UDC 621.314;537.39

ANALYSIS OF THE EFFECT OF ELECTRO-DISCHARGE WATER TREATMENT ON ITS PURIFICATION DEGREE

Shaimerdenova K.M.[1], Stoev M.[2], Tusypbaeva A.S.[1], Rakhmankyzy A.[1], Sekerbaeva G.[1]

[1]Ye.A. Buketov Karaganda State University, 100028, Karaganda, Kazakhstan, gulzhan.0106@mail.ru

[2]Neofit Rila University, South-West, Blagoevgrad, Bulgaria

This article discusses the study of the analysis of the effect of electric discharges on the degree of water purification. A description of the technique for measuring specific electrical conductivity using a conductivity meter is presented. The technical process operation procedure for obtaining purified and decontaminated water during the electro-discharge treatment is given. In the course of the research, the change in the salinity and the specific electrical conductivity of the tap water and natural water samples after the treatment with the electric pulse method was studied. The experiments took into account the processing time and the number of electric pulse discharges.

***Keywords*:** water purification, water quality, electrical conductivity, electric pulse method, pulse discharge.

Introduction

The use of electric hydro-pulse effects is a promising method in the technology of purification, disinfection and activation of water. The electric pulse processing technology based on the unique effect of instantaneous energy release at the moment of electrical discharge in a liquid has huge hidden opportunities and new unexpected broad spheres of useful application due to its versatility [1]. Water quality is an important factor that affects the possibility and practicability of successful cultivation of products and plants. Increasing concentration of salts leads to a decrease in the number of basic macronutrients that can be introduced into the nutrient solution, while maintaining the optimum electrical conductivity of water.

When calculating fertilizers and total electrical conductivity of the treatment solution, it is necessary to take into account the concentration of individual macroelements, as well as sulfates, in order not to exceed the permissible amount of 100 mg/l SO_4. If the water is significantly saline, in order not to reduce the amount of fertilizers applied with the process solution, it is necessary to use ballast-free, readily soluble mineral fertilizers and, if possible, salts with lower electrical conductivity: potash, calcium and magnesium nitrate, monopotassium phosphate [2]

The salt content and electrical conductivity of tap and natural water, treated by electropulse method, were studied as well. In tap water, the salt content usually does not exceed 1000 mg/l, and, as a rule, is in the range of 300-600 mg/l. An electric hydro-pulse plant for water purification and activation has optimal parameters that make it possible to effectively purify, disinfect and activate natural water samples.

This paper presents the results of a study of the effectiveness of using electric pulse discharges for purification and disinfection of water from various natural sources in Central Kazakhstan.

.

1. Experimental technique

The measurements of the specific electrical conductivity were carried out on a Mark-602 conductivity meter with a conductivity sensor CS-025S and CS-2S. Advantages feature of the brand 602 conductivity meters with a conductivity sensor CS-025 and CS-2S are as follows:

- control of water chemistry treatment at thermal and nuclear power facilities;
- specialized water treatment;
- two channels;
- freely programmable measurement ranges;
- the possibility of independent measurements at two points;
- convenience and accuracy of measurements, minimum maintenance;
- double automatic compensation;
- the possibility of placing the converter unit at a remote distance from the sampling point to 100 meters;
- communication with external devices;
- galvanically isolated current outputs 0-5/4-20/0-20 mA;
- RS-485 port;
- programmable settings with “dry contact” type output;
- aluminum IP65 case;
- the device is reliably protected from dust and moisture;
- illuminated graphic indicator;

Using a conductivity meter, data on the electrical conductivity and salinity of tap and natural water were obtained. Water samples were processed using experimental equipment. During the experiment the plant parameters were as follows: U=18-40 kV, C=0.25, 0.5 μF, l_p=6-8 mm, the processing impulse f =2-2.5 Hz. The experiment was carried out taking into account the different number of electrical discharges and with the subsequent measurement of electrical conductivity and salinity of the water samples under study [3].

2. Process operation procedure for obtaining purified and disinfected water after electrical discharge treatment

To provide a special mode of pulsed water treatment, the test equipment of an electric pulse plant has been developed and constructed [5]. The plant for the implementation of the process operation procedure of purified and disinfected water obtained by electric discharge processing of natural water includes: a cylindrical water tank with the working space of 10 l; working site with a paraboloid reflector and a cylinder-shaped electrode. This site is designed for electric discharge water treatment. To conduct experimental work on obtaining purified and disinfected water in the "Laboratory of Physics of Pulsed Phenomena in Heterogeneous Media" of the Department of Engineering Thermophysics named after Professor Akylbaev Zh.S., a technological scheme for obtaining purified and activated water was assembled. The optimal parameters of the electric discharge technology to provide the process operation procedure for preparation of purified and decontaminated water are shown in Table 1.

The plant works as follows: the untreated water flows into the storage tank with a water level control. Water supply valves open. Reverse feed valves are used depending on the need to rerun treatment. A circulation pump makes for control of the water supply to the decontaminating device. After turning on the EHP plant, the voltage on the capacitor with a capacity C rises to the value U, at which spontaneous breakdown of the air forming gap takes place.

