Promising technology of wastewater treatment with natural ameliorants

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Abstract. The article presents the results of testing filter media with various natural sorbents. When studying the absorbing properties of zeolite, charcoal and gravel sand, their properties of removing heavy metals such as Zn, Ca, Cu, Fe, as well as ammonium nitrogen were studied. During experimental studies, all studied ion exchangers showed absorption properties to varying degrees. After calculating the static capacities of each of the studied sorbents, he showed that the best absorption properties are aluminosilicate (zeolite). After completing experimental studies within 48 hours, the best moisture-absorbing effect was observed with zeolite, after 12 hours of contact with poultry wastewater, it removed 64.7 percent of the total iron, and activated carbon and gravel sand only 15.4 percent. The result of research in the study of the absorption properties of heavy metals, ammonium nitrogen ions, showed that zeolite has the highest quality wastewater treatment. The removal of ions of chemical elements was more than 60 percent within 12 hours of being in the liquid phase, in contrast to charcoal and gravel sand.

1. Introduction

At present, the state of surface and underground waters is of concern, since their quality does not meet the standards of sanitary supervision. The reason for this is not conscientious purification of wastewater [1, 2, 3] and their discharge into rivers, lakes, etc. When studying the qualitative indicators of water analysis, it shows an increased content of toxic substances in the form of metals, sulfates, nitrates, ammonium, oil products [4, 5, 6, 7].

Wastewater is purified by various methods, such as reagent, without reagent, filtration, cascade filtration, multistage, sorption [8, 9, 10, 11].

The best from the point of technical and economic predominance are the processes of sedimentation and filtration, since in these methods of loading exhibit better properties of sorption in relation to toxic chemical elements.

Water absorption occurs when the sorbent absorbs a liquid or solid substance in this, and this is the process of sorption itself. This method makes it possible to produce a high degree of wastewater treatment [12, 13, 14, 15] from toxic impurities, which is the main advantage of this process. The absorption process largely depends on the correctly selected sorption material, on its granule size, crystal lattice, porosity, and resistance to a chemical environment.
The water absorption capacity of the selected sorption ion exchangers is influenced by factors such as residence time in an aqueous medium, pH, volumetric capacity, etc. There are several types of volumetric containers - static, absolute and dynamic.

When selecting a filtration material and its quality of poultry wastewater treatment in relation to toxic heavy metals and ammonium ion, all of the above parameters are necessary. Zeolite, also called aluminosilicate, has good static ion exchange capacity. Aluminosilicate has a porous structure and a well-developed crystal lattice, which allows it to conduct high selectivity to large ions. For the complete absorption of harmful substances from wastewater, an optimal contact time of aluminosilicate with soluble substances is required. There are many sorbents in the modern world, both natural and synthetic. The most high-quality and durable are natural sorbents, while studying the absorbing properties of zeolite, charcoal and gravel sand, their properties of removing heavy metals such as Zn, Ca, Cu, Fe, as well as ammonium nitrogen were studied [16, 17, 18, 19, 20].

To study the most effective sorbent for the absorption of chemical impurities were determined under static conditions [21, 22, 23].

2. Materials and methods
When studying the moisture-absorbing properties of zeolite, charcoal, gravel sand, the method for determining static conditions was used, developed at the Scientific Research Institute of Mineral Raw Materials – Russian Geological Society Standard «STO RosGeo 08-002-98».

Before performing the experiment, it is necessary to prepare containers for injecting the studied sorbent, add poultry wastewater, stir for several seconds to develop the reaction of the sorbent with a liquid medium, then separate the liquid phase from the solid by settling, filter the solution and perform photocolorimetric analysis of the test filtrate.

The volume of wastewater was taken in an amount of 250 ml, for this, volumetric flasks were used to which each sorbent was added in equal weights of 60 grams, the experiment was carried out under laboratory conditions.

3. Results and discussion
During experimental studies, all studied ion exchangers showed absorption properties to varying degrees. After calculating the static capacities of each of the studied sorbents, he showed that the best absorption properties are aluminosilicate (zeolite). After completing experimental studies for 48 hours, the zeolite showed the best moisture-absorbing effect after 12 hours of contact with poultry wastewater, it removed 64.7 percent of the total iron, and activated carbon and gravel sand only 15.4 percent. The combined composition of sorbents absorbed only 19.7 percent of heavy metals. Contact within 48 hours showed that the aluminosilicate (zeolite) reduced its sorption capacity to 54.6 percent, as the crystal lattice saturation occurred, and in the complex of activated carbon, gravel sand and zeolite up to 3.1%, respectively, in the activated coal and gravel sand sorption was not observed. Therefore, the best contact time of the sorbent with the liquid phase is observed within 12 hours (Figure 1).
Figure 1. The ability of various sorbents to absorb heavy metals and ammonium ions.

