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Populations of Earthworms (Lumbricidae) in Forests of the Middle Urals in Conditions of Pollution by Discharge from Copper Works

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Abstract—Pollution of the middle and southern taiga forests with heavy metals combined with SO_2 is leading to a sharp decline of earthworm populations. The territory around the source of pollution, about 50–80 km^2 in area, represents a "lumbricid desert." The dependence between concentrations of metals in the soil and the number of earthworms is nonlinear. The earthworm population size begins to decrease when pollution exceeds the background level 2.0–2.3 times. When this level is exceeded 4.0–4.5 times, earthworms disappear.

INTRODUCTION

Earthworms are a significant component of the forest soil biota with respect to their abundance and functional role. Therefore, they should be included in the analysis of anthropogenically disturbed ecosystems (Krivolutskii, 1994). The influence of pollutants on lumbricids is being studied intensively. Trends in toxicant accumulation and shifts in physiological and biochemical parameters of earthworms have been studied in detail, whereas information on the response of their entire population to pollution under conditions of natural ecosystems is scarce. At the same time, such data are important for understanding the regularities of anthropogenic transformations of the biota and developing systems of ecological diagnosis, monitoring, and scaling.

I studied the response of earthworm populations to emissions of copper works in taiga forests. Attention to this type of pollution is not accidental: the action of SO_2 and heavy metals is synergistic, which sharply aggravates toxic pressure on the biota. Therefore, the response to this type of pollution manifests itself very clearly, which makes analysis simpler.

STUDY AREA AND METHODS

The work was conducted in Sverdlovsk oblast, in the subzones of southern taiga (the town of Revda, Middle Ural Copper Works, MUCW) and middle taiga (the town of Krasnoural'sk, Krasnoural'sk Integrated Copper Works - KICW). The structure of emissions in both areas is similar. In the area of MUCW (operating since 1940), sampling plots were located west of the factory (against the prevailing winds) at distances of 1 to 30 km, in spruce–fir, birch, and pine forests growing on gray and brown mountain–forest soils. In the area of KICW (operating since 1932), sampling plots were located north, south, and west of the factory at distances of 1 to 21 km, in secondary birch forests growing mainly on brown mountain–forest soils. The data on pollution of the territory and transformation of plant cover and soils were described previously (Vorobeichik *et al.*, 1994; Vorobeichik and Khantemirova, 1994; Kaigorodova and Vorobeichik, 1996; Vlasenko *et al.*, 1995).

Earthworms were counted by handpicking from soil blocks 20 × 20 × 20 or 25 × 25 × 20 cm in size, 10–40 samples per plot. To study the vertical distribution of earthworms, each block was divided into the following strata: litter, 0–10 cm, and 10–20 cm. The samples were treated in the laboratory. The work in the area of MUCW was performed in July 1988 (8 plots) and June–July 1989 (12 plots), and in the area of KICW, in June–July 1990 (9 plots) and June–July 1991 (26 plots).

The value of toxic pressure was estimated as the content of mobile forms (extraction by 5% HNO_3) of priority pollutants (Cu, Pb, and Cd) in the upper 0- to 5-cm layer of the horizon A1. The concentrations were determined in an AAS-3 atomic absorption spectrophotometer (Karl Zeiss). To reduce the dimensions in which the data on pollution is expressed, I used the index of toxic pressure:

$$K_i = D_i/\min(D_i),$$

$$D_i = [\mathrm{Cu}]_i/[\mathrm{Cu}]_f + [\mathrm{Pb}]_i/[\mathrm{Pb}]_f + [\mathrm{Cd}]_i/[\mathrm{Cd}]_f,$$

where $[\ ]_i$ is the concentration of an element on the *i*th plot and $[\ ]_f$ is its local background concentration. The index is measured in relative units and indicates the excess of concentrations of all metals over the background concentration. In the area of MUCW, one unit of the coefficient corresponds to 15.5 μg/g Cu, 16.4 μg/g Pb, and 1.1 μg/g Cd; in the area of KICW, the respective values are 20.7, 5.9, and 0.7 μg/g.

