Technology of preparation of natural waters for irrigation

O V Bocharnikova, M A Denisova and V S Bocharnikov
Volgograd State Agrarian University, 26, Universitetsky Ave., Volgograd, 400002, Russia
E-mail: volgau@volgau.com

Abstract. Research and search for the most effective and cost-efficient ways of water treatments is relevant today. We propose the use of a natural sorbent as a filter load of a sorption filter for the preparation of natural water for irrigation of crops. The object of study is the water of the Volga River in the Volgograd region. In this work, we propose the use of a sorption filter for purification of natural water, where natural zeolite will be used as a filter load. Before the experiment, a chemical analysis was performed to determine the contaminants in the water and their concentrations. The fractions of zeolite were selected using fractional sieves. Based on the results of sedimentation, the optimal fraction of natural zeolite in terms of absorption properties and contact time with the studied water was selected. Based on the results, the statistical processing of the experimental data was performed and the dependences presented in the form as a power model were obtained. Thus, on the basis of the conducted studies, it can be concluded that it is advisable to use a sorption filter with a zeolite filter load for the preparation of natural waters to be used in irrigation.

1. Introduction
The main sources of natural water pollution are wastewater from industrial and agricultural enterprises. According to the results of the state report summarized in the Water of Russia, a popular Russian scientific encyclopedia, we can say that of discharged wastewaters only 62% are treated to any degree; of them 70% are insufficiently treated, and only 10% are properly treated. If sewage that is not properly cleaned gets into natural surface waters, it will result in introduction of chemical impurities into the environment, such as zinc, copper, phenols, aluminum, ammonia nitrogen, which have a cumulative effect over the years.

All natural surface waters are divided into four classes of pollution: conditionally clean, slightly polluted, polluted and extremely polluted. In Europe, the Volga, Danube and Pechora rivers have the largest water flow [1–4]. The Volga River in the Volgograd oblast is assessed as «polluted». The main pollutants of the river include compounds of copper, zinc, phenols, nitrite nitrogen, ammonium nitrogen, which are stable every year, exceed the maximum permissible concentration. Over the past eight years, the water of the Volga River section in the Astrakhan oblast has been evaluated as «dirty»; in this section of the river the concentration of oil pollution has increased [5–8].

Most of the farms use this water as irrigation, without any preliminary treatment is not performed, that is, the chemical indicators present get into the soil, agricultural products, and of course into groundwater [2, 3]. The best option is pre-treatment of irrigation water before irrigation of crops, which will prevent the entry of chemically hazardous impurities into groundwater and soil [8, 9].
2. Materials and methods
In this study, we propose the use of a sorption filter, where natural zeolite will be used as a filter load, for purification of natural water. The choice of this sorbent is explained by the fact that it is sorption-developed, non-toxic, chemically stable in aggressive environments and durable [9–13]. Now many natural sorbents are used as filter loading [14–17]. At present, activated charcoal is more in demand, but after conducting an analytical review of this material, some of its disadvantages have been identified [18]. Compared to a zeolite-containing rock, activated carbon is inferior in its physical properties such as abrasion, durability, and also in sorption properties. This sorbent does not produce sorption of heavy metals; mainly its properties are limited to absorption of petroleum products and ammonia. Zeolite has good porosity, as well as the ability to quickly close adsorbed ions of chemical impurities, and it absorbs well a large number of different elements, not only heavy metals, but also oil products, salts and other chemical compounds [19, 20].

The object of study is the water of the Volga River. Before the experiment, a chemical analysis was performed to determine the contaminants in the water and their concentration.

An optimal selection of the granule size of natural zeolite through special fractional sieves was carried out. The sorption filter consists of housing, piping, shutoff valves (Figure 1).

![Figure 1. Sorption filter with zeolite loading: 1 – filter housing; 2 – zeolite loading; 3 – supply of source contaminated water; 4 – rinse water; 5 – rinse water supply; 6 – discharge of purified water.](image)

3. Results and discussions
Before filtering the test water, it is necessary to conduct a chemical analysis for the concentration of impurities. The analysis was carried out on a certified portable expert-colorimeter Expert-003 with a set of standard state samples (Table 1).

