Technical solutions for cleaning drainage water from irrigated areas

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Abstract. In recent years, there has been an increasing shortage of fresh water suitable for irrigation, which does not subsequently cause soil salinization. To solve the above problem, it is necessary to reconstruct the collector-drainage system into a circulation system. Using the example of open collectors, the dynamics of the chemical composition during the growing season was studied, which showed its dependence on the intensity of irrigation, the salinity of irrigation water, and the seasonal amount of precipitation. A comprehensive assessment of the suitability of water from open collectors for irrigation in terms of salinity, chloride salinity, sodium and magnesium alkalization and soda formation has been carried out. The necessity of additional treatment of drainage and waste waters to exclude soil salinization has been established. Technical solutions for the purification of the drainage runoff in the stream and with the help of a mobile treatment plant are proposed. A diagram of a removable filter cassette operating in a honeycomb type for water purification in a stream is presented.

1. Introduction
Global warming has changed the temperature regimes and the distribution of precipitation in many agricultural regions of Russia and in other agricultural countries. This, in turn, caused a shortage of fresh water, which led to an increase in the socio-economic burden in the field of water supply and water use. Agrarians faced, on the one hand, with the problem of a shortage of water suitable for irrigation, and, on the other hand, with large volumes of polluted drainage runoff discharged into natural water bodies. In addition, there are colossal losses of fresh water due to the unsatisfactory technical state of hydraulic systems. All these problems lead to the need to search for additional sources of water resources suitable for irrigation, the main of which should be considered drainage and waste water [1-6].

Currently, dozens of effective technologies for purification of drainage waters by biological, biochemical and chemical methods have been developed and proposed both in Russia and in foreign countries [7-16]. However, in conditions of a shortage of water resources, it is not enough to simply purify drainage water in order to reduce the negative impact on water bodies, ensuring the natural and technical water cycle, such technologies require the alienation of significant territories, the construction of rather complex hydraulic structures, the availability of qualified personnel, subject to the seasonality of work. There is a need for re-use of treated drainage water for irrigation, the possibility of their use in hydroponics technology, which can be implemented by mobile technical solutions for cleaning.
In connection with the above, the purpose of the work is to develop mobile technical solutions for cleaning drainage flow from irrigated areas, contributing to the rational use of water resources and ensuring the environmentally friendly operation of irrigation and drainage systems.

2. Materials and methods
The object of research was open collectors in the earthen channel K-3, LS-2, MKL-7, BGMS-4, TsS, which are under the jurisdiction of the Semikarakorsk branch of the FGBU “Management “Rostovmeliовodkhoz”.

The obtained results of the study of the chemical composition of water in open collectors in the earthen channel showed sharp fluctuations in the content of salt-forming ions during the growing season associated with leaching irrigation regimes, replenishment of collectors to maintain the water level with fresh hydrocarbonate waters from the main canal, uneven precipitation (for example, the MKL collector -7) (figure 1) [16, 17].

![MKL-7](image)

**Figure 1.** Dynamics of the percentage of ions in water collector MKL-7 during the growing season.

The study of the dynamics of the content of individual ions in the water of the collectors showed an increase in the concentration of hydrocarbonate ions during the irrigation period, which is due to the chemical composition of the irrigation water. In September, with the cessation of irrigation, a decrease in the concentrations of sulfate, chloride and sodium ions was observed, which is associated with the termination of intensive soil wetting and, accordingly, the removal of mobile ions [16].

Based on the results obtained from the study of the chemical composition of water in collectors, in [17], a comprehensive assessment of the suitability of water for reuse for irrigation of agricultural lands was carried out according to various methods (table 1).
Table 1. Assessment of the suitability of water for irrigation in collector canals [17].

| Month  | Mineralization, mg/dm³ | Chloride salinization | Sodium alkalinization | Magnesium alkalinization | Soda formation |
|--------|------------------------|-----------------------|-----------------------|--------------------------|----------------|
| May    | –                      | –                     | –                     | +                        | +             |
| September | +                     | +/-                  | +/-                  | +                        | +             |
| May    | –                      | –                     | –                     | +                        | +             |
| September | +                     | +/-                  | +/-                  | +                        | +             |
| May    | –                      | –                     | +/-                  | +                        | +             |
| September | –                     | –                     | –                     | +                        | +             |
| May    | –                      | –                     | +/-                  | +                        | +             |
| September | +                     | +/-                  | –                     | +                        | +             |

Notes: + water suitable for irrigation; +/- suitable in combination with flushing irrigation modes; - unsuitable without preliminary cleaning

The results of the assessments showed that almost all collectors require additional treatment of water before using it for irrigation [16, 17].

