The earthworms study from closed uranium mining facilities in Buhovo Region, Bulgaria

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Abstract

The Lumbricidae communities were determined for three different regions in the Buhovo Mining Area in Bulgaria. A comparison of the number and species identification of the collected earthworms are performed. No significant difference was found between the size and the shape of earthworm communities in the different regions.

The work is part of an annual and seasonal investigation of the lumbricus earthworms collected from slightly urbanised areas.

Bulgaria is a country with intensive uranium mining activities. As such, radiological monitoring of closed uranium mining facilities in different regions of the country are both necessary and of a great interest.

Keywords: earthworms (Lumbricus), mining, uranium, Bulgaria.

Introduction

Most of the natural and man-made radionuclides in the environment remain mainly in the soil. Human mining activities can cause accumulation of radioactive elements modifying their natural concentrations into the soils of the mining areas. The assessment of activity concentration of the soil radionuclides is of particular importance as the principles of long-term environmental and human protection (Montes et al., 2012). The concentrations of natural radionuclides from mining activities in such areas are higher and the risk of higher human exposure is increased, which makes them the object of special interests and studies.

The organisation of soil horizons function as a diverse community incorporating the complex interconnections between invertebrates and microbial soil ecosystems (Lavelle et al., 2001). Soil animals, such as earthworms live on the soil surface and within the soil layers, also inhabiting the natural pore systems of the soils and utilising microbes and minerals available. Concentration of metals in the soil compose an exchangeable, potentially bio-available associations (Sauvé, 2002). Biotic interactions between soils and invertebrates and other soil organisms provide fundamental functions for the soil environment (Lavelle et al., 2003).

Material and Methods

Sample distribution

The period of investigation is carried out in months May and October of two years 2015 and 2016. The specimens were obtained by digging and hand sorting the 0.4x0.4 m blocks, as well as turning over rocks, debris, and logs. The earthworms were killed in 70% ethanol, fixed in 4% formalin solution, and stored in 90% ethanol. Identification and nomenclature of species were in accordance with Zicsi (1985), Šapkarev (1978), Mršić (1991), Csuzdi and Zicsi (2003), and Blakemore (2004).

Regional distribution

The samples were taken from the abandoned mining area "Buhovo" located in Western Bulgaria, according to the procedure described in ISO 18589-2 for collecting samples of undisturbed soil using a uniform approach. The object of the study is focused on three different parts of the area:

- ✓ The border between the new and the old tailing dams near Buhovo
- ✓ Quarry 82 near Seslavtsi
- ✓ "Iskra" mining site, near Katina
- ✓

Buhovo Mine	42°45'202"	Buhovo Background	42°44'545"
	23°34'466"		23°34'369"
Katina Mine	42°84'990"	Katina Background	42°83'897"
	23°34'179"		23°32'626"
Seslavtsi Mine	42°47'503"	Seslavtsi Background	42°46'294"
	23°31'266"		23°30'205"

The sampling plots were taken under consideration of the previous research of Arhangelova (2010), as places with higher levels of radionuclides into the soil.

Results

Environmental characteristics

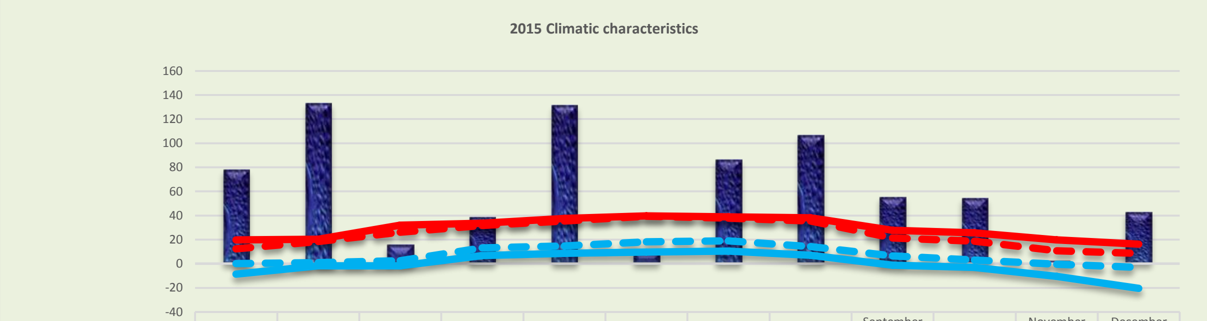
The historical first and one of the most important uranium deposit in Bulgaria is located in the region of the town of Buhovo. The locality is with an old alpine age. The fields are located northwest of the Buhovo town, at the altitude of approximate 700 - 800 m.a.s.l.

