engineering proceedings

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Proceeding Paper

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

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† Presented at the 2nd International Electronic Conference on Processes: Process Engineering—Current State and Future Trends (ECP 2023), 17–31 May 2023; Available online: https://ecp2023.sciforum.net/.

Abstract: Belgorod Region is one of the main agro-industrial regions of Russia. The volume of production of the livestock sector in 2022 amounted to 203 billion rubles [1]. Most often, livestock farms are located near agricultural land with plant crops, which increases the risk of contamination of the latter with various toxicants [2]. The purpose of this work was to study and assess contamination with heavy metal ions and toxic chemicals of soils of agricultural lands and nearby reservoirs of the Prokhorovsky district of the Belgorod region. As a bioindicator, watercress *Lepidium sativum* and crustaceans *Daphnia magna Straus*.

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

Citation: Kuzubova, E.; Grigorenko, N.; Shaidorova, G.; Ogneva, Z.; Potapova, M. Biotesting of Soil Contamination of Agricultural Land Prokhorovsky District of the Belgorod Region. *Eng. Proc.* **2023**, *35*, x. https://doi.org/10.3390/xxxxx
Published: 17 May 2023

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 [3].

The purpose of this work was to study and assess contamination with heavy metal ions and toxic chemicals of soils of agricultural lands and nearby reservoirs of the Prokhorovsky district of the Belgorod region. As a bioindicator, 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. The points of 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 of 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 the object No. 3 of the study are located 200 m east of the riverbed of the Koren, in the 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, as a result of which the germination and morphometric parameters of the aboveground and underground parts of the test object were determined—watercress [4]. 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].

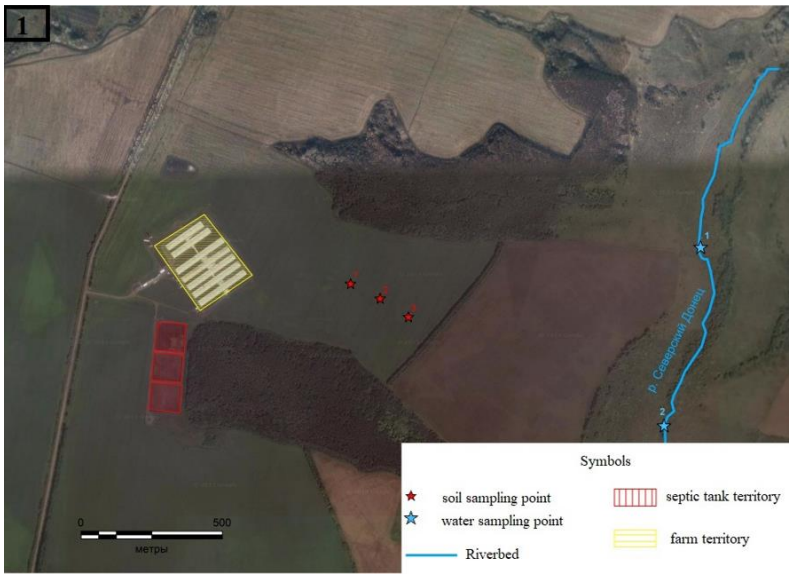
The toxicity index was assessed by the effect of inhibition of the length of the seedling was carried out according to the following criteria: less than 20%—phytotoxicity is not manifested (norm); 20–40%—weak phytotoxicity; 40–60%—average; more than 60%—strong phytotoxicity [6]. The toxicity index was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

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

Sc—the length of the sprout on the control

Se—the length of the sprout at the experimental site

For biotesting daphnia was used at the age of up to 24 h, which were 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 was previously settled for 3 days. Before biotesting determined the suitability of the culture of daphnia 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].