3. Results and its discussion

To correct the chemical composition of drainage and waste waters, it is recommended to build a storage pool in the flow at the point of convergence of second-order collectors into a first-order collector (figure 2).

At the outlet from the storage pool to the collector, an overflow partition is provided, which is a filtration cassette. A diagram of a removable filtration cassette installed at the outlet of the storage pool is shown in figure 3. Such a design will prevent the pool from overflowing on one side and filtering the water in the stream on the other.

At the same time, in order to correct the chemical composition of the water in the collector, the water from the pool is periodically pumped into the mobile cleaning station by a pump and purified is sent for reuse.

![Diagram of a removable filtration cassette](image_url)

Figure 2. Layout of the drainage drainage storage pool for subsequent cleaning.
Figure 3. Removable filtration cassette.

In full-scale conditions, the work of an experimental mobile installation was tested on one of the studied collectors, on which drainage and waste waters were purified. The diagram of the experimental mobile installation is shown in figure 4.

Figure 4. Scheme of a pilot mobile unit for cleaning DSV: 1-pump; 2 – disk mechanical filter; 3- ion exchange filters; 4 - filling tank of the pump unit; 5 - tank for receiving wash water; 6 - suction line; 7 - purified water line; 8 - filling line; 9 line for drainage of wash water.

Based on experimental data on water purification through an experimental mobile installation, with the initial salinity of the treated water sampled in the MKL-7 collector of 2370 mg/dm³, the installation provides a decrease in salinity by 2.3 times, the content of chlorides, sulfates - by 70%, and the removal
of hydrocarbons, nitrites, nitrates at 100%, phosphates at 50%, calcium at 40%, pH regulation at 7.0-7.5 (table 2).

Table 2. Results of quantitative chemical analysis of water from the MKL-7 reservoir.

| The investigated indicator     | Units  | Water from channel MKL-7 |
|-------------------------------|--------|--------------------------|
|                               |        | Before cleaning | After cleaning |
| pH,                           | un. pH | 7.70           | 7.5            |
| Suspended substances,         | mg/dm³ | 15.3           | 1.2            |
| Dry residue,                  | mg/dm³ | 2370           | 1032.76        |
| Chlorides,                    | mg/dm³ | 283            | 85.75          |
| Sulphates,                    | mg/dm³ | 965            | 292            |
| Hydrocarbonates,              | mg/dm³ | 412            | n/a            |
| Calcium,                      | mg/dm³ | 212            | 132            |
| Magnesium,                    | mg/dm³ | 77.8           | 77.8           |
| Rigidty,                      | °K     | 17.00          | 13.00          |
| Ammonium ion,                 | mg/dm³ | 0.113          | -              |
| Nitrite                       | mg/dm³ | 0.028          | -              |
| Nitrates,                     | mg/dm³ | 0.56           | -              |
| Phosphates,                   | mg/dm³ | 0.316          | 0.159          |
| Phosphorus phosphates,        | mgP/dm³| 0.104          | 0.052          |
| Iron total,                   | mg/dm³ | 0.068          | -              |
| Copper                        | mg/dm³ | n/a            | -              |
| APAV                          | mg/dm³ | n/a            | -              |
| Zinc                          | mg/dm³ | n/a            | -              |
| Petroleum products,           | mg/dm³ | 0.019          | -              |
| Sodium + potassium (calculation) | mg/dm³ | 428            | 198            |

4. Conclusion

An open irrigation and drainage system can be reconstructed into a circulating irrigation system. In order to correct the composition of the water, it is necessary to construct drainage basins along the collectors to purify the water and return part of it to the irrigation system, and part to the collector to dilute the DSW before being released into a natural water body.

Recommended technical solutions will allow:

- to minimize the negative impact of drainage and waste water on the environment while observing the norms and standards in force in the Russian Federation;
- to reduce the content of pollutants in the discharged waters to the required values in compact structures and with minimal costs;
- to exclude the ingress of pollutants from the collector into the soil, water bodies, since all elements of the mobile station are steel or plastic and provide the necessary tightness of structures;
- ensure uninterrupted and reliable operation of the mobile station;
- provide full automation of control over the process of cleaning DSV;
- to ensure complete mechanization of the removal of trapped oil products and precipitation;
- to improve the ecological safety of the operated engineering and reclamation systems.

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