

Change of trace elements content in sewage water under the influence of hydrophilic macrophytes

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Abstract. According to the researches carried out by authors in 2013, the estimate of the effectiveness of domestic sewage treatment with the help of hydrophilic vegetation was received. It has been shown that if sewage is treated with the help of macrophytes, copper and lead concentration reduces. Thus, if the volume of sewage treated by reed mace is 500 ml and 1 l, lead concentration decreases 5 and 3,5 times, if sewage is treated by reed, lead concentration decreases 2,5 times in both cases; if sewage is treated by reed mace copper concentration decreases 0,9 and 1,8 times (if the volume of sewage is 500 ml and 1 l), if sewage is treated by reed, copper concentration decreases 1,4 and 1,5 times respectively. The conclusion has been drawn: in West Siberia it is possible to use the shallow reservoirs with natural aeration and hydrophilic vegetation for effective sewage treatment from such heavy metals as lead and copper.

1. Introduction

Pollution of water objects represents a global problem. Sustainable social and economic development in all regions of the world is impossible without solving this problem because resources of waters suitable for household-drinking use are getting reduced. In this regard it is necessary to provide the effective sewage treatment to the level providing steady functioning of water and land ecosystems. Achievement of this purpose can be connected with the construction of new treatment facilities and the expansion (reconstruction) of existing ones. But at the same time cost that limits the scope of environmental protection measures dramatically increases. To solve this problem is to use the artificial or natural reservoirs with natural aeration and hydrophilic vegetation.

There is operational experience of similar objects in many countries including the Russian Federation. In particular, reservoirs with hydrophilic vegetation are applied in Novosibirsk, Murmansk, Kursk regions [1,2]. There is such experience in Tomsk region, in Tomsk and Kargasok districts, and usually a basic purpose of treatment facilities is to decrease the concentration of organic and biogenic substances [3,4]. The possibilities of sewage treatment from metal under sufficiently severe climatic conditions of Siberia are less studied and it has determined the appropriate purpose of considered research, i.e. the effectiveness assessment of domestic wastewater treatment from Al, Zn, Cu, Pb, Cd with a help of local types of hydrophilic vegetation – reed and reed mace [5].



2. Methods and materials

The goal of research is to clear up two main questions: 1) how change of the metal content in the presence of a reed and reed mace in sewage happens; 2) at what ratio of sewage and vegetation the greatest efficiency of cleaning is reached. Taking into account these questions the research method has included:

1) sewage sampling from the receiver tank of sewage pumping station (SPS-6) of LLC Tomskvodokanal; it is a factory providing household-drinking and technical water supply, sewage treatment and sewage disposal of Tomsk, it is an administrative center of the Tomsk region of the Russian Federation located in southeast part of West Siberia; the chemical composition of sewage sample was defined in the accredited laboratory of LLC Tomskvodokanal;

2) vegetation sampling (reed mace and reed) from Peschanoe Lake, located 4 km to the southwest from Tomsk; the mass of each sample is 50 g and its linear size is 1-1,6 m;

3) placement of vegetation samples with root system in polyethylene containers with the capacity of 5 l with sewage; total quantity of containers – 12 pieces, including: a) 3 pieces with reed and volume of sewage of 1 l; b) 3 pieces with reed and volume of sewage of 0,5 l; c) 3 pieces with reed mace and volume of sewage of 1 l; d) 3 pieces with reed mace and volume of sewage of 0,5 l; all containers were placed on the sunny side with constant lighting during all light day in the open room with air temperature from 15°C at night and to 30°C during the day; the start of experiment – August 11, 2013;

4) measurement of Al, Zn, Cu, Pb, Cd concentrations in sewage in 5, 9, 15 days after the start of experiment (August 16, 20 and 26, 2013); chemical analysis are carried out in the accredited hydrogeochemical laboratory of Tomsk polytechnic university with a help of atomic absorption spectrometry and inversion voltamperometry methods;

Reed mace (*Typha latifolia* L.) and reed (*Phragmites australis* L.) were selected as test objects as they are widespread, have a wide range of environmental tolerance and dominate among other hydrophilic plants.

