The results of the research on the pipelines protection from Dreissena on the water intake technological complexes of multi-purpose water supply systems for urban farms

E D Khetsuriani*, V L Bondarenko2, A I Ilyasov3, E A Semenova4
1M.I. Platov South-Russian State Technical University (Novocherkassk Polytechnic Institute), 132 Prosveshcheniya, Novocherkassk, 346428, Russia
2 Novocherkassk Engineering and Land Reclamation Institute of Don State Agrarian University, 24 Krivoshlykov street, Novocherkassk, 346493, Russia
3 branch WTL (USA) in Asia, 7A Innovators street, Moscow, 119421, Russia
4 North-Caucasus Federal University, 1 Pushkin street, Stavropol, 355029, Russia

E-mail: goodga@mail.ru

Abstract. The main purpose of the Sengileevsky reservoir is currently the flow part accumulation of the Nevinnomyssky canal for municipal and industrial water supply of the city of Stavropol, the city of Mikhailovsk, Shpakovsky and Grachevsky districts, the irrigation of the river Egorlyk and the water supply regulation in the Rostov region and the Republic of Kalmykia, provision of water to the Right-Egorlyk Canal, Mezhdurechenskaya Environmental Protection Agency and incidentally, Egorlykskaya and Novotroitskaya Hydroelectric Power Station, Stavropol CPP. From the Sengileev reservoir water is supplied to the city of Stavropol and several other districts of the region, with more than 1 million people being provided with water. Water intake structures with a pumping station on the Sengileev reservoir are unique and have no analogues in Russia. Water is taken by pumps from a depth of 10 meters and then supplied by three pumping stations to a height of about 500 meters.

The water quality in the reservoir in different years mainly corresponds to classes II – III, “pure” or “moderately polluted” with a WPI close to 1, whereas in the tributaries for a number of sections the water quality may decline in certain periods to V-VI as “Dirty” and “extremely dirty”.

The main idea of the work is to use an environmentally safe technology to combat drainage, pre-purification of water in front of the sewage treatment plant and ensuring uninterrupted water supply in settlements at any time of the year.

Introduction

In connection with the river flow redistribution and climatic changes, the zebra mussel mollusk penetrated into the reservoir. Attaching to the water intake pipes, the zebra mussels cover the passage openings, which impedes the pumping of water by pumps, reduces their performance, creates threats of an ecological-toxicological nature, entails additional costs of electricity and is costly to clean the structures.
The above-mentioned circumstances and first of all the exceptionally significant role of the reservoir as a drinking water reservoir for the regional center - Stavropol, predetermined the relevance of the chosen subject.

The aim of the work was to study the biological state of the Sengileev reservoir, to develop the scientifically based recommendations on the organization of the ecological and biological monitoring system of the zebra mussel population and recommendations on its bio-melioration.

When conducting research, the following tasks were set:
1. To analyze the existing regulatory legal acts of the Russian Federation and the Stavropol Territory regarding the implementation of monitoring of aquatic ecosystems.
2. To develop a hydrobiological monitoring program for the zebra mussel of the Sengileev reservoir, including the frequency of seasonal surveys to identify the horizontal and vertical stratification of the object, the methodological justification for studying the ecological and biological features, abundance and biomass of the mollusk, as a special factor creating a threat to the water supply of the population of Stavropol and a number of administrative districts of the region.
3. To study the ecological and biological characteristics of the main groups of invertebrate hydrobionts of the Sengileev reservoir, the determination of their density, abundance, productivity and biomass.
4. To assess the quantitative and qualitative composition of the ichthyofauna of the reservoir; to study the main fish community structure.

Among the important tasks of the water intake equipment of water utilities is ensuring the reliability and safety of the system. Fouling reduces the throughput of plants. Dreissena mollusk can in some months completely block the lumen pipes.

The problem is complicated by the fact that, on the one hand, large hydrobionts (mostly mollusks) are damaged during the water intake, get dead and are a source of mechanical interference for the movement of water. On the other hand, on the valves of dead mollusks and stuck in the tubes, small live mollusks (4-8 mm) remain intact, which are intact during the water withdrawal, and are capable of growing in the water supply system. During the operation of the water supply system in pipes and settling facilities, hydrodynamic and hydrothermal conditions are formed, contributing not only to the existence of the mollusk Dreissena in them, but also to its high growth rate (flow through, constant flow of oxygen and nutrients). In addition to adult mollusks, their larvae (veliger), getting into the water supply system and cooling ponds with water from natural reservoirs, settle there and cause fouling of pipelines, tanks, process equipment. The presence of hydrotechnical structures in the water in the form of various grids and pipelines serving as a substrate for bio blowers also contributes to the resettlement of bio brewers.