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RESULTS AND DISCUSSION

Earthworm population dynamics. The number of earthworms in the background territory is very large: with cocoons taken into account, it may exceed half of the total number of mesobionts (Table 1). Such values often significantly exceed estimations made by other authors for the same region (Perel', 1979; Korobeinikov, 1978) but do not exceed the maximum number of earthworms recorded in forest soils (Lee, 1985). The optimal combination of hydrothermal conditions on particular plots at the time of census may serve as a possible explanation for this fact. This may also explain the wide annual variation in the number of earthworms. For example, the plot "fir–20 km" in 1990 was excessively moistened, as compared to 1991, and signs of slight gleying of the upper soil horizons were observed. In the plot "pine–20 km," the samples were taken in a much drier site in 1990 than in 1991. In both cases, the excess or deficiency of water determined the abundance of earthworms. Another possible reason for the high number of earthworms in this study is that a virtually complete account of all age stages, including cocoons and small juveniles, was taken. This was achieved by careful manual treatment of samples in the laboratory. Other methods, including sample processing *in situ*, produce results that are too low. In addition, I included juvenile forms and recently abandoned remains of egg cocoons in the estimation of earthworm abundance. Hence, the number of earthworms may be overestimated as a result of "double census" of the same individuals at different development stages.

Closer to the source of emissions, the number of lumbricids decreased sharply, and they became less important in the mesofauna. Moreover, the difference in this parameter between polluted plots and the background territory significantly exceeded the range of its natural variation in the latter. Earthworms were absent at distances less than 3.8 km from the MUCW and 5 km from KICW, and this territory may be regarded as a "lumbricid desert" with an area of no less than 50–80 km^2. The type of changes in lumbricid abundance in both regions and in all forest types studied was similar.

The decrease in the abundance of earthworms and their subsequent elimination obviously resulted from a high soil toxicity, of which two aspects may be distinguished: high concentrations of heavy metals and high acidity. Many laboratory experiments revealed an increase in mortality and a decrease in the rates of growth, regeneration, cocoon production, and survival of juvenile forms under the influence of toxicants from emissions of copper works, such as Cu, Pb, and Cd (Rhee, 1977; Malecki *et al.*, 1982; Bengtsson *et al.*, 1986); As and Hg (Beyer *et al.*, 1985; Fischer and Koszorus, 1992); or fluorides (Vogel and Ottow, 1992). Similar but less pronounced effects were recorded upon an increase of soil acidity (Bengtsson *et al.*, 1986). In our case, high concentrations of metals are necessary but are an insufficient condition for the manifestation of toxic effect: a decrease in soil pH is also required. This follows from the fact that high concentrations of metals are recorded at distances of 7–8 km from MUCW (Vorobeichik *et al.*, 1994), but there is no decline in the number of earthworms. This decline becomes evident at a distance not less than 4 km from the factory, where soil pH decreases from 5.5–6.2 to 4.7–5.2 (Vorobeichik, 1995). On the other hand, earthworms are tolerant to changes in pH within the range of 4.5–6.5 (Lee, 1985; Lofts-Holmin, 1986). Hence, the increased soil acidity alone cannot explain the disappearance of earthworms from the area located 4 km away from MUCW. More evidence is the point displaced from the dose–effect curve (Fig. 1), which characterizes a high abundance of earthworms on the heavily polluted plot with atypically low soil acidity. Our idea agrees with the results of experiments demonstrating the synergism of heavy metals and acidity, which leads to increased accumulation of metals in an organism (Ma *et al.*, 1983) and, correspondingly, higher mortality (Bengtsson *et al.*, 1986).

