Floating water intake clarifier

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Abstract: *This article addresses the problem of purifying high-turbidity rivers for water supply in small settlements. In the Republic of Azerbaijan, more than 70% of the population relies on high-turbidity surface water from the Kura and Araz rivers for drinking. Existing methods for purifying high-turbidity water for large cities are primarily based on reagent-based process flow diagrams. These processes are highly dependent on the turbidity of the source water. Small local water treatment plants are widely used to supply water to rural settlements. A new design for a water intake and clarifier for high-turbidity rivers is proposed.*

Key words*: river, turbidity, sedimentation tank, water supply, population, sediment.*

Research objective: Due to the intensive development of agriculture, the treatment of highly turbid water for water supply systems in arid regions is particularly important. In most cases, underground sources in these areas are highly saline, and surface water requires extensive treatment. In the Republic of Azerbaijan, more than 70% of the population relies on highly turbid surface water from the Kura and Araz rivers for drinking. Foothill settlements rely on highly turbid mountain rivers for their water supply. All rural settlements in Turkmenistan rely on highly turbid surface water from the Karakum Canal for drinking, while in Uzbekistan, more than 60% rely on water from the Amu Darya, Syr Darya, Naryn, and Chirchik rivers. Hydrological observations show that the turbidity of many mountain rivers fluctuates sharply throughout the day (from an average of 1.0-3.0 g/L to a maximum of 15-20 g/L). Under these conditions, radial horizontal settling tanks and slow filters, which are currently widely used to treat highly turbid surface waters, are ineffective, require large capital investments, and the quality of water treatment does not always meet modern requirements.

Existing methods. Existing methods for purifying highly turbid waters are primarily based on reagent-free and reagent-based process flow diagrams. The reagent-based method is most widely used, primarily in large water supply systems in cities and towns. Small local water treatment plants are widely used to supply water to rural communities, for which the reagent-free method is the most effective. The capacity of such plants is typically 10-1000 m3/day. The creation of low-capacity water treatment plants for clarifying highly turbid waters (turbidity exceeding 25.00 g/L) is of great economic importance. About 20 small towns with a total population of over 1.5 million people in the Republic of Azerbaijan live in an arid zone, where groundwater and underground water are highly saline (mineralization up to 20 g/L). The only water source for these populations is the highly turbid waters of the Kura and Araz rivers. To provide drinking water to a number of rural communities, the first stage of a group water pipeline with a capacity of 50,000 cubic meters per day was built between 1978 and 1981. This pipeline utilizes reagent-free pre-clarification technology for the water withdrawn directly into the Kura River. A floating thin-layer settling tank was added to the floating pumping station for pre-clarification (Fig. 1).

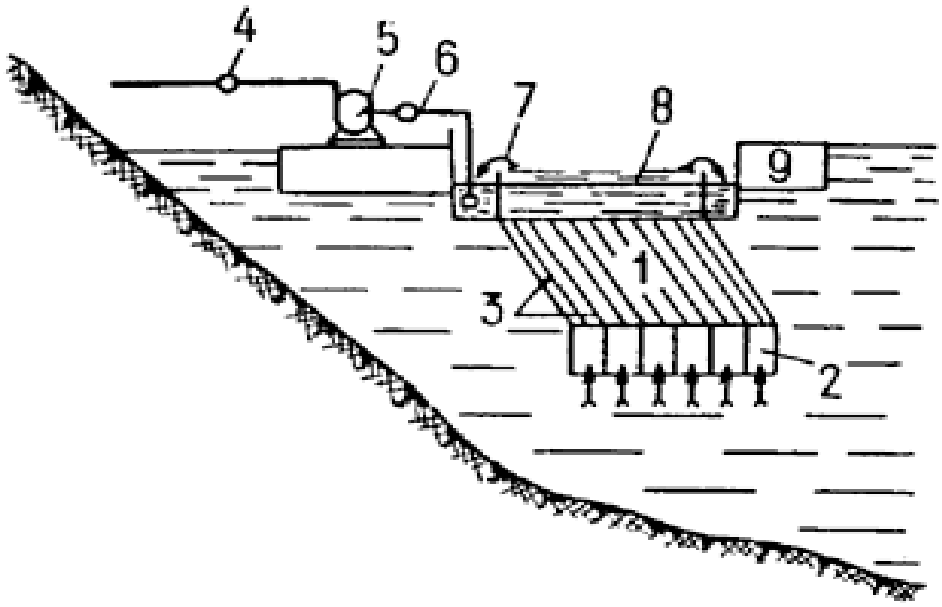

Fig. 1. Design of a floating water intake and clarifier.