In this connection, it is necessary to periodically clean the pipes during the shutdown of the water intake or to develop the progressive methods of cleaning or preventing the piping system from bio forming.

The scientific novelty of the research lies in the development of:
- the scientific basis of the theory of computational and constructive methods to increase the level of protection of the natural environment in water bodies of multi-purpose water supply systems (WSS) to obtain the necessary result for ensuring environmental safety (ES) in the zones of influence of the water-intake technological complex (WITC);
- for the first time, using the progressive electro-hydraulic method, cleaning or preventing the pipeline system from biofouling;
- preliminary cleaning of the water intake before the sewage treatment plant

The work is devoted to the problems of the water supply system caused by the overgrowth of Dreissena mollusk and in connection with this disruption of the drinking water supply systems of urban economy and populated areas. Practically all the structural elements of a domestic drinking water intake are subjected to internal fouling by aquatic organisms, among which zebra mussels are most often presented. Fouling is significant due to its leading to critical pressure losses in the absorbing system of water intake and the threat of stopping pumping stations.
In the drinking water supply system, zebra mussel larvae rarely move independently, mainly under the action of water flow. Zebra mussel settlements focus on the underwater parts of ferroconcrete and metal structures of pumping stations, lining of water intake buckets on the ends of the supply lines, on trash grids (Figures 1) in pressure and water supply lines, pumping units of the first lifting stations.

![Figure 1. Double-leaved Dreissena clam scored grids](image)

The growth rate of zebra mussel in water-pressure pipelines is twice as high as in a pond. At the beginning the mollusks of zebra mussels settle in the areas where the water velocities are the lowest. The overgrowth formed in the first year is a place for further colonization of the mollusks, since the improved conditions arise for them in these places. There is a gradual increase in the fouling layer and the resulting focus is expanded in size. The density of zebra mussel settlement reaches its highest values where the flow of water forms a turbulence. In the conditions of constantly operating equipment and pipelines, almost unlimited growth of zebra mussel biomass is possible.

Dreissena shells, getting into the pumping units and pipelines of the Sengileev water intake, disrupt the blades and block the cross-sections of the through-holes. As a result, this leads to a decrease in the performance of hydraulic equipment, as well as to an increase in power consumption up to 10–12 million kWh / year, which accounts for 10–12% of the total electric energy consumption by all the intake facility pumping stations. The zebra mussel layer on the inner walls of pipelines can reach 7 ... 10 cm, and the fouling mass can reach up to 7 kg / m². As a result, with such an accumulation the working section is significantly narrowed, the resistance of the pipeline increases, leading to a decrease in the operating equipment performance. In addition, the accumulation of zebra mussel in reservoirs and pipelines leads to the drinking water microbiological indicators deterioration.

The fight against zebra mussel should be considered not only as a means of uninterrupted water supply of settlements and cities, but also as a measure of electrical energy savings. The patterns that determine the development of fouling organisms on structures and equipment of hydraulic structures are similar to those in natural conditions. The difference is the absence of competitors in these specific conditions, which may be the reason for the massive development of one organism, for example, the zebra mussel. The thickness of the fouling layer per year is 25-50 mm. When the cooling water temperature decreases, the composition of the zebra mussel population developing on the structures and equipment is “preserved”, as if all processes are suspended. When the water temperature rises to 11 °C, the livelihoods of the mollusks resume.

**Experimental studies**

The paper presents the methodology and results of experimental studies.

The electro-hydraulic effect is the occurrence of high pressure as a result of a high-voltage electric discharge between electrodes immersed in a non-conductive fluid. With the electro hydrate effect, a discharge current in the liquid reaches tens and hundreds of kiloamperes, temperatures of about 10,000 K are observed. Due to the low compressibility of the liquid, the pressure rises to about 1000 MPa. This pressure is transmitted in all directions, creating a shock wave in the liquid. As a result of such huge energy in water the destruction of living organisms occurs.
The electro-hydraulic effect is a universal way to combat the scum formation, the sediments and biological fouling on the inner surface of pipes and heat exchange equipment. Electro-hydraulic effect is used both separately and in combination with other methods.

The experiment was carried out by the laboratories of SPC EKOFES LTD (Figure 2). The high-precision measuring equipment was used and calibrated in specialized laboratories for the experiment.