Our results are similar to the data obtained by other authors, who registered a decline of earthworm populations under soil pollution with heavy metals (Rhee, 1977; Yeates *et al.*, 1995), in particular, near copper works (Nekrasova, 1993; Bengtsson *et al.*, 1983). The differences concern the existence of a vast zone of lumbricid desert, because in Sweden earthworms were found even at the distance of 275 m from the factory (Bentsson *et al.*, 1983). Probably, this situation resulted from the synergism noted above. In the areas where the decrease in the number of earthworms was less pronounced or absent, metal pollution occurred against the background of neutral soil reaction (Wright and Stringer, 1980).

Changes in species composition. Eight species of earthworms typical of the Urals have been recorded in the habitats studied (Table 1; Perel', 1979). *Aporrhectodea rosea* dominates among endogean earthworms, and *Perelia diplotetratheca* (endemic for the Urals), among epigean species. In the area of KICW, *Eisenia nordenskioeldi*, a widespread Siberian species, is a subdominant, whereas in the area of MUCW, *Dendrobaena octaedra* is fairly numerous.

Against the general background of earthworm population decline, changes in proportions of species demonstrated no apparent trends. It should be noted that *Ap. rosea*, an endogean species, was the first to disappear upon an increase of pollution, and only litter and soil–litter forms remained on polluted plots. Among epigean species, *P. diplotetratheca* maintained its dominance in the area of MUCW to the border of the lumbricid desert. The only exception was one plot where *D. octaedra* prevailed. In the area of KICW, the proportion of *E. nordenskioeldi* tended to increase, and that of *P. diplotetratheca*, to decrease as the source of pollution was approached.

All species, at least those belonging to the epigean complex, seem to respond to pollution in the same way,

Table 1. Parameters of lumbricid populations on the plots studied (only the plots where earthworms were found are considered)

Distance from the factory, km	Soil type*	Year	Density of lumbricids, ind. per m^2	Proportion, %										
				of cocoons	of lumbricids in total mesofauna	of lumbricids in litter	of species*** in the total population (without cocoons)							
