Heavy metal level in the ecosystem components of small rivers in the Amur-Zeya Plain agricultural landscape

Heavy metal level in the ecosystem components of small rivers in the Amur-Zeya Plain agricultural landscape

A P Pakusina, T P Platonova and S A Lobarev

Far Eastern State Agrarian University, 86, Politekhnicheskaya St., Blagoveshchensk, Russia

E-mail: pakusina.a@yandex.ru

Abstract. The article considers the results of the heavy metals determination in the components of ecosystems of small rivers (water, sediments, macrophytes) of the Amur-Zeya Plain agricultural landscape. In the waters of small rivers, a high level of iron, zinc and copper is due to the natural factor. The lead and cadmium level in the waters of small rivers did not exceed the maximum permissible concentration (MPC). The level of heavy metals in bottom silt of small rivers corresponded to background values. Excessive concentrations of cadmium, manganese, and lead are characteristic of aquatic moss and rooting hydrophytes. The results of studying the level of heavy metals in the components of aquatic ecosystems of the Amur-Zeya Plain are the basis for further study of the technogenic load on small rivers of the agricultural landscape.

1. Introduction

The Amur region has historically been the agricultural “breadbasket” of the Far East. The development of agriculture has led to the transformation of natural territories into agricultural landscapes. Soybeans and cereals are grown mainly in the agricultural fields. The use of fertilizers, herbicides and other means of chemicalization has an adverse effect on the condition of soils and small rivers. According to the FSBI, Station of the Agrochemical Service "Amur" in the arable soil of the southern zone of the Amur region annually about 12 thousand tons of mineral fertilizers are applied [1]. Mineral fertilizers are sources of heavy metal compounds [2]. It is well known that mineral fertilizers change the pH of the soil solution, increase the mobility of iron, manganese, zinc, copper [3] compounds, and contribute to an increase in heavy metals in the soil, in particular lead and cadmium [4]. Heavy metals from soils in the period of floods fall into the water of small rivers. Heavy metals are dangerous pollutants of the environment; they have a toxic effect on living organisms [5].

The purpose of this work is to study the migration of heavy metals in the ecosystem components of small rivers in the Amur-Zeya plain agricultural landscape.

2. Objects and research methods

The objects of study are the small rivers, the Simonovka, Gryaznushka (Tunsara), left tributaries of the Amur River. The Simonovka River flows into the river Amur 1970 km from the river mouth, the length of the watercourse is 20 km, the catchment area is 220 km^2 [6], the Tunsara river is 1996 km from the mouth, the length of the water collecting area is 23 km, the water collecting area is 115 km2 [7]. On the Tunsaraa river reservoir for irrigation was built in the 80s of the last century. The basins of the

Simonovka and Tunsara rivers are located in the south of the Amur-Zeya Plain where agriculture is highly developed.

The sampling of water, sediment and macro phytes was carried out from 2013 to 2018. The mass concentration of heavy metals was determined by the atomic absorption method on a Kvant-Z.ETA spectrometer (RD 52.24.377-2008).

3. Research results and discussion

The acid-base properties (pH) of the waters of small the Simonovka and Tunsara rivers changed from neutral to slightly alkaline (6.90-8.20). In rivers, seasonal fluctuations in the pH of the water were observed. The specific electrical conductance (SEC) of water was 30.1–103.2 μS / cm; it indicates a low salinity of water in rivers. The lowest MPC values of water were observed in the spring, the highest in the fall (table 1). Low mineralization of water and acidic conditions increase mobility heavy metals [8].

Table 1. pH and specific electrical conductance of waters of small rivers on the territory of the Amur-Zeya Plain.

River	pH	S

Note: The table shows the minimum values, maximum values and in brackets the average value of the indicators.