Peschanoe Lake has been chosen as a typical reservoir for the South taiga subzone of West Siberia. This lake can also be used for dumping of domestic sewage. Thus, the experiment allows to estimate efficiency of sewage treatment at the most rigid influence when 0,5 and 1 l of drains are the share of 50 g of a plant and it can be observed in low water level. The choice of hydrochemical indicators (concentration of Al, Zn, Cu, Pb, Cd) is due to the fact that these trace elements in accordance with their assessment of toxicity belong to hazard category III and II, and they are characterized as substances moderately dangerous (Cu, Zn) and highly hazardous (Al, Pb, Cd) nature. When maximum permissible concentration of these elements enters the human body, disruption of the functioning and the occurrence of development undesirable processes in an organism is observed. The loss of calcium from the bones depending on high contents of cadmium, paralysis of nerves of bending and unbending extremities, convulsions and coma, decrease of hemoglobin concentration in blood, being observed at poisoning with lead; growth stop, the low content of hemoglobin, abnormality in the liver, kidneys, brain tissue because of chronic excess of copper belong to such processes. Therefore it is so important to pay particular attention to these trace elements in the process of sewage treatment [6-8].

3. Results and discussion

Crude sewage of SPS-6 of LLC Tomskvodokanal according to O. A. Alekin's classification [9] is characterized as fresh with salinity, as to pH value it is alkalescent, it contains a significant amount of organic compounds, including hydrocarbons of the oil series, phenols, anionic surfactants (table 1). Sewage falls short of accepted standards of household-drinking water management in conformity with Fe, PO_4^{3-} , anionic surfactants, NH_4^+ , oil products content, it falls short of accepted to standards of fishery water use according to BOD_5 , PO_4^{3-} , NH_4^+ content.

Table 1. The average chemical composition of sewage of SPS-6 of LLC Tomskvodokanal, August 2013.

Index	SPS- 6	Index	SPS- 6
pH	7,67		
mg/dm ³			
Suspended matters	225	Al	–
Dry residue	541	Zn	0,0372
Cl ⁻	62,7	Cd	<0,0002
SO ₄ ²⁻	40,5	Pb	0,0059
NO ₃ ⁻	3,86	Cu	0,0165
NO ₂ ⁻	1,25	Oil products	2,96
NH ₄ ⁺	14,4	Phenol	0,0122
PO ₄ ³⁻	5,07	Anionic surfactants	1,31
Fe	3,52	BOD ₅ , mgO ₂ /dm ³	152
Mn	0,094	COD, mgO/dm ³	333

The analysis of the received results showed that

1) at physiological level the increased concentration of considered trace elements can cause insufficiency of necessary elements, imbalance of plant food elements, change of permeability of membranes, causing their ruptures. At phenological level, adverse influence on plants is evident as marginal chlorosis, loss of their turgor, witherings and stooling delay.

2) the greatest efficiency of treatment is achieved by use reed mace and a ratio of 0,5 l of drains on 50 g of vegetation.

Table 2. The average chemical composition of sewage before and after treatment by hydrophilic vegetation.

Inde x	SPS- 6	Sample volume 1 l						Sample volume 0,5 l					
		Reed			Reed mace			Reed			Reed mace		
	11.0 8.13	16.0 8.13	20.0 8.13	26.0 8.13	16.0 8.13	20.0 8.13	26.0 8.13	16.0 8.13	20.0 8.13	26.0 8.13	16.0 8.13	20.0 8.13	26.0 8.13
mg/ dm ³													
Al	–	0,06 8	0,09 6	0,15 1	0,06 9	0,07 4	0,07 2	0,12 4	0,12 4	0,16 5	0,08 5	0,03 4	0,03 7
Zn	0,03 72	0,04 8	0,04 8	0,05 9	0,15	0,1	0,04 3	0,05	0,03 3	0,03 45	0,16	0,04 7	0,07 7
Cd	<0,0 002	<0,0 002	<0,0 002	<0,0 002	<0,0 002	<0,0 002	<0,0 002	<0,0 002	<0,0 002	<0,0 002	<0,0 002	<0,0 002	<0,0 002
Pb	0,00 59	0,00 52	0,00 24	0,00 26	0,01 2	0,00 38	0,00 16	0,00 18	0,00 14	0,00 22	0,00 58	0,00 076	0,00 11
Cu	0,01 65	0,01 7	0,00 86	0,01 1	0,01 6	0,01 2	0,00 92	0,01 3	0,01	0,01 2	0,02 8	0,01 8	0,01 7

