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Biotesting of Soil Contamination of Agricultural Land Prokhorovsky District of the Belgorod Region †

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Abstract: Belgorod Region is one of the main agro-industrial regions of Russia. The volume of production in the livestock sector in 2022 amounted to 203 billion rubles. Most often, livestock farms are located near agricultural land with plant crops, which increases the risk of contamination of the latter with various toxicants. The purpose of this work was to study and assess the contamination with heavy metal ions and toxic chemicals of the soils of agricultural lands and nearby reservoirs in the Prokhorovsky district of the Belgorod region. Watercress (*Lepidium sativum*) and crustaceans (*Daphnia magna Straus*) are bioindicators.

Keywords: bioindication; agricultural land; *Lepidium sativum*; *Daphnia magna Straus*; water reservoir; rural household

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1. Introduction

Contamination of agricultural soils with heavy metals, antibiotics, waste from livestock complexes, and toxins leads to the accumulation of these substances in crops and further transmission along the food chain [1].

The purpose of this work was to study and assess the contamination with heavy metal ions and toxic chemicals of the soils of agricultural lands and nearby reservoirs in the Prokhorovsky district of the Belgorod region. As bioindicators, watercress (*Lepidium sativum*) and crustaceans (*Daphnia magna Straus*).

2. Materials and Methods

The study analyzed the condition of reservoirs and adjacent agricultural fields: the Seversky Donets River, the Koren River, and the pond in the Prokhorovsky district of the district [2]. The points for taking soil samples at 1 object are located in the conditions of agrocenosis on a laid-out area of the field, at a distance of 700 m to the west of the Seversky Donets riverbed. The sampling sites for object 2 are located 100 m east of the reservoir under study and 30 m southwest of the liquid manure sedimentation tanks.

The sampling points are located in the conditions of agrocenosis on the laid-out area of the field. Experimental The experimental sections of object No. 3 of the study are located 200 m east of the riverbed of the Koren, in conditions of agrocenosis. The relief is ravine-girder, the northern slope of the beam (Figure 1).

When studying the soil of the territory, the method of biotesting was used, resulting in the germination and morphometric parameters of the aboveground and underground parts of the test object being determined as watercress [3,4]. The phytotoxicity of soils was determined by the degree of germination of *Lepidium sativum*; the following gradation was

used: 100% plant growth—the sample is non-toxic, 80–90%—very low toxicity, 60–80%—weak, 40–60%—medium, 20–40%—high toxicity, 0–20%—very high, close to death [5].

The toxicity index was assessed by measuring the effect of inhibition on the length of the seedling according to the following criteria: less than 20%—phytotoxicity is not manifested (norm); 20–40%—weak phytotoxicity; 40–60%—average; more than 60%—strong phytotoxicity [6]. The toxicity index was calculated by the formula:

$$I_f = \frac{S_c - S_e}{S_c} \times 100\%, \quad (1)$$

S_c—the length of the sprout on the control (1)

S_e—the length of the sprout at the experimental site (1)

For biotesting, Daphnia was used at an age of up to 24 h and was seated in a container with a volume of 100 mL. 10 eks of crustaceans were placed in each repetition. The duration of the experiment was 96 h. In the control and experimental tanks, tap water was used, which had been previously settled for 3 days. Before biotesting, the suitability of the culture of Daphnia was determined by establishing the average lethal concentration of a solution of the reference substance potassium bicarbonate ($K_2Cr_2O_7$) for 24 h of biotesting [7,8]. The methodology for assessing toxicity is based on establishing the difference between the number of dead individuals of the test object in the pond water, which is analyzed (experience) in comparison with water that does not contain toxic substances (control). The criterion of acute lethal toxicity is the death of 50 or more percent of the test subjects in the experiment compared to the control after 96 h. For each sample, three parallel experiments were carried out on the survival of the *D. magna* species [9,10].