**Table 1.** The chemical composition of the studied water of the Volga River

| No. | Chemical name       | Chemical concentration, mg/l | Maximum allowable concentration according SanPin «2.1.4.1074-01», mg/l |
|-----|---------------------|------------------------------|---------------------------------------------------------------------|
| 1   | copper              | 0.01                         | 0.001                                                               |
| 2   | zinc                | 0.045                        | 0.01                                                                |
| 3   | petroleum products  | 0.56                         | 0.3                                                                 |
| 4   | nitrites            | 4.6                          | 3.3                                                                 |
| 5   | ammonium nitrogen   | 6                            | 2                                                                    |
As a result of chemical analysis, impurities in the source water were revealed that exceed the maximum permissible concentration, which must be reduced to SanPin standards, which will make it possible to use this water as irrigation in the future.

Before loading the sorption filter, we screened the natural zeolite through fractional sieves. The selection of the optimal size of the fractions was carried out on the basis of sedimentation of the source water with different sizes of zeolite to select the best by its absorption properties. For this, in laboratory conditions, weighed portions of 250 ml of natural sorbent of various fractions were placed in 250 ml conical flasks, after which sedimentation was carried out at time intervals of 1, 4, 8, 12 and 24 hours. After each period of time, a chemical analysis was carried out to determine the residual concentration of impurities in the source water. (Table 2).

Table 2. The optimal selection of fractions of zeolite as a filter load

| No. | Chemical name          | Contact time of natural zeolite with test water, h | Maximum allowable concentration, mg/l |
|-----|------------------------|---------------------------------------------------|----------------------------------------|
|     |                        | 1  | 4  | 8  | 12 | 24 |                          |
| 0.75 mm |                            |    |    |    |    |    |                          |
| 1    | copper                 | 0.009 | 0.008 | 0.007 | 0.007 | no | 0.001                     |
| 2    | zinc                   | 0.042 | 0.039 | 0.033 | 0.031 | sorption | 0.01                     |
| 3    | petroleum products     | 0.53 | 0.5 | 0.45 | 0.42 | n | 0.3                         |
| 4    | nitrites               | 4.3 | 4.2 | 3.87 | 3.85 | 3.3 |                          |
| 5    | ammonium nitrogen      | 5.8 | 5.1 | 4.31 | 4.23 | 2 |                          |
| 1.0 mm |                            |    |    |    |    |    |                          |
| 1    | copper                 | 0.007 | 0.004 | 0.002 | 0.001 | no | 0.001                     |
| 2    | zinc                   | 0.034 | 0.028 | 0.013 | 0.01 | sorption | 0.01                     |
| 3    | petroleum products     | 0.5 | 0.45 | 0.36 | 0.03 | n | 0.3                         |
| 4    | nitrites               | 3.96 | 3.81 | 3.34 | 3.3 | 3.3 |                          |
| 5    | ammonium nitrogen      | 4.8 | 3.21 | 2.4 | 2.1 | 2 |                          |
| 1.5 mm |                            |    |    |    |    |    |                          |
| 1    | copper                 | 0.008 | 0.007 | 0.005 | 0.005 | no | 0.001                     |
| 2    | zinc                   | 0.04 | 0.04 | 0.03 | 0.03 | sorption | 0.01                     |
| 3    | petroleum products     | 0.5 | 0.4 | 0.4 | 0.4 | n | 0.3                         |
| 4    | nitrites               | 4.2 | 4.0 | 3.1 | 3.1 | 3.3 |                          |
| 5    | ammonium nitrogen      | 5.7 | 5.3 | 4.3 | 4.2 | 2 |                          |

Table 2 shows, that the most optimal fraction of natural zeolite in terms of absorption properties is 1.0 mm. A time was also chosen for the complete absorption of chemical impurities by the zeolite to the maximum permissible concentration, which was 12 hours. Based on the results obtained, statistical processing of the experimental data was performed and the dependences presented in the form of a power-law model were obtained (Fig. 2).
Figure 2. The graph of the efficiency of oil product removal in the studied water of the Volga River

In the sorption filter, we will use natural zeolite with a fraction of 1.0 mm and carry out filtering from top to bottom for 12 hours.

4. Conclusion
Thus, on the basis of the conducted studies, it can be concluded that it is advisable to use a sorption filter with a zeolite filter load providing a continuous process of reducing the concentration of chemical impurities to the optimum of natural waters. The service life of the sorbent is 5 years, which leads to minimal economic costs.

