Assessment of the Possibility of using Sosnowsky's Hogweed for Wastewater Treatment in the Arctic

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Abstract: The study is devoted to the problem of identifying the most effective plant species for biological wastewater treatment at high latitudes. For the experiment, Sosnowsky's hogweed was selected, characterized by a high growth rate and resistance to low temperatures. The ability of Sosnowsky's hogweed to absorb ammonium ions, nitrate, nitrite, phosphate and chloride ions has been studied. The assessment was carried out in vegetation vessels with a volume of 5 and 10 liters with sand, filled with sewage water. Wastewater from the airport in the village of Murmashi was used for the study. It is shown that this species absorbs biogenic elements from water quite intensively. Nitrogen compounds are most intensively absorbed. It was also found that the most effective extraction of toxic ions occurs in vessels with a volume of 5 liters, which suggests that planting plants of this species on a bioplateau can be carried out quite densely.

1 INTRODUCTION

Physical (mechanical), chemical and biological methods of purification and their combinations are widely used for wastewater treatment. The choice of a particular method is due to a number of factors: the volume of discharge, the composition of pollutants and the toxicity of waters, the features of the landscape, the proximity of the water intake. Economic aspects are also of great importance, namely, the cost of treatment (Borisova, 2011).

In the process of physical treatment, it is possible to separate coarse particles, sand, fats and petroleum products. Chemical purification involves neutralization (using lime, ammonia or mineral acids), oxidation (for effluents containing highly toxic organic compounds) and precipitation (with the formation of insoluble hydroxides) (Voronov, 2007). Chemical cleaning often leads to secondary contamination of the treated waters. Physical and chemical methods include flotation (passing air through wastewater separating fine particles), coagulation (converting dissolved particles into insoluble form in the form of large flakes separated by physical methods) and adsorption (binding of polluting particles to the surface of sorbents) (Borisova, 2011).

Removal of compounds of biogenic elements (nitrogen, phosphorus, sulfur) is most advisable to be carried out by biological methods, since this approach does not cause secondary contamination with reagents. Among biological methods, there are artificial (feasible in special structures – aerotanks and methane tanks) and natural (carried out in natural depressions of the landscape) – lagoons, bioplateaus, irrigation fields. Artificial methods are widely used, and the resulting solid residue has previously been used as fertilizers. Currently, the possibilities of using this type of waste are sharply limited, since many highly toxic substances are found in its composition, such as pesticides, heavy metals, dioxins (Voronov, 2007).

One of the promising natural methods is bioplateau, where purification is carried out with the use of higher aquatic vegetation. For a number of species, high efficiency in the purification of both sanitary and industrial waters is shown. The most promising in this regard are such species as the water hyacinth (Eichcornia crassipes) (Chen 1992; Chen, 1992a; Fox, 2008), Lemna minor, Pistia floating (Borzenkov, 2010), Elodea canadensis (Bondareva, 2008; Dunbabin,1992; Ding Yanhua, 1992).

For many sparsely populated territories (workers' settlements, military units, agricultural enterprises), the use of traditional types of wastewater treatment is

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extremely expensive, since the construction of sewage treatment plants, even for small volumes of discharge, is estimated at tens of millions of rubles, and the construction of bioplateaus and lagoons does not require large expenditures (Direnko, 2006).

2 MATERIALS AND METHODS

The studies were carried out on the wastewater of the Murmashi airport, located in the Murmansk region. The airport is located at a considerable distance from the village of Murmashi and cannot be connected to a centralized wastewater disposal and wastewater treatment system. The effluents are dominated by ions of biogenic elements.

Young balsam plants having 1 pair of true leaves were planted in washed coarse sand in vegetative vessels with a volume of 2, 5 and 10 liters and filled with sewage water to the mark. The plants were vegetated for a week under a canopy made of polyethylene film to prevent dilution of water in the vessels with rainwater. To account for the evaporation of water by leaves after exposure, the water in the vessel was topped up to the mark with distilled water, after which water was used in the vessel for analysis.

The ion content was determined spectrophotometrically:

The content of ammonium ions was determined using a Nessler reagent, the selective absorption of infrared radiation of the solution was measured at a wavelength equal to 425 nm in cuvettes, the absorption wavelength of the layer of which is 1 or 5 cm.

The phosphorus content was determined using ammonium molybdate at a wavelength of 690 nm

The content of nitrate ions was determined using salicylic acid at a wavelength of 690 nm in cuvettes with a thickness of 20mm, and nitrite ions using sulfanylic acid at a wavelength of 520 nm.