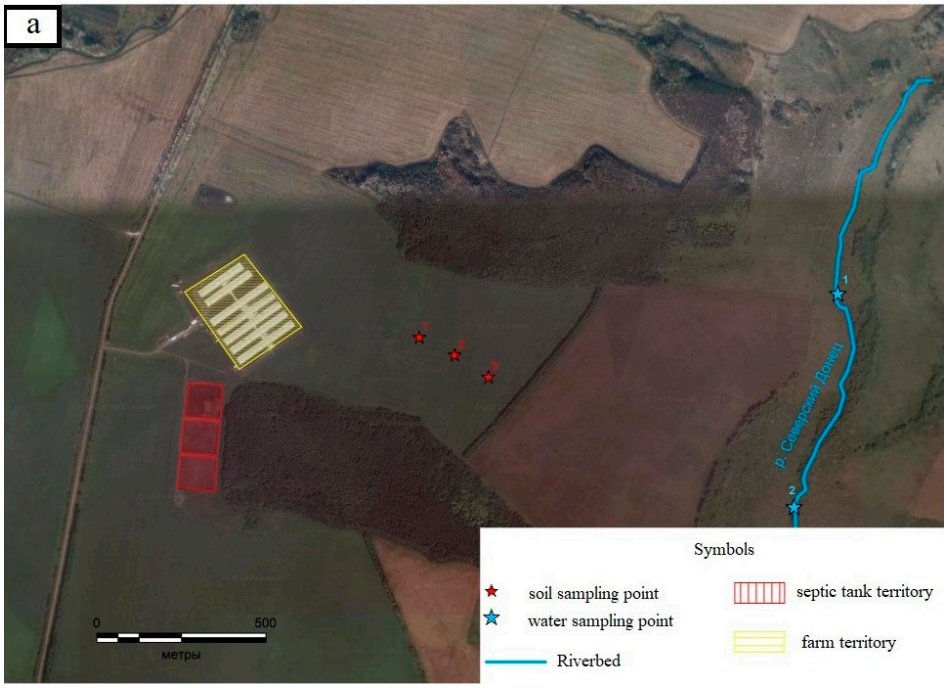

Figure 1. *Cont.*

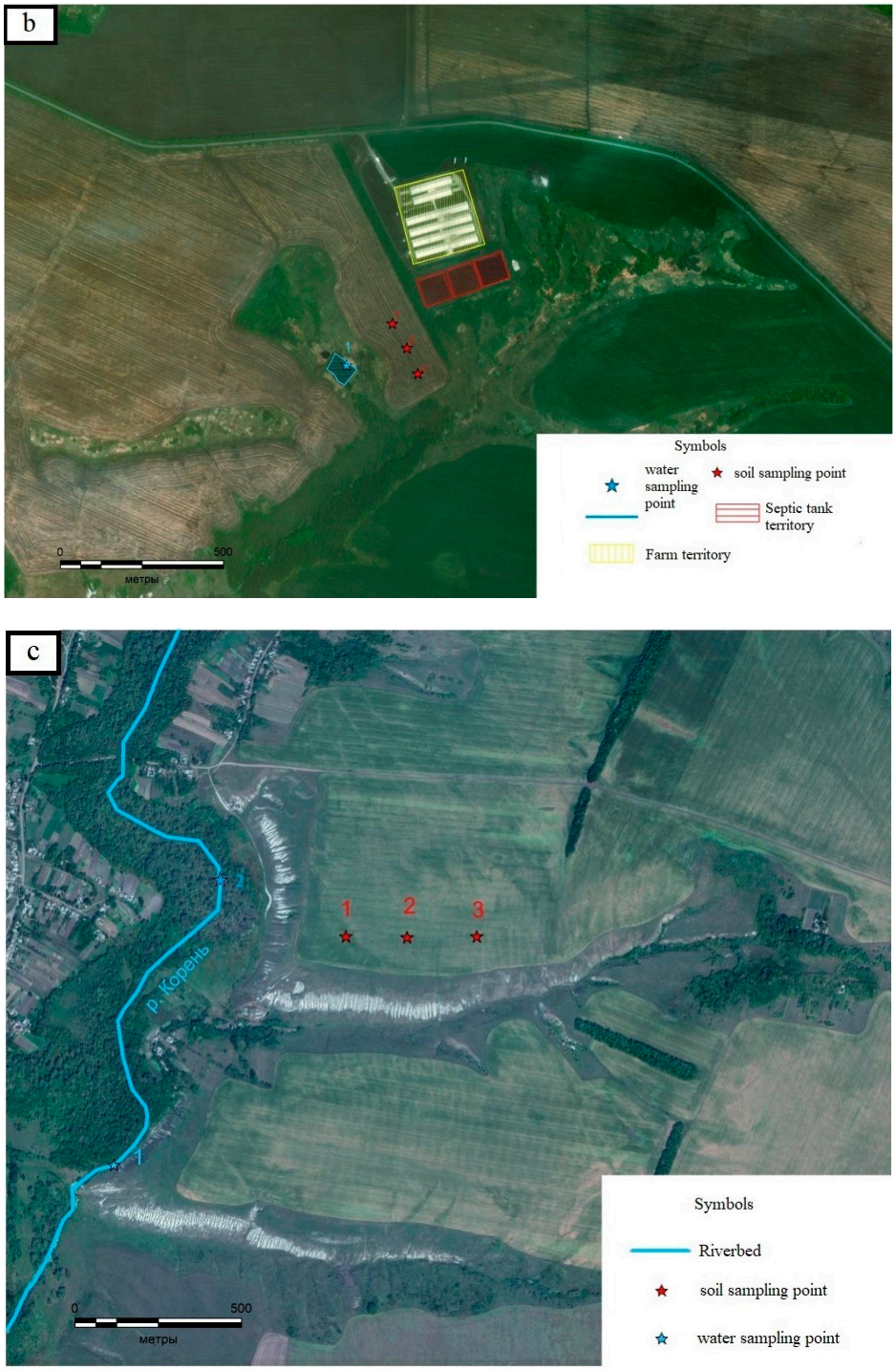

Figure 1. Satellite images of sampling sites. (**a**) The Seversky Donets River. (**b**) Pond in the Prokhorovsky district, Podolkhi village. (**c**) The Koren River.

