Cascade method of wastewater treatment using various natural sorbents

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Abstract. In the presented paper the sorption properties of natural sorbents were studied. Quartz sand, activated carbon with a fraction of 0.3 mm and zeolite with a fraction of 0.75 mm were selected. Experiments were carried out in laboratory conditions, filtration was carried out through each of the presented sorbents, then chemical analysis was performed for residual concentration of chemical impurities in wastewater. There was also a comparison when filtering through each sorbent and cascade. The best result is filtering by cascade method, where the sorption of chemical impurities was more than 90%, which is a satisfactory result for compliance with sanitary norms.

1 Introduction

Wastewater is an environmental problem all over the world [1]. Many modern scientists are looking for and developing new methods and technologies for wastewater treatment. Also actively searched for the use and application of natural sorbents or adsorbents [2-5]. Why exactly natural, as these minerals have a long service life in contrast to synthetic ones. Synthetic ones mostly last from half a year to two years, as their abrasion, porosity, contact time with aggressive medium is not as durable as that of natural ones [6-7].

Natural sorbents have a finer and more porous crystal lattice, the abrasion process is very slow, have a more stable state to the aggressive environment of wastewater.

Many naturally occurring sorbents are known, including quartz sand, activated carbon, zeolite, peralusite, etc [8-11].

Currently, vertical filters with medium fraction quartz sand are used in wastewater treatment plants for the process of mechanical treatment of wastewater. This sorbent has a shorter service life than activated carbon and harder sorbents [12-13].

Activated carbons are used in the water treatment process to remove oil products, surface active substances, biological films, gasoline stains, etc. Also this sorbent is widely used in industrial production for wastewater treatment, but the range of chemical substances removal is not so wide.

Zeolite sorbents are known to be natural minerals that have a very porous structure and have a wide range of chemical impurities removal. They are easy to regenerate and have a service life of more than five years. Zeolites well sorb iron of various forms, nitrogen

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compounds, petroleum products and some heavy metals, which is not a small important quality of this sorbent. That is, the use of zeolite as a sorption load will remove heavy metals without the use of chemical reagents, which is an environmentally friendly way of wastewater treatment.

The study aims to utilize three natural sorbents for wastewater treatment by cascade filtration method.

2 Materials and methods

Taking into account the sorption properties of the filter load in the form of activated carbon, zeolite and quartz sand, we propose a cascade filtration method.

Filtering in this way will allow a study on each sorbent. The study will make it possible to obtain the adsorption dynamics of each natural material, and to investigate the sequence of their placement depending on the chemical impurities prevailing in water.

Three glass columns in which natural sorbents were placed were chosen for experimental studies in laboratory conditions. In the first column was placed activated carbon with a fraction of 0.3 mm. The next one was filled with zeolite with 0.75 mm fraction, and quartz sand was poured into the third one. All sorbents were pre-washed with distilled water to remove dust.

Wastewater was taken for preliminary chemical analysis to determine the substances contained. Chemical analysis was carried out using a photocolorimeter.

3 Results

When conducting preliminary determination of chemical elements in wastewater by photocolorimetry showed that all have exceeded the maximum permissible concentration of.

Table 1. Wastewater composition.

No. p/p	Chemical substance	Initial concentration, mg/l	MPC, mg/l
1	Total iron	35.5	0.3
2	Iron II	15.6	0.1
3	Iron III	25.3	0.1
4	Copper	3.5	0.001
5	Zinc	1.3	0.01
6	Ammonium	10.5	2.0
7	Petroleum products	4.5	0.3
8	Chromium	1.1	0.07

Experiments were carried out in 4 stages in the beginning filtration was carried out through each sorbent separately and chemical analysis was carried out.

The first stage of filtration was quartz sand, which showed clarification of wastewater and retention of coarse particles, but the maximum allowable concentration was not reduced, that is, quartz sand works well for removal of mechanical impurities.

Table 2. Experimental filtration data on quartz sand.

No. p/p	Chemical substance	Initial concentration, mg/l	MPC, mg/l
1	Total iron	35.5	0.3
2	Iron II	15.6	0.1
3	Iron III	25.3	0.1
4	Copper	3.5	0.001
5	Zinc	1.3	0.01
6	Ammonium	10.5	2.0
7	Petroleum products	4.5	0.3
8	Chromium	1.1	0.07

The second stage of filtration was activated carbon, this stage showed the result of good sorption of petroleum products and ammonium, the other chemical elements had a slight reduction.

Table 3. Experimental filtration data on activated carbon.

No. p/p	Chemical substance	Initial concentration, mg/l	MPC, mg/l
1	Total iron	15.3	0.3
2	Iron II	7.6	0.1
3	Iron III	10.1	0.1
4	Copper	1.5	0.001
5	Zinc	0.75	0.01
6	Ammonium	4.6	2.0
7	Petroleum products	1.32	0.3
8	Chromium	0.95	0.07

At the third stage with zeolite chemical elements were adsorbed almost 70%, this sorbent showed the best result of all presented, but the concentration of substances still exceeds the maximum permissible concentration, which does not meet sanitary standards.

Table 4. Experimental filtration data on zeolite.

No. p/p	Chemical substance	Initial concentration, mg/l	MPC, mg/l
1	Total iron	5.6	0.3
2	Iron II	1.6	0.1
3	Iron III	6.3	0.1
4	Copper	0.91	0.001
5	Zinc	0.23	0.01
6	Ammonium	2.7	2.0
7	Petroleum products	1.5	0.3
8	Chromium	0.15	0.07

The fourth step is the process of cascade filtration from the beginning through a column of quartz sand, then activated carbon and a column with zeolite. The result of cascade filtration showed the best option for the removal of chemical elements from the wastewater. The concentration of the substances was reduced to the maximum permissible concentration.

Table 5. Experimental data of cascade filtration.

No. p/p	Chemical substance	Initial concentration, mg/l	MPC, mg/l
1	Total iron	0.31	0.3
2	Iron II	0.097	0.1
3	Iron III	0.101	0.1
4	Copper	0.0014	0.001
5	Zinc	0.011	0.01
6	Ammonium	1.75	2.0
7	Petroleum products	0.26	0.3
8	Chromium	0.067	0.07

4 Discussion

Obtaining results for each sorbent is not satisfactory individually natural sorbents work only on certain chemical elements, which is not sufficient to achieve the maximum permissible concentrations.

From the experimental data obtained, it can be seen that filtering by cascade method is the most effective. The removal of substances amounted to more than 90%. Since each sorbent absorbed chemical elements from wastewater to a greater or lesser extent. Complex work of natural sorbents shows the best variant of wastewater treatment, which meets sanitary norms, which allows its reuse for technical purposes, or discharge into water bodies.

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5 Conclusion

Cascade filtration method is more effective than filtering through each sorbent separately. Experimental results showed that when filtering through quartz sand the concentration of impurities in wastewater remained unchanged, the sorbent worked only for clarification and retention of coarse particles. Activated carbon removed chemical elements by 45% and petroleum products by almost 75%. The best result was shown by natural zeolite removal of 80%. But it was not enough, as the wastewater did not meet sanitary standards. At cascade filtration all sorbents worked well, which led to a better result of wastewater treatment. The removal of impurities amounted to more than 90%, which corresponds to sanitary norms for the discharge of wastewater into water bodies or its reuse.

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