The content of chloride ions was determined titrimetrically using a silver nitrate solution

Sosnowsky's hogweed (*Heracleum sosnowsky*) is a representative of the genus Hogweed – *Heracleum* of the *Apiaceae* (*Umbelliferae*) family –a south-temperate Caucasian species adventitious for the north, which escaped from cultivation and is now found in a wide variety of plant communities, currently not only Sosnowsky's hogweed lives in the Murmansk region, but also various interspecific hybrids (Menshakova, 2011), showing weak phytotoxicity and allelopathic activity (Menshakova, 2013).

3 RESULTS AND DISCUSSION

The results of the experiment on the efficiency of absorption of anions from wastewater by Sosnowsky's hogweed are presented in Tables 1 and 2. Just as in the experiment with Impatiens roylei in all variants of the experiment, in vegetative vessels of various volumes, a decrease in the concentration of chlorides, phosphates, ammonium nitrogen, nitrates and nitrites is observed in an aqueous solution. The greatest absorption by the roots of the plant occurred in vessels with the smallest volume (except ammonium). The concentration of chloride anions in vessels with a volume of 10 liters decreased by 2 times, while in vessels with a volume of 5 liters by almost 9 times. The content of phosphates in water in the variant of the experiment with vegetative vessels with a volume of 10 liters decreased slightly, interestingly, the concentration in vessels with a volume of 5 liters increased slightly. Also of particular interest are the concentrations of nitrates in vessels of 10 liters and 5 liters, which decreased by 3 times. Nitrite anions were most actively absorbed.

Table 1: Concentration of anions in an aqueous solution in the experiment with Sosnowsky's hogweed before and after the experiment (first sampling).

Volume vessel, l	Average chloride concentration, mg/l ^{3}	Average phosphate concentration, mg/l ^{3}	Average ammonium nitrogen concentration, mg/l ^{3}	Average nitrate concentration, mg/l ^{3}	Average nitrite concentration, mg/l ^{3}
10	47.96	0.172	1.06	5.2866	0.036
5	8.19	0.195	0.67	5.785	0.0112
Concentration of anions before the experiment	73.40	0.186	14.86	16.155	0.458

Table 2: Concentration of anions in an aqueous solution in the experiment with Sosnowsky's hogweed before and after the experiment (second sampling).

Volume vessel, l	Average chloride concentration, mg/l [3]	Average phosphate concentration, mg/l [3]	Average ammonium nitrogen concentration, mg/l [3]	Average nitrate concentration, mg/l [3]	Average nitrite concentration, mg/l [3]
10	16.37	0.154	0.284	5.083	0.0147
5	11.73	0.082	0.147	1.136	0.004
Concentration of anions before the experiment	75.15	0.088	10.25	25.98	0.687

Concentrations in vessels with a volume of 5 liters decreased by 41 times, while in vessels with a volume of 10 liters by 11 times.

Analyzing the data, it can be concluded that Sosnowsky's hogweed in the vegetative period most actively absorbs nitrate and ammonium ions. Interestingly, the concentration of phosphate ions in vessels with a volume of 5 liters increased, while vessels with a volume of 10 liters decreased

During repeated sampling, the content of chloride anions, ammonium ions, nitrates and nitrite ions in the aqueous solution turned out to be less than during the primary sampling, in all variants of the experiment. The content of chloride anions turned out to be lower in the secondary sampling from vessels with a volume of 5 liters. The concentrations of phosphate anions in vessels with a volume of 10 liters were lower in the first experiment, but the concentration in a vessel with a volume of 5 liters became lower in the secondary sampling (Table 2).

From the data in Tables 1 and 2, it can be seen that the roots of the plant absorbed anions, and it can also be concluded that during the growing season, Sosnowsky's hogweed most actively absorbs ammonium and nitrate ions. Interestingly, in a vessel with a volume of 10 liters, the hogweed began to give off phosphate ions, which caused an increase in the concentration of these ions.

It can be concluded that hogweed exhibits the ability to absorb most actively in vessels with the smallest volume.

4 CONCLUSION

1. As a result of the study, it can be concluded that Sosnowsky's hogweed has a pronounced ability to absorb toxic anions.
2. The roots of the Sosnowsky's hogweed most actively absorb during the flowering period: nitrate-, nitrite-ions and ammonium ions, chloride ions, except for vessels with a volume of 10 liters, phosphate ions, except for vessels with a volume of 5 liters.
3. The root system of the Sosnowsky's hogweed most actively absorbs toxic ions in vessels with the smallest volume.

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