With the highest environmental risk in the region Buhovo are Yana and Seslavtsi villages. Above Selslavtsi, on the slopes are located the largest number of mining quarries of the country. They are result of half a century of exploitation of the Buhovo and Seslavtsi uranium hills. In this area, the waste materials have accumulated over approximate 5 millon m³ rock mass. This part of the mountain is dehydrated. Water comes as a precipitation, which appears only as a surface running water. Soils in the area are anthropogenic with sandy loam texture, highly contaminated with radioactive elements and heavy metals (Bojkov, 2000).

For both years of investigation (2015-2016) are reported the climatic characteristics as a sum of precipitation, minimum and maximum air temperature, also minimum and maximum temperature of the soil (presented in table 1a and 1b).

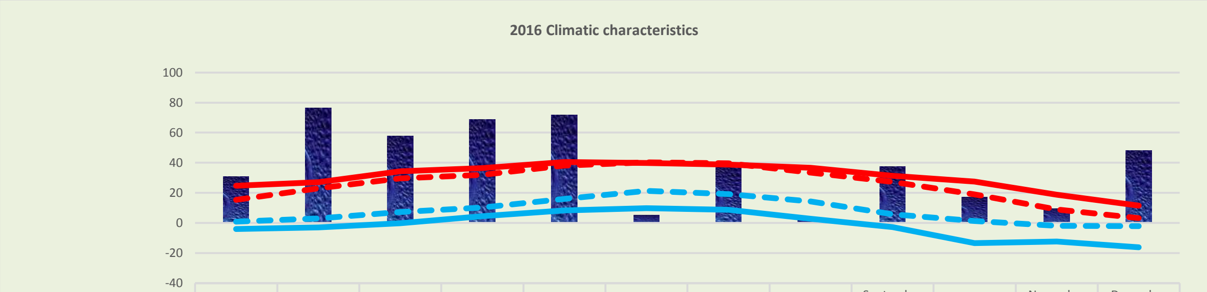
The values of the min and max soil and air temperature are similar for both years of the investigation. There is significant difference in the summary of the precipitation values, 755.6 mm for 2015 and only 463 mm for 2016. At the spring sampling period these numbers are quite different too. For May 2015 – 131.6 mm, and for May 2016 – 71.6 mm only. The tendency follows the autumn sampling also, October 2015 – 54.4 mm and October 2016 – 17.2 mm.

Table 1a: Climatic characteristics of Buhovo area January – December 2015.



	January 2015	February 2015	March 2015	April 2015	May 2015	June 2015	July 2015	Augost 2015	September 2015	October 2015	November 2015	December 2015
SUM [mm]	78.2	133.4	15.8	38.6	131.6	9.6	86.2	106.8	55.4	54.4	2.6	43
Soil t MIN	0	0.8	2.5	13.1	14.7	18.1	18.8	14.2	6.4	3	-0.4	-3.1
Soil t MAX	12.2	18.5	26	31.7	35.4	39.3	37.8	35.3	21.4	18.7	10.6	8.5
Air t MIN	-8.8	-1.7	-1.7	6.8	8.6	9.5	10.4	6.9	-1.2	-3	-10.5	-20.5
Air t MAX	19.6	20.2	32	33.5	37.4	39.5	38.8	38.1	27.8	25.6	19.8	16.2

Table 1b: Climatic characteristics of Buhovo area January – December 2016.



	January 2016	February 2016	March 2016	April 2016	May 2016	June 2016	July 2016	Augost 2016	September 2016	October 2016	November 2016	December 2016
SUM [mm]	30.8	76.4	57.8	68.8	71.6	5.2	37.4	3	37.6	17.2	9.4	48
Soil t MIN	0.8	2.9	7.2	10.3	15.9	21.3	19.2	14.3	5.7	1.4	-1.9	-2.2
Soil t MAX	15.4	23.1	29.7	32	38.1	40.2	39.6	33.5	27.2	18.9	9	3.3
Air t MIN	-4.1	-2.9	-0.1	4.4	8.4	9.9	8.7	2.8	-2.8	-13.5	-12.4	-16.2
Air t MAX	24.8	27.1	34.3	36.5	40.4	39.9	38.8	36.6	31.3	27.6	18.8	11.5

According to some authors invertebrate characteristics depend a lot on environmental factors (Doblas-Miranda et al., 2009; Kicay & Qirjo, 2010). Although the lower values of precipitations, the number of all collected individuals is higher for 2016 for all the sampling plots.

Biotic characteristics

The specimen characteristics and the number of individuals for all established species for objects Buhovo, Seslavtsi and Katina, for both years of investigation are presented below.

For both years of investigation, the number of immature individuals is higher. For 2015 the ratio between the mature and immature individuals is 68 to 79 and for 2016 – 89 to 100. The most frequent species is *A.rosea rosea* for 2015 and 2016 also.