During the 2013 historical flood, 1.3-1.5 MPCof copper was found in the waters of small rivers, maximum permissible concentration in water (MPCW= 6 μg / dm3), for example, in the Simonovkait was 9 μg / $dm^{3.}$ in the Tunsarit was 24 μg / dm^3. During the flood period, heavy metals in the water of small rivers came from the surface layers of the soil, which are occupied by arable land.

From 2014 to 2017. in the waters of small rivers, the concentration of cadmium and lead did not exceed the MPC. The high level of zinc, manganese and iron in natural waters is explained by regional peculiarities. The concentrations of heavy metals in the waters of small rivers are arranged in a row in descending order: Fe>Mn>Zn>Cu>Pb>Cd (table 2).

Table 2. The level of heavy metals in the water of small rivers, μg / dm^3.

River	Mn	$Fe_{общ}$
Simonovka		
Tunsara		
MPC_{f-r}		
M		

Note: MPC_{f-r} is the maximum permissible concentration of fisheries, $MPC_{h.-d.c.-p}$ is the maximum allowable concentration of household and drinking and cultural purposes.

The maximum concentrations of heavy metals in the waters of the small rivers of the Amur-Zeya Plain were observed in autumn samples (table 2).

Pollutants are collected in the bottom sediments. Therefore, the accumulation of heavy metals there is studied by researchers from various countries [9–11]. The level of heavy metals in the bottom sediments of small rivers of the Amur-Zeya plain decreases in the series: Fe>Mn>Zn>Pb>Cu>Ni>Cd (table 3). The level of cadmium, lead, copper and zinc in the bottom sediments of small rivers does not exceed background values. The background is the level of heavy metals in uncontaminated bottom sediments of lakes in Muravyovsky Park [12].

IOP Conf. Series: Earth and Environmental Science **315** (2019) 042023 doi:10.1088/1755-1315/315/4/042023

Table 3. The level of heavy metals in bottom sediments of small rivers, mg / kg.

River		Mn	Fe	Ni
Simonovka	0			
Tunsara	0			
	0.1 – 0.3			

The investigation of the heavy metals accumulation in higher aquatic vegetation is an urgent task, since macrophytes are used to indicate the ecological state of water objects [13–16].

The concentrations of heavy metals in the moss *Fontinalis* and hydrophytes are arranged in a row in descending order: Fe>Mn>Zn>Cu>Pb>Ni>Cd. copper (17–27 mg / kg), zinc (25–62 mg / kg), nickel (3.6–6.8 mg / kg) is at a normal level in hydrophytes. Water mosses and rooting hydrophytes are characterized by excessive concentrations of cadmium (> 2 mg/kg), manganese (> 300 mg/kg), lead (> 10 mg/kg).

Table 4. The average level of heavy metals in aquatic plants of small rivers of the Amur-Zeya Plain, mg / kg.

Ecogroup 1. Water mosses	
	Simonovka
	Tunsara
Ecogroup 2. Hydrophytes freely floating in the water thickness	
s p i	Tunsara
	Simonovka
	Tunsara
Ecogroup 4. Rooted hydrophytes with leaves floating on water	
Tacla natans Pall. ex Georgi	Simonovka
N i m	Tunsara
Ecogroup 5. Hydrophytes, freely floating on the surface of the water	
	Tunsara

Hydrophytes rooting accumulate from sediments of copper, nickel, cadmium, lead and manganese, since the coefficient of biological absorption (CBA) is more than 1 (table 4).

Table 5. CBA of heavy metals by aquatic plants of small rivers (plant / region).

	River name
Ecogroup 1. Water mosses	
	Simonovka
	Tunsara
	Simonovka
	Tunsara
Ecogroup 4. Rooted hydrophytes with leaves floating on water	
T	Simonovka
N	Tunsara

4. Conclusion

Heavy metals in small rivers fell from the surface layers of the soil of agricultural arable land during the period of floods. The study revealed that in the waters of the small rivers of the Amur-Zeya Plain there were high concentrations of iron, zinc and copper caused by natural factors. The level of heavy metals in bottom sediments of small rivers did not exceed background values.