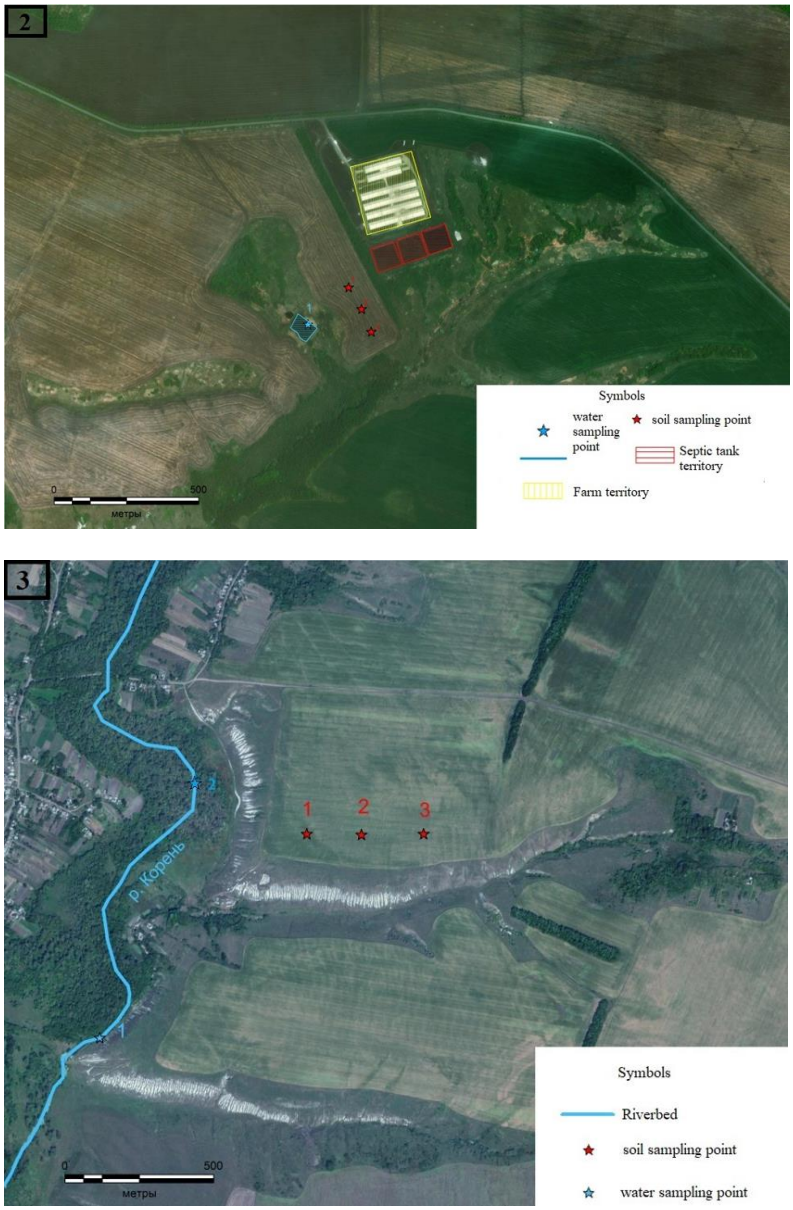


Figure 1. Satellite images of sampling sites.

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 3 different agricultural fields located near reservoirs did not visually differ from the control ones. Phytotoxicity in the samples varies from 80% to 92% 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%

* Std. Deviation.

5 water samples were taken from 3 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 2nd 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 of water bodies.

	Test object—	**Time from the Start of Biotesting**				
	D. magna species	**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 (deviation from the control of 15%), the length of the aboveground part was 16,75 cm (deviation—13.3%), root weight was 1248 mg (deviation—20%), phytotoxicity—86,2% (very low toxicity). The toxicity index did not exceed 20% in all samples. This indicates that phytotoxicity is not manifested (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 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.

Author Contributions: Conceptualization, G.S.; methodology and visualization, E.K.; formal analysis, Z.O.; investigation, M.P.; writing—review and editing, N.G. All authors have read and agreed to the published version of the manuscript.

Funding: FZWG-2023-0007 Adaptive reactions of microorganisms: theoretical and applied aspects

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: https://drive.google.com/drive/folders/1s9cVmxxz02T636-L0bRYPjnTLPfsRCd7?usp=sharing.

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

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