							1	2	3	4	5	6	7	8
Middle Ural Copper Works														
Birch forests														
5.6	B	1991	1.6 ± 1.5	0.0	1.2	100.0	100.0	–	–	–	–	–	–	–
5.8	G	1991	280.0 ± 67.4	78.3	36.2	22.9	21.1	–	76.3	2.6	–	–	–	–
6.9**	B	1991	25.6 ± 22.6	6.2	21.6	100.0	53.3	–	46.7	–	–	–	–	–
19.0	G	1991	736.0 ± 91.6	29.1	50.1	39.1	26.7	0.6	70.2	2.5	–	–	–	–
Fir–spruce forests														
3.8	G	1991	92.8 ± 25.4	74.1	33.7	86.2	6.7	–	–	93.3	–	–	–	–
4.0	G	1991	8.0 ± 3.4	80.1	5.4	60.0	100.0	–	–	–	–	–	–	–
5.2	G	1990	43.8 ± 10.3	45.7	17.8	–	73.7	15.8	5.3	–	5.3	–	–	–
		1991	52.8 ± 11.3	63.6	9.1	100.0	100.0	–	–	–	–	–	–	–
5.6	G	1990	19.0 ± 4.0	55.3	31.4	–	29.4	11.8	29.4	29.4	–	–	–	–
		1991	65.6 ± 17.6	92.7	31.8	53.7	66.7	33.3	–	–	–	–	–	–
7.5	G	1990	344.0 ± 36.1	52.9	59.2	–	98.8	–	0.9	0.3	–	–	–	–
		1991	750.4 ± 140.9	66.7	54.6	50.7	91.7	2.6	–	5.1	–	–	0.6	–
20.0	G	1990	168.8 ± 22.3	51.2	55.8	–	62.3	–	34.6	3.1	–	–	–	–
		1991	1705.6 ± 198.8	67.4	55.1	13.2	37.2	–	58.8	2.3	–	–	1.7	–
30.0	G	1991	668.8 ± 81.9	67.0	35.7	33.7	68.1	–	7.2	17.4	–	–	7.2	–
Pine forests														
3.9	B	1990	8.3 ± 3.8	0.0	10.4	–	–	–	100.0	–	–	–	–	–
5.0	B	1991	1.6 ± 1.5	0.0	1.2	0.0	–	–	–	–	–	–	–	100.0
10.9**	B	1991	164.8 ± 26.2	59.2	31.9	61.2	50.0	–	–	11.9	2.4	2.4	–	33.3
20.0	B	1990	63.3 ± 26.3	23.7	27.9	–	44.8	–	51.7	3.5	–	–	–	–
		1991	1027.2 ± 104.6	49.5	37.0	9.3	25.6	0.3	65.7	7.7	–	–	0.6	–
Krasnoural'skii Integrated Copper Works														
North														
6.0	B	1989	0.6 ± 0.6	100.0	0.9	0.0	–	–	–	–	–	–	–	–
11.0	B	1989	68.8 ± 11.0	79.1	22.4	55.5	39.1	60.9	–	–	–	–	–	–
13.0	B	1989	130.0 ± 16.7	84.6	24.3	56.3	78.1	18.8	–	–	3.1	–	–	–
16.0	B	1989	122.5 ± 14.3	80.1	29.4	77.6	71.8	28.2	–	–	–	–	–	–
East														
5.0	B	1989	17.7 ± 6.1	93.1	9.9	75.9	50.0	50.0	–	–	–	–	–	–
7.0	B	1988	0.0	–	0.0	–	–	–	–	–	–	–	–	–
		1989	1.3 ± 0.9	100.0	3.6	0.0	–	–	–	–	–	–	–	–
11.0	M	1988	43.1 ± 7.3	94.2	15.0	–	50.0	25.0	–	–	25.0	–	–	–
		1989	40.0 ± 5.8	89.1	5.2	71.9	85.7	14.3	–	–	–	–	–	–
20.0	M	1988	113.8 ± 14.8	61.0	33.0	–	76.1	23.9	–	–	–	–	–	–
		1989	443.6 ± 38.7	83.7	48.9	49.0	90.7	2.6	–	–	6.8	–	–	–
South														
7.0	B	1988	181.9 ± 27.2	85.9	14.2	–	92.7	7.3	–	–	–	–	–	–
11.0	B	1988	30.0 ± 5.5	66.7	13.6	–	93.8	6.2	–	–	–	–	–	–
21.0	B	1989	123.8 ± 12.6	67.5	22.6	33.0	71.4	27.1	–	1.5	–	–	–	–