All studied ion exchangers showed their sorption properties in various percentages, the results of which are summarized in Table 1.

Table 1. Determination of sorption of various sorbents in waste water in relation to heavy metals and ammonium ions.

| Name of substance | Zeolite Fraction 0.75, 1.0, 4.0 mm | Activated carbon and gravel sand | Activated carbon, gravel sand and zeolite |
|-------------------|----------------------------------|---------------------------------|------------------------------------------|
|                   | Comparison, mg/l | Siskh-Comparison, mg/l | SOE, mg/g | Comparison, mg/l | Siskh-Comparison, mg/l | SOE, mg/g | Comparison, mg/l | Siskh-Comparison, mg/l | SOE, mg/g |
| Iron total        | 35.5             | 25.5                          | 10        | 0.04            | 35.0             | 0.5       | 0.44            | 32.2             | 3.3       | 0.01       |
| Iron II           | 15.6             | 10.6                          | 5         | 0.021           | 15.3             | 0.3       | 0.001           | 14.6             | 1.0       | 0.004      |
| Iron III          | 25.3             | 16.3                          | 9         | 0.037           | 24.3             | 1.2       | 0.004           | 22.3             | 3.0       | 0.008      |
| Chromium          | 1.1              | 0.55                          | 0.55      | 0.002           | 1.0              | 0.1       | 0.0004          | 1.0              | 0.1       | 0.0004     |
| Zinc              | 1.3              | 0.63                          | 0.67      | 0.003           | 1.3              | 0         | No sorption     | 1.0              | 0.3       | 0.001      |
| Copper            | 3.5              | 1.62                          | 1.88      | 0.007           | 3.5              | 0         | No sorption     | 2.5              | 1.0       | 0.004      |
| Cadmium           | 1.6              | 1.3                           | 0.3       | 0.001           | 1.6              | 0         | No sorption     | 1.3              | 0.3       | 0.001      |
| Name of substance | $S_{ub}, \text{mg/l}$ | Zeolite | Activated carbon and gravel sand | Activated carbon, gravel sand and zeolite |
|-------------------|----------------------|---------|---------------------------------|--------------------------------------------|
|                   |                      | Fraction 0.75, 1.0, 4.0 mm | Comparison, mg/l | Siskh-Comparison | SOE, mg/l | Comparison, mg/l | Siskh-Comparison | SOE, mg/l | Comparison, mg/l | Siskh-Comparison | SOE, mg/l |
| Ammonium           | 10.5                 | 6.4     | 4.1                             | 0.017                                      | 9.5 | 1.0                   | 0.004                                      | 8.5 | 2.0                   | 0.008                                      |
| Iron total         | 35.5                 | 15.5    | 20.0                            | 0.08                                       | 32.0 | 3.5                   | 0.45                                       | 30.1 | 5.4                   | 0.02                                       |
| Iron II            | 15.6                 | 5.25    | 10.35                           | 0.043                                      | 14.2 | 1.4                   | 0.005                                      | 13.5 | 2.1                   | 0.008                                      |
| Iron III           | 25.3                 | 8.35    | 16.95                           | 0.07                                       | 24.0 | 1.3                   | 0.005                                      | 21.4 | 3.9                   | 0.016                                      |
| Chromium           | 1.1                  | 0.35    | 0.75                            | 0.003                                      | 1.0  | 0.1                   | 0.0004                                     | 0.95 | 0.15                  | 0.0006                                     |
| Zinc               | 1.3                  | 0.26    | 1.04                            | 0.004                                      | 1.3  | 0.1                   | 0.0008                                     | 0.93 | 0.37                  | 0.0007                                     |
| Copper             | 3.5                  | 1.1     | 2.4                             | 0.01                                       | 3.5  | 0.0                   | 0.002                                      | 2.0  | 1.5                   | 0.006                                      |
| Cadmium            | 1.6                  | 0.8     | 0.8                             | 0.003                                      | 1.3  | 0.3                   | 0.001                                      | 1.0  | 0.6                   | 0.0025                                     |
| Ammonium           | 10.5                 | 3.4     | 7.1                             | 0.029                                      | 8.5  | 2.0                   | 0.008                                      | 7.3  | 3.2                   | 0.012                                      |
| Iron total         | 35.5                 | 12.5    | 23.0                            | 0.09                                       | 30.0 | 5.5                   | 0.46                                       | 28.5 | 7.0                   | 0.03                                       |
| Iron II            | 15.6                 | 4.8     | 10.8                            | 0.045                                      | 13.7 | 1.9                   | 0.007                                      | 11.6 | 4.0                   | 0.01                                       |
| Iron III           | 25.3                 | 6.3     | 19.0                            | 0.08                                       | 23.6 | 1.7                   | 0.007                                      | 19.3 | 6.0                   | 0.025                                      |
| Chromium           | 1.1                  | 0.14    | 0.96                            | 0.004                                      | 0.9  | 0.2                   | 0.0008                                     | 0.75 | 0.35                  | 0.001                                      |