1 - thin-layer module; 2 - baffle guides; 3 - thin-layer plate; 4 - water supply pipeline; 5 - pump; 6 - articulated joint; 7 - spillway; 8 - clean water bin.

The floating water intake and settling tank is a rectangular vessel without a bottom sedimentation section. The clarifier is equipped with an inclined element in the form of a tube package (thin-layer elements). In the bottom section of the settling tank, vertical transverse and longitudinal partitions are fixed at the edges of the thin-layer elements, forming cellular blocks (grids). The floating settling tank is equipped with side gutters for uniform collection of clarified water along the entire perimeter of the thin-layer modules. The clarified water enters the collection gutters and is directed by a flexible pipe to a floating pumping station. The thin-layer settling tank is suspended in the water by a pontoon. Two processes occur simultaneously in this structure: preliminary clarification of the water in the inclined tubes and the supply of this water to the shore structure /1, 2/. Since the water velocity through the cells into the channels is significantly lower than the river current, the suction of fish fry into the system is prevented.

The use of a floating water intake and settling tank eliminates the need for on-shore structures for sediment treatment and removal after preliminary water clarification, significantly reducing water consumption for the water treatment facilities' own needs. According to laboratory studies and data obtained in industrial conditions on the Kura River, the optimal performance was 25-40 m8/h m2. The maximum velocity at the inlet of the floating clarifier was 0.01-0.02 m/s, while the flow velocity in the Kura River was 1-1.5 m/s. The floating thin-layer settling tank was tested in a pilot plant with a capacity of 10,000 m3/day during 1980-1981. The total area of the floating settling tank in plan was 48.6 m2 (2.7; 18). The immersion height of the floating settling tank was - 1.5 m. The water depth at the water intake location in the Kura River was 7...10 m. During the testing period, the turbidity of the water in the Kura River at the water intake site varied from - 570 mg/l to 34160 mg/l. / 2 /.

The results of testing the floating thin-layer settling tank showed the following:

- the clarification effect depends on the depth and flow velocity of the river;

- the clarification effect of the incoming waters depends heavily on the river's wave conditions;

- at river depths greater than 7 meters, the clarification effect of the incoming waters was 20-55%;

- decreasing the depth of the floating thin-layer settling tank (less than 3-4 meters) significantly affects (impairs) the sedimentation of suspended sediments.

Author's contribution. To improve the efficiency of the floating thin-layer settling tank and eliminate the aforementioned shortcomings, a new floating thin-layer settling tank design for collecting water from rivers with high turbidity was developed based on our research /3,4/. Compared to previous designs, the new design offers the following key advantages:

- the clarification of the collected water is independent of river velocity;
- the clarification of the collected water is independent of river wave conditions;
- the design allows for collecting water from rivers with depths greater than 3 m;
- high sedimentation efficiency is achieved at a depth of 1-2 m under the floating thin-layer settling tank;
- prevents larger sediment fractions from entering the floating thin-layer settling tank;
- the design prevents fish fry from being sucked into the unit.

The water intake/clarification unit is a floating device with a hopper element, the lower section of which is designed as a Confusor, and the upper section is equipped with a water seal. A lighting unit with thin-layer elements and a water collection system are mounted inside the hopper (Fig. 2). The lower section of the hopper is designed as a Confusor, which ensures sediment removal. The Confusor is positioned so that its axis is at least 45°-60° relative to the river water table. This Confusor position creates a vortex zone at its end, characterized by reduced pressure. Thus, the resulting vortex zone beneath the hopper draws sediment from the hopper. The design ensures that the hydraulic resistance in the water seal is lower than in the Confusor, so water from the river enters the hopper through the water seal. Thus, water is drawn from the surface, more clarified layer of the river (Fig. 2).

