly influenced by the presence of heavy metals in the soil.

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Table 3. Values of the density (number), the abundance and the frequency (%) of soil mezobiota in 1 m³

Taxon	Density (number)		Frequency (%)		Abundance	
	sample	control	sample	control	sample	control
Family *Lumbricide*	59.629	106	45.2	45.3	0.452	0.453
Class *Miriapoda*	8.148	17	6.1	7.5	0.061	0.075
Order *Oniscoidea*	11	26	8.4	11.3	0.084	0.113
Larvae of class *Insecta*	20.740	27	15.7	11.8	0.157	0.118
Order *Coleoptera*	14.074	22.962	10.6	9.7	0.106	0.097
Class *Arachnidae*	7.037	16	5.3	7.0	0.053	0.070
Family *Carabidae* – larvae	11	16	8.4	7.0	0.084	0.070

The research interest was directed to investigate and monitor how the density and the index of diversity of Simpson will change with increasing the distance from the source of pollution.

The results show that the higher is pollution of the soils (the samples from 250 m distance) the lower are the values of the soil mezobiota density and the index of diversity of Simpson. When the distance from the source of pollution is increasing (the samples from 500 m) the above two parameters are increasing. This result shows the negative impact of the heavy metals on the ecological properties on soil mezobiota diversity (Table 4).

Table 4. Distance from the pollution source and the soil mezobiota density.

Taxon	250 m from the pollution source		500 m from the pollution source	
	density	*D*	density	*D*
Family *Lumbricidae*	42		57	
Class *Miriapoda*	5		7	
Order *Oniscoidea*	7	$D = 3.623$	11	$D = 3.921$
Class *Insecta* – larvae	14		20	
Order *Coleoptera*	7		14	
Class *Arachnidae*	3		6	
Family *Carabidae* – larvae	7		11	

The analysis of the results shows that the index of equality of Simpson in sampled and control fields is lower in the soils polluted with heavy metals in comparison with those without pollution ($E = 0.553$ in the sample and $E = 0.663$ in the control plot).

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CONCLUSIONS

1. During the investigation seven taxons of soil mezobiota organisms were detected.

2. The density of the identified taxon groups is lower within the fields that are polluted with heavy metals compared to non-polluted ones.

3. The frequency and abundance of the taxon groups identified are lower in the sampled field polluted with heavy metals.

4. The index of diversity and the index of equality of Simpson show lower values in the samples from soils polluted with heavy metals.

5. Increasing the distance from the source of pollution there is detected increase of the values of soil mezobiota density and the index of diversity.

6. The presented investigation shows that all monitored ecological parameters of the soil mezobiota hare been influenced negatively by the presence of heavy metals in the soil. This research presents an opportunity to use the ecological parameters of the soil mezobiota and their changes in the monitoring systems of the soils polluted with heavy metals. In addition, this research gives an opportunity to use the organisms of the family *Lumbricidae* as bio-indicators for polluted with heavy metals soils.

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Received 19 November 1999
Revised 13 July 2000

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