* Soil type: G, gray forest; B, brown forest; M, meadow–forest.

** Sampling plots located east of MUCW.

*** Lumbricid species (after Easton, 1983): 1—*Perelia diplotetratheca* (Perel, 1967); 2—*Eisenia nordenskioldi* (Eisen, 1879); 3—*Aporrectodea rosea* (Savigny, 1826); 4—*Dendrobaena octaedra* (Savigny, 1826); 5—*Octolasion lacteum* (Örley, 1881); 6—*Aporrectodea caliginosa* (Savigny, 1826); 7—*Perelia tuberosa* (Svetlov, 1924); 8—*Lumbricus rubellus (*Hoffmeister, 1833). Dash means the lack of data or species.

Table 2. Age structure of populations of dominant earthworm species in the zone of MUCW in 1991. *n* is number of individuals recorded; proportions in %: juv, of young bandless individuals; subad, of adult bandless; and ad, of banded individuals

Distance from the factory, km	*P. diplotetratheca*				*Ap. rosea*				*D. octaedra*			
	n	juv	subad	ad	*n*	juv	subad	ad	*n*	juv	subad	ad
Birch forests												
5.6	1	0.0	0.0	100.0	–	–	–	–	–	–	–	–
5.8	8	75.0	12.5	12.5	29	24.1	20.7	55.2	1	0.0	0.0	100.0
6.9	8	100.0	0.0	0.0	7	100.0	0.0	0.0	–	–	–	–
19.0	87	74.7	10.3	14.9	229	77.3	20.5	2.2	8	25.0	50.0	25.0
Fir–spruce forests												
3.8	1	100.0	0.0	0.0	–	–	–	–	14	71.4	14.3	14.3
4.0	1	100.0	0.0	0.0	–	–	–	–	–	–	–	–
5.2	12	58.3	8.3	33.3	–	–	–	–	–	–	–	–
5.6	2	50.0	50.0	0.0	–	–	–	–	–	–	–	–
7.5	143	55.2	17.5	27.3	–	–	–	–	8	37.5	50.0	12.5
20.0	129	72.1	13.2	14.7	204	68.6	16.2	15.2	8	25.0	50.0	25.0
30.0	94	52.1	17.0	30.9	10	90.0	10.0	0.0	24	29.2	33.3	37.5
Pine forests												
10.9	21	28.6	14.3	57.1	–	–	–	–	5	0.0	60.0	40.0
20.0	83	79.5	9.6	10.8	213	89.2	6.1	4.7	25	12.0	44.0	44.0

with differences leveled off owing to toxic pressure. In this respect, therefore, a certain morphoecological group of species can be regarded as a fairly uniform complex. My conclusion differs from ideas of other authors about species specificity of lumbricid reactions to toxicants (Edwards and Brown, 1982; Ejisackers, 1983) and, correspondingly, greater informativeness of changes in the species structure compared to the overall abundance.

Changes in age structure were analyzed for dominant species in the area of MUCW (Table 2). The data on *P. diplotetratheca* are most representative. At a higher abundance of this species, proportions of different age groups are fairly stable: juvenile forms comprise 50–80%; adults (banded), 15–30%; and large bandless forms, 10–20%. Different stages disappear as abundance decreases: only juvenile forms occurred in some plots of the impact zone, whereas only adults were found in other plots. The situation with other species was similar. The same concerns the proportion of worms and their cocoons (Table 1). Note that, since species identification of the cocoons is difficult, these proportions are given for the entire lumbricid population. In the background zone of MUCW, the cocoons accounted for 50–70% of the total number of earthworms in spruce forests and for 30–50% in birch and pine forests. Upon heavier pollution, their proportion either increased to 80–90%, or they disappeared. The proportion of cocoons in the background zone of KICW was 60–80% and tended to increase upon heavier pollution. The lack of obvious trends in changes of age structure appears to be associated with a low accuracy of density estimates under conditions of low abundance, when the randomness of findings of particular stages becomes important. Nevertheless, I can conclude that the occurrence of juvenile stages and egg cocoons at the technogenic limit of earthworm distribution provides evidence that these animals reproduce in polluted habitats. However, since the subsequent fate of juveniles and the intensity of earthworm migration from neighboring plots are unknown, the problem of self-maintenance of populations in the impact zone remains open.

Vertical stratification of lumbricid populations changes in two ways. The first variant was observed in most plots of the MUCW area. More than half of the earthworms concentrated in the upper soil layer, less in the litter (Table 1), and still less (ca. 10%) in the deeper soil layer. Closer to the source of emissions, an upward shift of the maximum density took place: no worms were found in the lower soil layer, and the ratio of earthworm numbers in the soil and litter became inverted. This occurred because *Ap. rosea* disappeared, and the activity of other species was displaced to the litter. This eventually leads to the situation where earthworms at the technogenic limit of their distribution are often found only in the litter. The second variant of change in the vertical structure was observed in the zone of KICW and, partly, MUCW: earthworms were absent or rare in the litter of polluted plots.