The hydrophytes contained normal copper, zinc, and nickel. The excessive concentrations of cadmium, manganese, and lead are typical for water mosses and rooting hydrophytes.

The results of heavy metals level in the components of small rivers are the basis for further study of the anthropogenic load on small rivers of the Amur-Zeya of the Plain agricultural landscape.

References

[1] Dudukalov K A 2017 The fertility status of arable soils in the southern zone of the Amur region *Zemledelie* pp 130–2

[2] Orabi Orabi El-Badry A A El-Monsef Abd and AlhejojIkhlas 2018 Response of Mollusk Assemblages to Environmental Conditions: A Case Study from the Burullus Lagoon, Egypt *J of the Geological Society of India* **91(5)** 583–8

[3] Zhukova L M and Blagoveshchenskaya Z K 1981 Changing the agrochemical properties of soils with long-term use of fertilizers *Selyskoe khozyaystvo za rubezhom* **9** 8-15

[4] Slabko Yu A Lopatina AA 2016 Cadmium accumulation in the soil and soybean plants under the influence of mineral fertilizers *Bulletin of KrasGAU* **2 (113)** 14-21

[5] Kabata-Pendias A and Pendias H 2001 *Trace elements in soils and plants Boca Raton* (London; New-York; Washington: CRC Press)

[6] State water register: Simonovka river Available from: http://www.textual.ru/gvr/index.php?card=289125 available at 24.05.2018

[7] State Water Registry: River Gryaznushka Avaialable from: http://textual.ru/gvr/index.php?card=289127 available at 24.05.2018

[8] Davydova O A, Korovina E V, Vaganova E S, Guseva I T, *et al* 2016 Physical – Chemistry Aspects of Migratory Processes of Heavy Metals in Natural Aqueous Systems *Bulletin in the South Ural State University Ser Chemistry* **8(2)** 40-50

[9] Polyakov D M and Utkin I V 2018 Accumulation of Subcolloidal Fraction Elements of Bottom Sediments in Amur Bay (Sea of Japan) *Oceanology* **58(6)** 900–8

[10] Wang Z, Yao L, Liu G and Liu W 2014 Heavy metals in water, sediments and submerged macrophytes in pondsaround the Dianchi Lake *China Ecotoxicology and Environmental Safety* **107** 200–6

[11] Gapeeva M V, Zakonnov V V, Lozhkina R A, Pavlov D F and Borisov M Ya 2018 Heavy metals pollution assesment of underpopulated regions using the example of the north-western region of Russia *Human Ecology (Russian Federation)* **3** 4-9
[12] Pakusina A P, Platonova T P, Lobarev S A and Smirenski S M 2018 Chemical and Ecological Characteristics of Lakes Located in the Muraviovka Park *Asian Journal of Water Environment and Pollution* **15(4)** 27-34
[13] Hadad H R, Mufarrege M M, Di Luca G A and Maine M A 2018 Long-term study of Cr, Ni, Zn, and P distribution in Typha domingensisgrowing in a constructed wet land *Environmental Science and Pollution Research* **25(18)** 18130–7
[14] Amare E, Kebede F, Berihu T and Mulat W 2018 Field-based investigation on phytoremediation potentials of Lemna minor and Azolla filiculoides in tropical semiarid regions: Case of Ethiopia *Int Journal of Phytoremediation* **20(10)** 965–72
[15] Minkina T M, Fedorov Y A, Nevidomskaya D G, Polshina T N, Mandzhieva S S and Chaplygin V A 2017 Heavy metals in soils and plants of the Don river estuary and the Taganrog Bay coast *Eurasian Soil Science* **50(9)** 1033–47
[16] Borisova G, Chukina N, Maleva M, Kumar A and Prasad M 2016 Thiols as biomarkers of heavy metal tolerance in the aquatic macrophytes of Middle Urals, Russia *Int Journal of Phytoremediation* **18(10)** 1037–45