The laboratory installation was made for the experiment. Dreissena were subjected for artificial cultivation; there were two aquariums with a volume of 20 and 30 liters. Veligers were grown in the 20 liter - these are the Dreissena mollusks, and after 30 days they were transplanted in a 30-liter aquarium for growing the Dreissena.

For the cultivation of individuals Dreissena need comfortable conditions, such as water temperature of 25-27 degrees, lighting and oxygen. Special feed and clean water are the priority conditions.

Tap water, salt water (20%) purified by the osmotic installation and brought from the river Tuzlov was used for the experiment.

Utensils with a volume of 0.5 liters were used to monitor the state of electro-copied Dreissena. All utensils were numbered: No. 1 - the Dreissena original specimen prior to the experiment; No. 2 - Dreissena after applying electric shock in 1 impulse; No. 3 - Dreissena after applying an electric shock in 3 impulses; No. 4 - Dreissena after the supply of an electric shock in the 5th impulse; No. 5 - Dreisen after applying an electric shock to the 7th impulse; No. 6 - Dreissena after the supply of an electric shock in the 10th impulse; No. 7 - Dreissena after the supply of an electric shock in the 15th impulse.

The results of the experiment
The results of the experiment are presented in the form of dependencies in Figure 3.

Figure 2. Experimental laboratory

Figure 3. a surviving specimens’ number graph (Dreissena) from the observation time, hours. (Tap water)
Findings
The analysis of the results of the above-mentioned studies allows to make the following conclusions:

- when experimenting on a 20% NaCl solution, the survival rate of Dreissena is 28% (with 9 pulses);
- in the experiment on tap water, the survival rate Dreissena is 20% at the 1st impulse; 4% - on 3 pulses and 0% at 6 and 9 pulses;
- when experimenting on osmotic water, the survival rate Dreissena is 8% at the 1st pulse; 0% - on the 3rd, 6 and 9 impulses;
- when experimenting on water Tuzlov river, Dreissena survival rate of 8% at the 1st impulse; 4% - on the 3 impulses and 0% at 6 and 9 impulses;

It turned out that the efficiency of the proposed innovative technology of Dreissena electro reduction is 90-97%.

The application of the proposed technology to eliminate the need for primary disinfection of water with chlorine or to reduce chlorine consumption to a minimum gives stability to the water treatment regime and significantly reduces the cost of cleaning water from blue-green algae during the water bodies flowering, protects the water supply system from Dreissena and eventually uninterrupted water supply to the consumer.

According to the study results we propose a constructive scheme for the Syngileev reservoir in-process technological node conversion.

The scheme is presented in Fig. 10, which is recommended for re-equipment of the water intake node when drawing water from the channel water intake structure. “Installation of the electro reduction plankton water intake structure 2VUEKP-1000” (2-chamber with a capacity of 1000 m³ / hour) by the authors: Bogdanov NI, Fesenko L.N., Hetsuriani E.D., Dektyarev D.M., Bondarenko V.L.

This development relates to the devices for electro reduction, electrohydraulic treatment and disinfection of drinking water and waste liquid media by creating electro-hydraulic shocks in the processed medium, reaching pressures of hundreds of thousands of atmospheres, and can be used in various sectors of the national economy, including to combat zebra mussel.

Having set the task of pre-treatment of water during water extraction, it is important not to forget about the conservation of the pond’s eco-system. In addition to protecting and eliminating injury to juvenile fish during the water abstraction, it is necessary to take into account the fact that, after diverting the fish from the suction pipe, the conditions must be provided for the fish to stay in the reservoir and preserve the ecosystem.

For this purpose, the device of the proposed water intake and cleaning complex provides for fishery, facilitating the diversion of juvenile fish to the place of feeding and spawning. Thus, the ecological effect of fish protection is realized.

Summary
The proposed development performs the task of complex treatment plants under water-boron conditions and provides:

- protection of juvenile fish from entering water intake facilities during water intake;
- protection of water intake facilities against blue-green algae;
- protection of water intake equipment (pipes, pumps, etc.) from Draissena;
- disinfecting effect;
- preliminary process of surface water treatment before supplying them to the treatment plant;
- a water intake purification device ensures a reduction of at least 80% of pollution at the waste water treatment plant, which reduces the consumption of reagents, reduces water consumption for own needs of wastewater treatment plants, reduces the cost of obtaining drinking-quality water;
- high eco-economic effect.

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