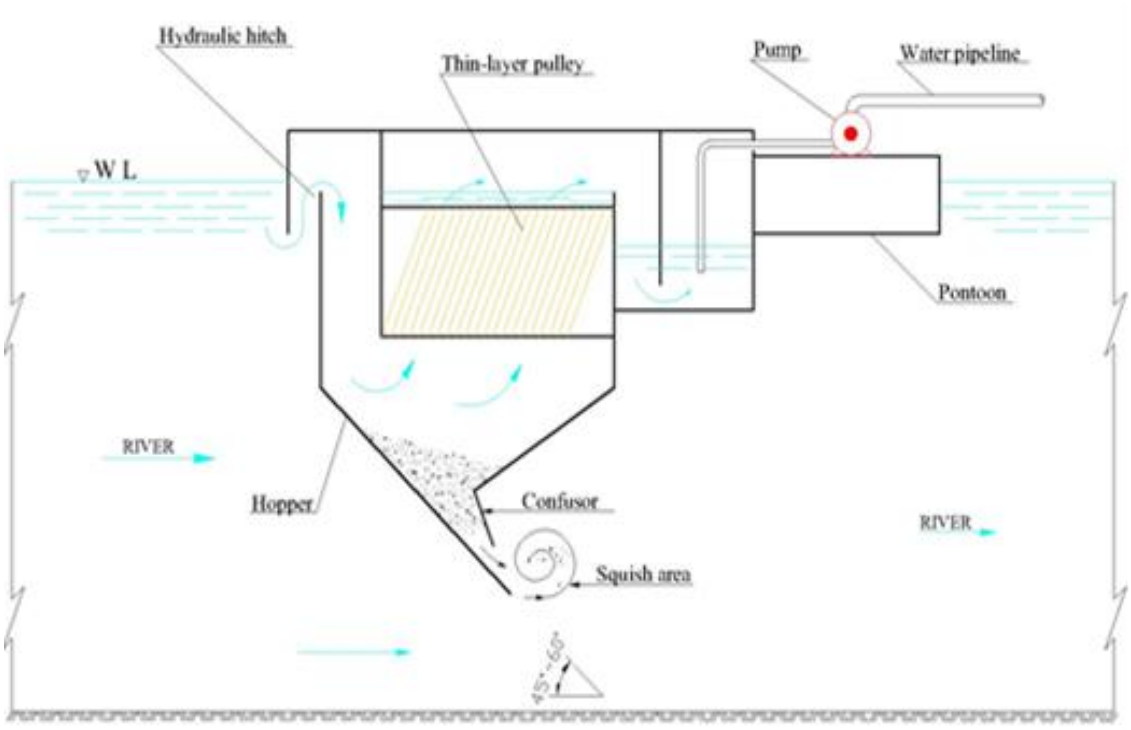

Fig. 2. New design of a floating water intake/clarifier.

In the new design, river waves have virtually no effect on sediment deposition in the thin-layer module. At shallower depths, this design works more efficiently because the flow rate increases in the lower part of the bin and, accordingly, increases the suction of sediment from the bin.
The water intake/clarifier operates as follows: incoming river water passes through a water seal into a hopper and then into thin-film clarifier elements, where, at a flow rate of 0.01-0.05 m/s, a significant portion of the suspended solids is separated. The purified water then enters the water intake system. The separated particles from the thin-film elements continuously slide into the hopper and are then removed through a Confusor into the river flow and transported downstream. Depending on the hydrological conditions on the river, the location of the intake can be changed by towing it to the desired location. A high purification efficiency (60-70%) is achieved with a source water turbidity of over 1000-1500 mg/l and is achieved primarily by separating particles with a hydraulic size greater than 0.15-0.20 mm/s. Such intakes are recommended for use at above-zero river water temperatures. The use of such a design ensures waste-free and reagent-free technological preliminary treatment of water taken into the river bed.

Main conclusions.

1. Small settlements primarily rely on river water for their water supply. In the Republic of Azerbaijan, more than 70% of the population relies on the highly turbid surface waters of the Kura and Araz rivers for drinking. Purifying highly turbid waters is a current priority.

2. Existing methods for treating highly turbid waters for large cities are primarily based on reagent-based process flow diagrams. These processes are highly dependent on the turbidity of

the source water. Small local water treatment plants are widely used to supply water to rural settlements.

3. A new design of water intake clarifier has been proposed for clarification of water withdrawn directly into the riverbed. This new design allows for clarification of water intake (60-70%) with source water turbidity exceeding 1000-1500 mg/L by separating particles with a hydraulic size greater than 0.15-0.20 mm/s.

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