References
[1] Alekseeva T P, Burmistrova T I, Trunova N M, Naumova L B and Shilyaeva L P 2017 Assessment of effectiveness of zeolite in acceleration of oil degradation in soil Biotechnology 33(4) 85-91 (in Russian)
[2] Anopolsky V N, Feldstein G N and Feldstein E G 2010 Some aspects of water supply and protection of the hydro sphere from pollution Interdisciplinary scientific and applied journal Biosphere 2(3) 336-374
[3] Anopolsky V N, Feldstein G N and Feldstein E G 2012 The problem of pollution of the hydro sphere by products used for water and wastewater treatment Interdisciplinary scientific and applied journal Biosphere 4(2) 167-176
[4] Ilyin P A, Milushkin V M, Nazarenko O B and Smirnova V V 2010 Development of new methods for purifying water from soluble impurities of heavy metals Bulletin of Tomsk Polytechnic University 317(3) 40-44
[5] Kruzhilin I P, Ovchinnikov A S, Kuznetsova N V, Kozinskaya O V, Fomin S D, Bocharnikov V S and Vorontsova E S 2018 Water pressure monitoring in irrigation piping as quality management tools of sprinkler irrigation ARPN Journal of Engineering and Applied Sciences 13(13) 4181-4184
[6] Kruzhilin I P and Kozinskaja O V 2011 Assessment of the condition of the field and irrigation and drainage techniques for the quality of irrigation with sprinkling machines Fertility 2 52 (in Russian)
[7] Klyukova E N and Ivanskaya N N 2011 Study of the adsorption properties of certain natural sorbents with respect to iron cations Bulletin of Bashkir University 16(1) 25-28
[8] Kazeminejadfard F and Hojjati M R 2019 Preparation of superabsorbent composite based on acrylic acid-hydroxypropyl starch phosphate and clinoptilolite for agricultural applications J. of Applied Polymer Science 136(16) 4736

[9] Moskalev E V, Kudryashov A F and Rabin A V 2017 Application of graphene sorbent in filters for surface water and hot water purification Ecology and industry of Russia 21(12) 18-23

[10] McCusker L B, Olson D H and Baerlocher C 2007 Atlas of Zeolite Framework Types, Available at: http://www.sciencedirect.com/science/book/9780444530646 ISBN: 978-044453064-6 doi: 10.1016/B978-0-444-53064-6.X5186-X

[11] Matsak A and Tsytlishvili K 2018 Using different filter media of stormwater treatment performance Norwegian Journal of Development of the International Science 1(20) 19-22

[12] Nazarov V D and Nazarov M V 2017 Electrochemical filters for the treatment of natural and waste water Water purification. Water treatment. Water supply 5(113) 16-24

[13] Feng X, Wang X, Chen Z and Chen J 2019 Nitrogen removal from iron oxide red wastewater via partial nitrification-anammox based on two-stage zeolite biological aerated filter Bioresource Technology 17-24

[14] Ovchinnikov A S, Bocharnikov V S and Denisova M A 2019 Technology of wastewater treatment of poultry enterprises using natural sorbents with the addition of ferrite suspension Proc. of the Lower Volga Agro-University Complex: science and higher professional education 1(1) 15–22

[15] Ovchinnikov A S, Loboyko V F, Bocharnikov V S, Ovcharova A Yu and Fomin S D 2019 State of the small rivers of the Volga basin within the lower Volga IOP Conference Series: Earth and Environmental Science 341 012107

[16] Ovchinnikov A S, Borodichev V V, Lytov M N, Bocharnikov V S, Fomin S D, Bocharnikova O V and Vorontsova E S 2018 Optimum control model of soil water regime under irrigation Bulgarian J. of Agricultural Science 24 909–913

[17] Rybalova O, Artemiev S, Sarapina M, Tsymbal B, Bakhareva A, Shestopalov O and Filenko O 2018 Development of methods for estimating the environmental risk of degradation of the surface water state Eastern-European Journal of Enterprise Technologies 2(10-92) 4-17

[18] Chertkov M P 2017 Application of biological methods of water purification during water treatment and wastewater treatment Russian engineer 1 44-49

[19] Yurkov A K, Kozlov I A and Biryulin S V 2018 Investigation of the possibility of using carbon filters for purification of radon-containing water Ural Geophysical Bulletin 2(32) 67-70

[20] Jalovaja N P and Barsuk I P 2011 Purification of natural waters from oil-containing wastewater pollution Bulletin of the Brest State Technical University. Water construction, heat power and geotechnology 2 87-90