3. Results

The results of soil biotesting in the studied zones demonstrate a weak and very weak degree of toxicity (Table 1). The plants showed good germination; the first shoots of watercress appeared on the second day. Morphological parameters showed that plants grown on soil taken from three different agricultural fields located near reservoirs did not visually differ from the control ones. The phytotoxicity in the samples varies from 80% to 92%, which is very low toxicity.

Table 1. Soil biotesting results.

Indicator	Test Object—*Lepidium sativum*			
	Object No. 1	**Object No. 2**	**Object No. 3**	**Control Object**
Root length, cm	5.5 ± 0.33	4.6 ± 0.3	5.7 ± 0.26	6.2 ± 0.3
The length of the aboveground part, cm	17 ± 0.3	15.5 ± 0.22	17.7 ± 0.41	19.3 ± 0.38
Weight of the aboveground part, mg	1317 ± 40.2	989 ± 56.4	1437 ± 40.6	1555 ± 35.7
Root weight, mg	788 ± 45.3	546 ± 33.5	809 ± 29.8	821.5 ± 16.7
Phytotoxicity, %	86%	82%	93%	100%
Toxicity index, %	11.9%	19.7%	8.3%	0%

Five water samples were taken from three experimental reservoirs near agricultural lands. The water from the 1st and 3rd objects of the study (samples 1–4) corresponded to the category of good quality; the D. magna mortality index did not exceed 20%. In the sample from the second object of the study (sample 5), the mortality index of Daphnia did not exceed 30%; that is, no acute toxicity was registered in these samples (Table 2).

Table 2. Results of testing water bodies.

	Test Object—*D. magna* Species	**Time from the Start of Biotesting**				
		1 h	**24 h**	**48 h**	**62 h**	**96 h**
Mortality of Daphnia in the experiment, %	Object No. 1 (samples 1,2)	0%	0%	0%	20%	0%
	Object No. 2 (sample 5)	0%	10%	15%	0%	0%
	Object No. 3 (samples 3,4)	0%	0%	20%	0%	0%
	Control object	0%	0%	0%	0%	0%

4. Conclusions

Soil testing of 3 agricultural lands showed that, on average, the length of the roots of Lepidium sativum was 5.27 cm (a deviation from the control of 15%), the length of the aboveground part was 16.75 cm (a deviation of 13.3%), root weight was 1248 mg (a deviation of 20%), phytotoxicity—86.2% (very low toxicity). The toxicity index did not exceed 20% in all samples. This indicates that phytotoxicity is not manifested (the norm).

According to the results of biotesting, the water in reservoirs adjacent to agricultural land corresponds to Class II, category "slightly polluted". It was revealed that the soils of the agricultural lands of the agroholding have initial manifestations of toxic effects. It is necessary to regularly monitor the condition of the soil and, in case of deterioration, take measures to neutralize toxicants.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Zhilyakova, E.E.; Anichin, V.L.; Zueva, E.N. Development of the agro-industrial complex of the Belgorod region in modern conditions. *Bull. ASAU* **2022**, *1*, 109–113.
2. Komarova, N.A. Agroecological aspects of the formation of vegetable crop yields and the quality of their products on soils contaminated with heavy metals. *Fertility* **2013**, *4*, 47–50.
3. Orlov, P.M.; Gladysheva, O.V.; Lunev, M.I.; Akanova, N.I. Dependence of the content of technogenic and natural radionuclides in the soils of the Central Federal District on the intensity of the use of mineral fertilizers and chemical meliorants. *Minist. Agric.* **2018**, *1*, 37–42.
4. Vasil'eva, E.; Melnik, I. Assessing state of water protection zones of Volga River within Ilyinka village area (Astrakhan region). *Vestn. Astrakhan State Tech. Univ. Ser. Fish. Ind.* **2021**, *1*, 91–97. [CrossRef]
5. Fedorova, A.I.; Nikolskaya, A.N. *Workshop on Ecology and Environmental Protection*; VLADOS Humanities Center: Moscow, Russia, 2001; 288p.
6. Fomina, N.V. The comparative analysis of action of oil pollution remediants on the level of phytotoxicity. *Probl. Mod. Agric. Sci.* **2018**, *1*, 1–5.
7. Yakovenko, V.A.; Fedorenko, E.V. Introduction of biotesting to study the water quality of fish ponds of the Krinichansky fishery. *Proc. VNIRO* **2017**, *167*, 179–184.
8. Braginsky, L.P. Methodological aspects of toxicological biotesting on Daphnia magna Str. and other branchous crustaceans. *Hydrobiol. J.* **2018**, *11*, 50–57.
9. Barkhatova, O.A.; Saxonov, M.N.; Balayan, A.E.; Taran, D.O. The evaluation of water quality of some rivers of Irkutsk with help methods of biological control. *Bull. Irkutsk State Univ. Ser. Earth Sci.* **2013**, *2*, 65–75.
10. Kokorin, A.M.; Razuvaeva, A.M.; Klimova, A.K. The use of plant test objects to assess the toxicity of the aquatic environment in freshwater reservoirs. *Herit. Sci.* **2020**, *57*, 3–7.