The difference between these two variants appears to be connected with differences in the type of changes

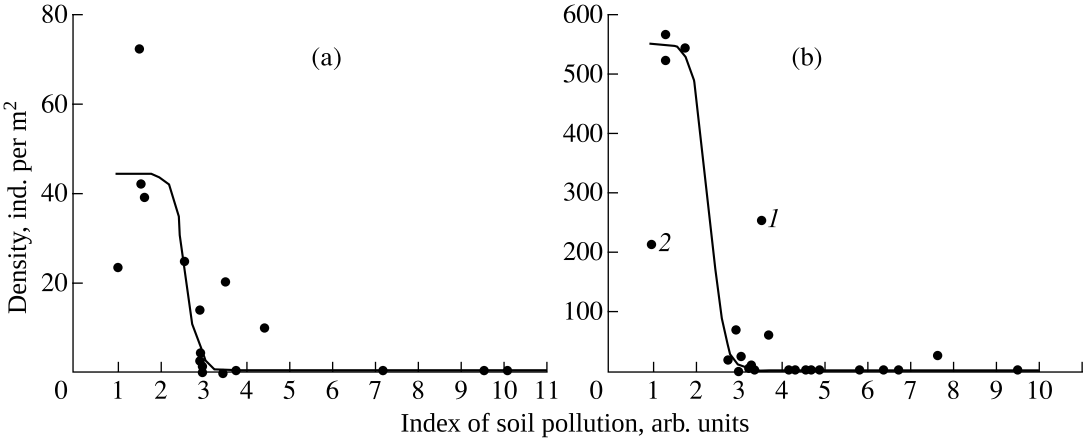

Fig. 1. Dose–effect curves for numbers of earthworms (population density of all species without cocoons) in the area of (a) KICW and (b) MUCW, approximated by the logistic equation. Deviant points are (*1*) high abundance in the highly polluted plot with atypically low acidity, pH 5.6; and (*2*) low abundance in the background plot due to low number of *Ap. rosea*.

in soil aeration and hydrologic properties important for earthworms (Lee, 1985). In the first case, inadequate aeration of mineral horizons due to excessive moistening makes them uninhabitable by lumbricids. In the buffer and impact zones of MUCW, for example, we observed strong gleying and the loss of soil structure (Kaigorodova and Vorobeichik, 1996), which is evidence for the formation of large anaerobic zones. This may be the main cause of earthworm migration to the litter. Although the litter exceeds the upper soil layer in the content of heavy metals (Vorobeichik *et al.*, 1994) and acidity (Vorobeichik, 1995), it is better aerated owing to its structural peculiarities, and this makes it a better substrate for earthworms under the conditions of excessive moistening. The second variant is determined by an opposite process: degradation of vegetation in birch and pine forests growing in well-drained habitats leads to litter drying and a corresponding shift of the maximal density of earthworms to deeper soil layers. The above variants of technogenic change in the vertical distribution of lumbricids have natural analogues. Only litter and soil–litter forms are represented in frequently flooded and swampy habitats of the taiga zone. Endogean species with the maximal density shifted to mineral soil horizons prevail in dry habitats (Perel', 1979).

Resistance to technogenic pressure in earthworm populations may be estimated by the analysis of dose–effect relationships between the level of soil pollution and the number of earthworms. Corresponding plots are strongly nonlinear and *S*-shaped (Fig. 1). Until a certain threshold value is attained, the abundance of earthworms varies but remains at a high level. When the pressure exceeds this level, their number decreases to very low values and, eventually, to zero. Thus, there are two relatively stable states of lumbricid populations in the process of technogenic transformation. The first state corresponds to the background level with a high population density, and the second, to the impact level with very low or zero density. The transition between them is very sharp.

The exact values of critical pressure can be estimated by approximating the dose dependence by the logistic equation and determining coordinates of three critical points by analyzing derivatives of the function (Vorobeichik *et al.*, 1994): the upper point corresponds to the "beginning." and the lower point, to the "end" of population decline (Table 3). In calculations, forests of all types were combined in one sample. Only materials collected in 1991 were used for the area of MUCW, and materials collected in both years, for KICW. Obviously

