Justification of parameters of electric activator applicable to reduce mineralization of collector-drainage water

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Justification of parameters of electric activator applicable to reduce mineralization of collector-drainage water

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Abstract. The article substantiates the relevance of the problem of using collector-drainage water and the advisability of using electroactivators for this purpose. It is of scientific and practical interest to use diaphragm electroactivators for demineralization of collector-drainage water, using the principle of electrochemical activation due to unipolar treatment of agricultural effluents. Unipolar treatment reduces the degree of mineralization, changes the chemical composition, increases the electrodynamic properties, and makes it possible to treat water to the required degree. Prior to the experiments, the main factors and optimization parameters were identified, and a planning matrix of the experiment was drawn up. The experimental results allow us to identify the degree of correlation of the optimization parameter with the main factors. Using the Box-Benken method, the optimal parameters of the electroactivator are found.

1. Introduction

Although Uzbekistan has its water resources, it is among the countries in need of water resources. This harms the intensive development of agriculture and improved living standards [1].

In some regions, the quality of water resources in the country is unsatisfactory. The highest level of mineralization and pollution is found in the middle and lower reaches of the main rivers. This poses a serious threat to the health and well-being of the population, and to maintain the standard of living. The main pollution of surface and ground water is agriculture. The share of industrial and municipal water wastewater is small, but by the level of damage, it is extremely dangerous and harmful [2].

2. Methods

To use mineral water, it must be retreated and prepared for use. It requires expensive technical equipment and technology, as required by the technological scheme [3].

Electrochemical activation of fluid with unipolar water treatment in diaphragm electroactivator for irrigation and minimization of collector-drainage water is a fundamentally new method. Unipolar treatment modes the electrochemical effect of the substance reduces its mineralization, alters the chemical and ion composition of the substance, enhances its physic-chemical and electrodynamic properties, and enables the proper amount of water [4]. The efficiency of unipolar processing is characterized by the traditional quality of electrochemical processes (the degree of decomposition of the substance, etc.), the pH difference of the initial and treated fluid, and the reaction time. The low cost of this method (1–2 $. / M3), the simplicity of the design, and simplicity of operation make it widely available in agriculture [5, 6]. Several experiments have shown that the use of unipolar electrochemical activation of substances in various technological processes is widely used [7].

3. Results and discussion

For the experimental studies, a 0.5-liter two-chamber organic glass bath was taken. Graphite plates that produce positive and negative poles in water are taken as electrodes. There is a barrier between the cameras and the material. Different mineralized water was obtained and unipolar treated, a total of 50 experiments were performed: treatment of mineralized water from 250 to 1900 mg/l at 24 V and 40 V with current from 0.2 to 5.5 A.

The processing time was 15 minutes in all experiments. Positive and negative ionized water was stored in a separate container, the treated water underwent physic-chemical analysis.

Based on the results, statistical methods were used and experiments were developed prior to the beginning of the experiments to select the optimal parameters of the electric activator.

The schematic of the general solution of the problem involves the change of the factor's influence on the optimization parameter first and then the correlation between them, giving a general overview of the expected functional connectivity [8, 9].

The issue will be considered step by step. This is the basic principle of experiment planning. In the first phase, the results of each experiment are searched for directions to move to the optimum area with varying sizes of variables, for which the results are studied in small sections and bordered to linear links. If the second-order equations do not give the expected results, in the previous experiments in each phase, the results will be followed by additional experiments based on their intuition [10, 11, 12].

This operation will continue until the optimum is found. Here, the number of experiments is quite large and the characterization of the optimum is characterized by a nonlinear function. The regression equation obtained from the experiments is a mathematical model of the process and, based on the magnitude of the coefficients, the effects can be summarized and the degree of correlation between the factors and the optimization parameter is evaluated. The statistical accuracy of coefficients indicates the accuracy or degree of effect of the corresponding effects [13, 14, 15].

The basic idea of experience planning is the optimal management of the mechanisms in the event. The general scheme of planning experiments for solving extreme problems consists of a series of processes (operations) that can be divided into the following steps [16, 17, 18]. Put the question; optimization option; factor selection; Planning of the second experiment; conduct a second-order experiment and view the model; extrusion search; analysis of results;

The experiments were conducted using mathematical planning. In the initial case, the regression equation is adopted as follows.

$$y = b_0 + \sum_{i=1}^{3} b_i x_i + \sum_{i=1\, j=1}^{n.m} b_{ij} x_i x_j + \sum_{i=1}^{n} b_{ii} x_i^2 \qquad (1)$$

The optimization parameter is the electrode surface, electrode spacing, and diaphragm types as factors that consume 1 liter of water. The experiments were repeated 3 times [19]. The quality of the catalyst in the activator is estimated by the number of salts it contains, the pH, the oxidation, and the potential for recovery.

Results analysis and examples. In addition to the aforementioned indicators, the active chloride is measured as an anolite. A laboratory copy of the activator used in the experiments is shown in Figure 1.