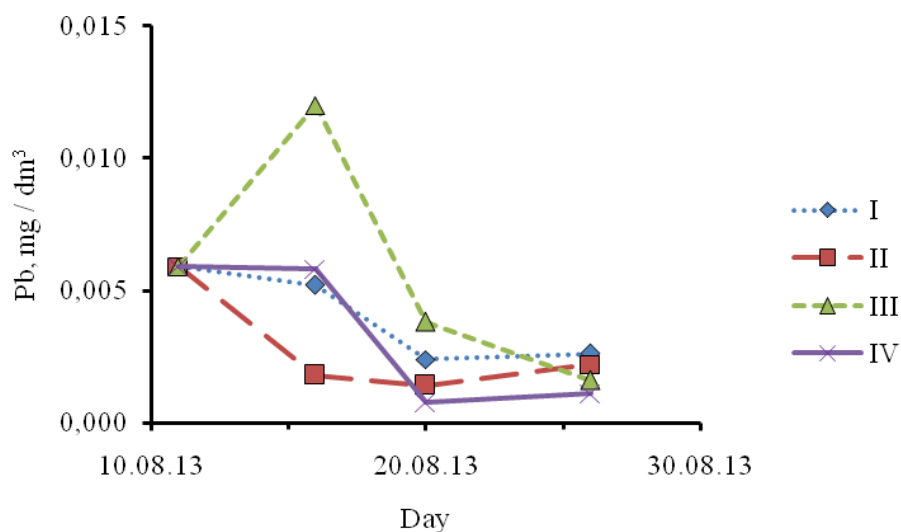


Figure 1. Change of Pb concentration in sewage according to conditions: I) vegetation is a reed, sample volume is 1 l; II) vegetation is reed, sample volume is 0,5 l; III) vegetation is reed mace, sample volume is 1 l; IV) vegetation is reed mace, sample volume is 0,5 l.

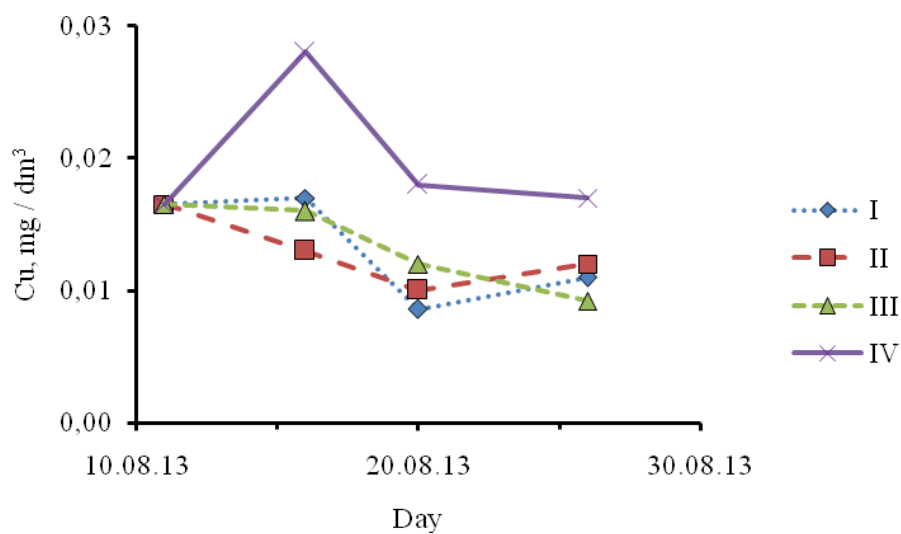


Figure 2. Change of Cu concentration in sewage according to conditions: I) vegetation is reed, sample volume is 1 l; II) vegetation is reed, sample volume is 0,5 l; III) vegetation is reed mace, sample volume is 1 l; IV) vegetation is reed mace, sample volume is 0,5 l.

4. Conclusion

The carried out investigation has shown that reed mace (*Typha latifolia* L.) and reed (*Phragmites australis* L.) can be applied to purify domestic wastewater from Cu and Pb in shallow reservoirs with natural aeration. The greatest effect is achieved by use of reed mace and a ratio of 0,5 l of drains on 50 g of the vegetation, the worst effect is achieved by use of reed and a ratio of 1 l of drains on 50 g of vegetation. Significant decrease of concentration is achieved on the average in 10 days.

Purification of domestic wastewater from Al, Zn in shallow reservoirs with natural aeration and hydrophilic vegetation isn't expedient. Probably, it is connected with that, on the one hand, absorbing ability of plants is effective till a certain moment (in case of experiment till 10th day). Then plants become unsuitable for further treatment or this biomass (50 g) isn't enough for effective removal of these elements from sewage. On the other hand, it can be assumed that such plants as reed mace and reed simply aren't suitable for removal of such trace elements as Al, Zn.

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