Table 3. Parameters of dose–effect relationships for populations of earthworms

Area	Group	Abscissa of critical point		r_{xy}	*D*
		upper	lower		
MUCW	*P. diplotetratheca*	1.96	2.60	–0.58**	96.2
	Ap. rosea	2.32	2.55	–0.43*	99.1
	D. octaedra	2.24	2.55	–0.48*	92.6
	All species of worms	2.13	2.56	–0.53**	92.3
	Cocoons	2.25	2.75	–0.56**	81.4
	Worms + cocoons	2.29	2.68	–0.53**	72.6
KICW	*P. diplotetratheca*	2.49	2.78	–0.53*	77.1
	E. nordenskioldi	1.96	3.03	–0.55*	68.2
	All species of worms	2.41	2.81	–0.57**	82.4
	Cocoons	2.78	3.01	–0.61**	69.0
	Worms + cocoons	2.71	2.94	–0.63**	77.0

Abscissas of critical points are expressed in arbitrary units. They indicate how many times the background level of pollution is exceeded; r_{xy} is the coefficient of linear correlation (level of significance is * 0.5% and ** 1%); *D* is the proportion (%) of variance explained by the logistic equation.

deviant points, especially in the background area, were excluded from the analysis, although they were indicated in the plot. Logistic equations adequately describe dose–effect relationships: the proportion of variance explained reaches 100%, which guarantees precision of the results. In the KICW zone, the scattering (along the abscissa) of the upper critical point values for different parameters is higher than in the MUCW zone, probably because of the smaller number of test plots. However, the values of the parameter under discussion are generally similar in both areas. Decline in lumbricid populations begins when pollution exceeds the background level 2.0–2.3 times (in the area of KICW, up to 2.8 times). The impact state corresponds to a 2.6- to 3.0-fold excess of pollution, and the complete elimination of earthworms, to a 4.0- to 4.5-fold excess.

Therefore, the process of technogenic transformation of populations, from the beginning of decline to the elimination of earthworms, occurs within a very narrow interval of pressures comprising only about 20% of the entire pollution gradient. This is evidence for the low tolerance of lumbricids to this type of pollution, moreover because they also exceed other components of the forest ecosystem by the absolute values of abscissas of the upper critical point (Vorobeichik *et al.*, 1994; Vorobeichik and Khantemirova, 1994).

CONCLUSION

Pollution of forest soils with polymetallic dust in a complex with SO_2 has an extremely negative effect on earthworms. Under the influence of toxic pressure, their populations decline sharply and then disappear. This leads to the formation of vast lumbricid deserts near the sources of emissions. The elimination of the most numerous group of soil mesofauna has a negative effect on the functioning of the entire forest ecosystem: the destruction of litter and turnover of biogenic substances are retarded, and the fecundity of the soil decreases.

Apparently, there is no specificity in the response of lumbricid populations to pollution, compared with their reaction to adverse natural factors. There is an analogy between technogenically induced population decline, disappearance of certain morphoecological groups, change in vertical stratification, and the reaction of earthworms to nontechnogenic deterioration of aeration and the hydrologic regime of habitats. Among all these parameters, the total number of earthworms is the most informative. Characteristics of the species, age, and vertical structure are less precise, because the effect of the technogenic component is difficult to identify. The earthworms serve as a “negative indicator”: their very absence indicates an extremely high level of soil pollution. This simplifies the use of this indicator in the zoning of territories. On the other hand, the nonlinear decline of a lumbricid population with an increase of pollution largely restricts the possibility of predicting parameters of their populations on the basis of data on soil pollution and, correspondingly, makes bioindication less precise. Only the transition of an earthworm population to one of three states (high, significantly decreased, or complete or almost complete absence) may be predicted relatively precisely. Within these gradations, the abundance of earthworms varies significantly and largely depends on the combination of natural factors.

Earthworms are widely used in applied studies as test objects for estimating the toxicity of substances and the contents of pollutants in the soil (Krivolutskii, 1994). They are also promising as indicators of radioactive pollution (Krivolutskii *et al*., 1980). Taking into consideration the leading role of earthworms in the primary destruction of litter in forest ecosystems and changes in parameters of their populations with an increase in toxic pressure, I can recommend including lumbricid abundance as one of the main parameters in procedures for estimating the impact of chemical pollution on natural complexes.

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