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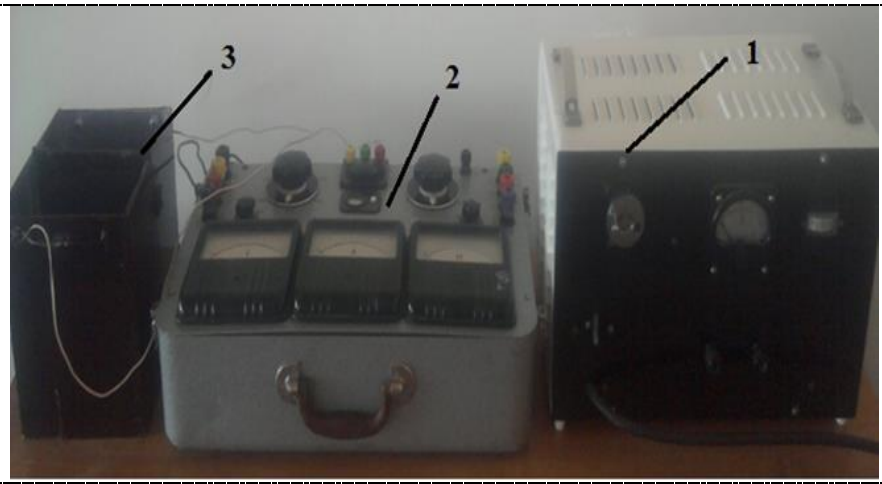

Figure 1. An overview of the electrochemical activator and its power supply; 1 is voltage generator, 2 is sets of measuring instruments (K-50), 3 is electrochemical drive unit.

The specifications of the electrochemical activator are as follows:
activator volume-1; rated voltage, 220 V; amount of electricity, -0.2-1,0 A; consumption power, 12-26 W; processing time, min-8-30; hydrogen ions activity, pH 3-13; water temperature, S0-45-55 (Tables 1, 2, 3).

Table 1. Factor coding and their quantities

Factors	Electrode surface, mm^2	Range of electrodes	Diagram
code	X_1	X_2	X_3
Basic level	2000	45	
Interval of change	500	10	
High level	2500	55	Bologna
Lower level	1500	35	cloth

Table 2. Matrix of statistical processing and baseline function of experimental results

g	X_1	X_2	X_3	*Y*
1	+1	+1	+1	21.2
2	+1	-1	+1	18.3
3	-1	+1	+1	11.8
4	-1	-1	+1	10.3
5	+1	+1	-1	31.5
6	+1	-1	-1	39.9
7	-1	+1	-1	31.5
8	-1	-1	-1	23.3
9	-1	0	0	18.5
10	+1	0	0	9.4
11	0	-1	0	9.5
12	0	+1	0	28.2
13	0	0	-1	23
14	0	0	+1	8.2

Table 3. b_j - the significance of the coefficients and t_j-criteria

The main function	j	z_j	b_j	$S^2(b_j)$	$S(b_j)$	t_j
1	0	284.6	12.31	0.71706	0.84680	14.53
X_1	1	24.9	2.49	0.17651	0.42013	5.93
X_2	2	22.9	2.29	0.17651	0.42013	5.45
X_3	3	-79.4	-7.49	0.17651	0.42013	-18.90
$X_1 \cdot X_2$	5	-15.2	-1.9	0.22063	0.46972	-4.04
$X_1 \cdot X_3$	6	0.8	0.1	0.22063	0.46972	0.21
$X_2 \cdot X_3$	8	4.6	0.58	0.22063	0.46972	1.22
X_1^2	11	216.7	1.89	0.71706	0.84680	2.24
X_2^2	12	225.5	6.29	0.71706	0.84680	7.43
X_3^2	13	219.0	3.04	0.71706	0.84680	3.59

The magnitudes of the regression coefficients are calculated using the following formulas:

$$b_0 = \frac{\sum_{n=1}^{n} y_{\text{mid.n}}}{N} \quad (2); \quad b_i = \frac{\sum_{n=1}^{n} X_{iu} y_{\text{mid.n}}}{N} \quad (3)$$

$$b_{ij} = \frac{\sum_{n=1}^{n} X_{ju} X_{iu} y_{\text{mid.n}}}{N} \quad (4)$$

The results of the experiment were statistically processed and tested for significance of the coefficients [20].

As a result, the following mathematical model was obtained

$$Y = 12.31 + 2.49x_1 + 2.29x_2 - 7.94x_3 - 1.9x_1x_2 + 1.89x_1^2 + 6.29x_2^2 + 3.04x_3^2$$

The optimal values of the process were determined using the Box-Benken method: the electrode surface is 2400 mm2, the distance between the electrodes is 50 mm and the diaphragm material is Bologna. The mineralization rate is 9.4 mg/*l*. it

4. Conclusion

1. Electrical activation causes electrochemical changes in the composition of the water, fluid mineralization decreases, oxidation, and recovery potential changes. The full-factor experiment determined the constructor parameters of the activator and the expression of the regression equation.
2. Optimized the following parameters: electrode surface - 2400 mm2, electrode spacing - 50 mm, and diaphragm material - Bologna. At the same time, the water salinity level is 9.4 mg / l when collector-drainage water is treated by electroactivators.

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