| Zinc               | 1.3                  | 0.16    | 1.14                            | 0.004                                      | 1.0  | 0.3                   | 0.001                                      | 0.83 | 0.47                  | 0.002                                      |
| Copper             | 3.5                  | 1.0     | 2.5                             | 0.01                                       | 2.8  | 0.7                   | 0.003                                      | 1.82 | 1.68                  | 0.007                                      |
| Cadmium            | 1.6                  | 0.7     | 0.9                             | 0.003                                      | 1.1  | 0.5                   | 0.002                                      | 0.9  | 0.7                   | 0.003                                      |
| Ammonium           | 10.5                 | 1.9     | 8.6                             | 0.035                                      | 6.5  | 4.0                   | 0.016                                      | 5.5  | 5.0                   | 0.02                                       |
| Iron total         | 35.5                 | 14.3    | 21.2                            | 0.09                                       | 30.0 | 5.5                   | 0.46                                       | 29.7 | 5.8                   | 0.02                                       |
| Iron II            | 15.6                 | 5.1     | 10.5                            | 0.043                                      | 14.0 | 1.6                   | 0.006                                      | 11.9 | 3.7                   | 0.015                                      |
| Iron III           | 25.3                 | 6.9     | 18.4                            | 0.07                                       | 23.9 | 1.1                   | 0.006                                      | 19.9 | 5.4                   | 0.022                                      |
| Chromium           | 1.1                  | 0.17    | 0.93                            | 0.003                                      | 1.0  | 0.1                   | 0.0004                                     | 0.78 | 0.32                  | 0.0013                                     |
| Zinc               | 1.3                  | 0.17    | 1.13                            | 0.005                                      | 1.2  | 0.1                   | 0.0004                                     | 0.85 | 0.45                  | 0.0018                                     |
| Copper             | 3.5                  | 1.3     | 2.2                             | 0.009                                      | 3.1  | 0.4                   | 0.001                                      | 1.85 | 1.65                  | 0.006                                      |
| Cadmium            | 1.6                  | 0.75    | 0.85                            | 0.0035                                     | 1.2  | 0.4                   | 0.001                                      | 0.93 | 0.67                  | 0.0027                                     |
| Ammonium           | 10.5                 | 2.0     | 8.5                             | 0.035                                      | 6.9  | 3.6                   | 0.015                                      | 5.9  | 4.6                   | 0.019                                      |
| Iron total         | 35.5                 | 16.1    | 19.4                            | 0.08                                       | 30.0 | 5.5                   | 0.46                                       | 31.4 | 4.1                   | 0.017                                      |
| Iron II            | 15.6                 | 5.6     | 10.0                            | 0.041                                      | 14.9 | 0.7                   | 0.003                                      | 12.2 | 3.4                   | 0.014                                      |
| Iron III           | 25.3                 | 7.5     | 17.8                            | 0.074                                      | 24.2 | 1.1                   | 0.004                                      | 20.5 | 4.8                   | 0.02                                       |
| Chromium           | 1.1                  | 0.23    | 0.87                            | 0.003                                      | 1.0  | 0.1                   | 0.0004                                     | 0.82 | 0.28                  | 0.0011                                     |
| Zinc               | 1.3                  | 0.29    | 1.01                            | 0.004                                      | 1.3  | 0.1                   | No                                          | 0.91 | 0.39                  | 0.0016                                     |

| Copper             | 3.5                  | 1.5     | 2.0                             | 0.008                                      | 3.4  | 0.1                   | 0.0004                                     | 1.93 | 1.57                  | 0.0065                                     |
| Cadmium            | 1.6                  | 0.85    | 0.75                            | 0.0031                                     | 1.35 | 0.25                  | 0.001                                      | 0.98 | 0.62                  | 0.0025                                     |
| Ammonium           | 10.5                 | 2.7     | 7.8                             | 0.032                                      | 7.2  | 3.3                   | 0.013                                      | 6.3  | 4.2                   | 0.017                                      |
Having completed the experimental study on the sorption properties under static conditions of ion exchangers and having performed the calculation of the volumetric capacity, it can be seen that aluminosilicate (zeolite) showed the best result than charcoal and gravel sand.

4. Conclusion
The result of research in the study of the absorption properties of heavy metals, ammonium nitrogen ions, showed that zeolite has the highest quality wastewater treatment. The removal of ions of chemical elements was more than 60 percent within 12 hours of being in the liquid phase, in contrast to charcoal and gravel sand.

Experimental data are focused on reducing the environmental load of water bodies, as well as use them as irrigation water for irrigation of industrial crops.

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