Table 2a: Distribution of Lumbricidae species collected from Bohovo Mine (May-October, 2015-2016).

Genus	Species	2015		2016	
		May	Oct	May	Oct
Aporrectodea	*A.rosea rosea* (Savigny 1826)	6	9	8	12
Eisenia	*Eisenia fetida* (Savigny 1826)	-	4	3	6
Octolasion	*Octolasion lacteum* (Orley 1881)	4	4	6	6
Immature individuals		13	20	22	24

Table 2b: Distribution of Lumbricidae species collected from Bohovo Background (May-October, 2015-2016).

Genus	Species	2015		2016	
		May	Oct	May	Oct
Aporrectodea	*A.rosea rosea* (Savigny 1826)	9	9	10	15
Eisenia	*Eisenia fetida* (Savigny 1826)	-	3	-	8
Octolasion	*Octolasion lacteum* (Orley 1881)	5	10	7	13
Immature individuals		15	25	20	40

Again, for both years of investigation, the number of immature individuals is higher. For 2015 the ratio is 122 to 129 and for 2016 – 136 to 148. At Object Seslavtsi there is significant increasing of the number of collected earthworms. The most frequent species is again *A.rosea rosea* for 2015 and 2016 also.

Table 3a: Distribution of Lumbricidae species collected from Seslavtsi Mine (May-October, 2015-2016).

Genus	Species	2015		2016	
		May	Oct	May	Oct
Aporrectodea	*A.rosea rosea (Savigny 1826)*	6	11	10	11
	A.smaragdina (Rosa 1892)	1	-	-	3
Eisenia	*Eisenia fetida* (Savigny 1826)	5	7	7	10
Octolasion	*Octolasion lacteum* (Orley 1881)	4	6	5	7
Lumbricus	*Lumbricis meliboues (Rosa 1884)*	1	1	-	2
	Lumbricis rubellus (Hoffmeister 1843)	1	3	2	4
	Lumbricis terestris (Linnaeus 1758)	2	5	5	3
Immature individuals		22	33	30	44

Table 3a: Distribution of Lumbricidae species collected from Seslavtsi Mine (May-October, 2015-2016).

Genus	Species	2015		2016	
		May	Oct	May	Oct
Aporrectodea	*A.rosea rosea (Savigny 1826)*	10	12	10	11
Eisenia	*Eisenia fetida* (Savigny 1826)	6	9	11	12
Octolasion	*Octolasion lacteum* (Orley 1881)	5	6	7	9
Lumbricis	*Lumbricis rubellus (Hoffmeister 1843)*	3	1	2	3
	Lumbricis terestris (Linnaeus 1758)	3	6	5	5
Immature individuals		30	37	39	42

Table 4a: Distribution of Lumbricidae species collected from Katina Mine (May-October, 2015-2016).

Genus	Species	2015		2016	
		May	Oct	May	Oct
Aporrectodea	*A.rosea rosea* (Savigny 1826)	8	12	12	16
Eisenia	*Eisenia fetida* (Savigny 1826)	2	3	5	7
Octolasion	*Octolasion lacteum* (Orley 1881)	4	7	3	12
Lumbricus	*Lumbricis terestris* (Linnaeus 1758)	2	5	5	11
Immature individuals		21	33	25	39

Table 4b: Distribution of Lumbricidae species collected from Katina Background (May-October, 2015-2016).

Genus	Species	2015		2016	
		May	Oct	May	Oct
Aporrectodea	*A.rosea rosea* (Savigny 1826)	11	10	14	18
Eisenia	*Eisenia fetida* (Savigny 1826)	5	7	9	10
Octolasion	*Octolasion lacteum* (Orley 1881)	4	7	5	11
Lumbricus	*Lumbricis terestris* (Linnaeus 1758)	3	6	7	10
Immature individuals		25	34	38	50

At Katina mining site also, for both years of investigation, the number of immature individuals is higher. For 2015 the ratio is 114 to 118 and for 2016 – 137 to 147. At Object Katina the number of collected earthworms is almost equal to those of object Seslavtsi and higher than object Buhovo. The most frequent species is again *A.rosea rosea* for 2015 and 2016 also.

We did not find a difference between the size and the shape of the collegeted earthworm species in the different regions. The diversity of lumbricidae was unevenly distributed across the plots surveyed. It was established low earthworms' diversity in all mine sampling plots, probably, due first to the soil texture (sandy loam) and low soil huminity (dehydrated soils), which confirmed the findings of Kasprzak (1986), and second to the level of pollution. The most frequent species for all the investigated period and for all the sample plots is *A.rosea rosea,* which is much adaptive and live among grass roots and in the top soil between 2 and 10 cm. The species is commonly found and very common in Bulgaria (Rosa, 1987; Černosvitov, 1937; Plisko 1963; Mihailova, 1964 & 1966; Šapkarev, 1986; Uzunov, 2010; Stojanović et al. 2012; Valchovski, 2014; Valchovski & Szederjesi, 2016).

References

Arhangelova, N. (2010) Natural Radionuclides abundance in the region of Buhovo Uranium Mines, *International Scientific Unitech Conference III*, pp. 397-401.

Blakemore, RJ. (2004) A provisional list of valid names of Lumbricoidea (Oligochaeta) after Easton, 1983. *In*: Moreno AG, Borges S, editors. *Avances en taxonomia de lombrices de tierra* [Advances in earthworm taxonomy] (Annelida: Oligochaeta). Editorial Complutense, Madrid, Spain: Universidad Complutense, 75–120 pp.

Bojkov, I. (2000) The Alto-Himalayan uranian province and the place of the Bulgarian uranium deposits in it. *Mining and geology*, 6-7, pp. 56-59.

Černosvitov, L. (1937) Die Oligochaetenfauna Bulgariens. *Mitteilungen aus den Königlich Naturwissenschaftlichen Instituten in Sofia*, 10 pp. 62–92.

Csuzdi, Cs. & Zicsi, A. (2003). *Earthworms of Hungary*. Pedozoologica Hungarica No 1. Budapest, Hungary: Hungary Natural History Museum.

Kasprzak, K. (1986) *Soil Oligochaeta III*. *Family Lumbricidae. Keys for the Identification of Polis Invertebrates*. PWN, Warszawa (in Polish).

Lavelle, P. & Spain, A.V. (2003) *Soil Science* Vol. 168, No. 3 Printed in U.S.A.

Lavelle, P. & Spain, A.V. (2001) *Soil Ecology*, Kluwer Academic Publishers.

Mihailova, P. (1964) Some species (Lumbricidae) new to the fauna of Bulgaria. *Annuaire de Université de Sofia*, 57 pp. 163–169

Mihailova, P. (1966) Lumbricidae (Oligohaeta) Earthworms in Thrace. *Fauna na Thrace, Bulgarian Academy of Science, Sofia*, 3 pp. 181–200.

Montes, M.L., Mercader, R.C., Taylor, A., Runco, J., Desimoni, J (2012) Assessment of natural radioactivity levels and their relationship with soil characteristics in undisturbed soils of northeast of Buenos Aires province, Argentina; *J Environ Radioactiv*, 105 pp. 30-39.

Mršić, N. (1991) *Monograph on Earthworms (Lumbricidae) of the Balkans I–II*. Ljubljana, Yugoslavia: Slovenska Akademija.

Plisko, G. (1963) Materialien zur Kenntnis der Regenwürmer (Oligochaeta, Lumbricidae) Bulgariens. *Fragmenta Faunisica,* Warsawa, 10 pp. 425–440.

Rosa, D., (1897) Nuovi lombrichi dell'Europa orientale (Seconda serie). *Bolletino dei Musei di Zoologia ed Anatomia Comparata della Reale Universita di Torino*, 12 (269) pp. 1–5.

Šapkarev, J. (1986) Earthworm fauna of Bulgaria (Oligochaeta: Lumbricidae). *Fragmenta Balcanica*, 13 pp. 77-94.

Sauve, S., Hendawi, M., Brousseau, P., Fournier, M. (2002) Phagocytic response of terrestrial and aquatic invertebrates following in vitro exposure to trace elements. *Ecotoxicology Environmental Safety*. 52 pp. 21-29.

Stojanović, M., Tsekova, R., Milutinović, T. (2012) Earthworms (Oligochaeta: Lumbricidae) of Bulgaria: Diversity and Biogeographical Review. *Acta Zoologica Bulgarica*, Suppl. 4 pp. 7-15.

Uzunov, Y. (2010) Aquatic Oligochets (Oligochaeta Limicola). *In*: Deltchev, C., Hubenov, Z. & Dobrev, D. (Eds.), *Catalogus Faunae Bulgaricae*. Professor Marin Drinov Academic Publising House, Sofia, №7, pp.118.

Valchovski, H. (2014) Diversity of earthworms (Oligochaeta: Lumbricidae) in Sofia Plain, Bulgaria. *Zoonotes*, 59 pp. 1-9.

Valchovski, H. & Szederjesi, T. (2016) New and additional records of earthworms (Oligochaeta: Lumbricidae) from Bulgaria: first finding place of endemic species *Cernosvitovia munteniana* on the Balkan Peninsula. *North-Western Journal of Zoology* (in press).

Zicsi, A. (1985) Uber die Gattungen *Helodrilus* Hoffmeister, 1845 und *Proctodrilus* gen. n. (Oligochaeta: Lumbricidae). *Acta Zoologica* Acad Sci H 31 pp. 275–289.