Stored in a capacitor water instantaneously flows through the positive electrode cable into the operating section to the interelectrode space l_p, where in the liquid a pulsed electrical discharge takes place, which is reflected from the paraboloid surface and the negative cylindrical electrode decontaminates the liquid [5].

Table 1. Process operation procedure for the preparation of purified and decontaminated water

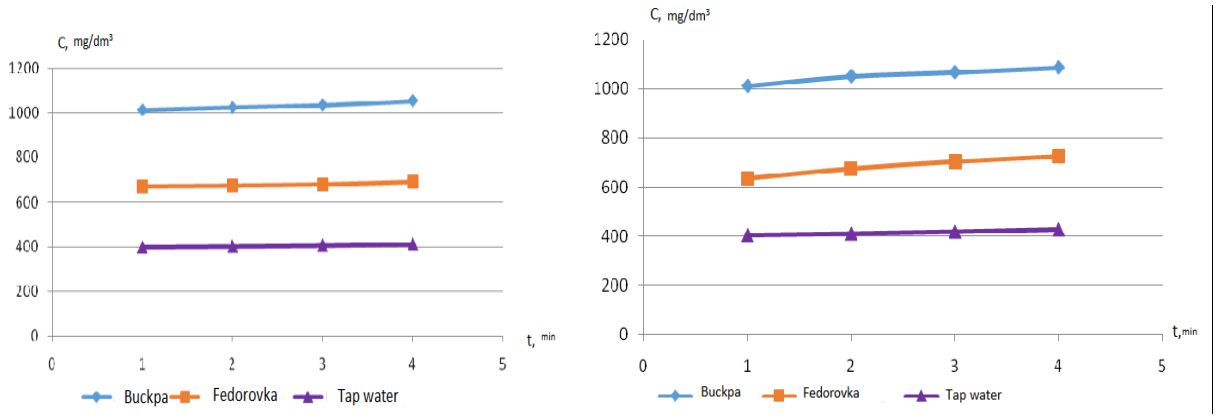
№	Names of indicators	Symbol	Unit of measurement	Numeric value
1	Voltage	U	kV	18-40
2	Interelectrode space	l_p	mm	6-8
3	Discharge energy	E	J	220-400
4	Capacitor capacitance	C	μF	0.25-0.5
5	Discharge rate	n	Hz	2 ÷ 2.5
6	Plant power	W	kW	1.5
7	Storage tank capacity	v	l	10
8	Pump power	W	W	60
9	Water treatment rate	F	l/min	80

3. Discussion of results

The experiment was conducted on a prototype of the electric hydropulse plant, taking into account the time and number of electrical discharges. The time interval ranged from 1 to 4 minutes, the number of discharges from 25 to 100 discharge blows.

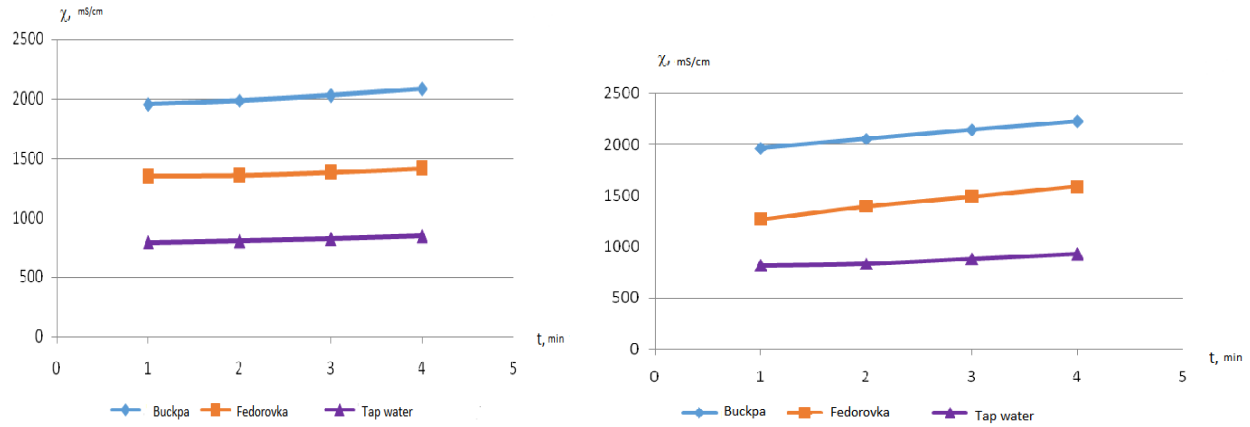
The researchers studied tap water with the following values of salt content C=401.5 mg/dm^3, SEC χ=784.3 μS/cm; water samples from the Fedorovsk reservoir were with the indicators C=664.9 mg/dm^3, SEC χ=1293 μS/m and the same indicators from the Bukpa River were C=1018 mg/dm^3, SEC χ=1891.2 μS/cm.

Based on the results of the experiment, graphs of the dependence of salt content and electrical conductivity of tap and natural water on the time and number of discharges were obtained (Figures 1-4).



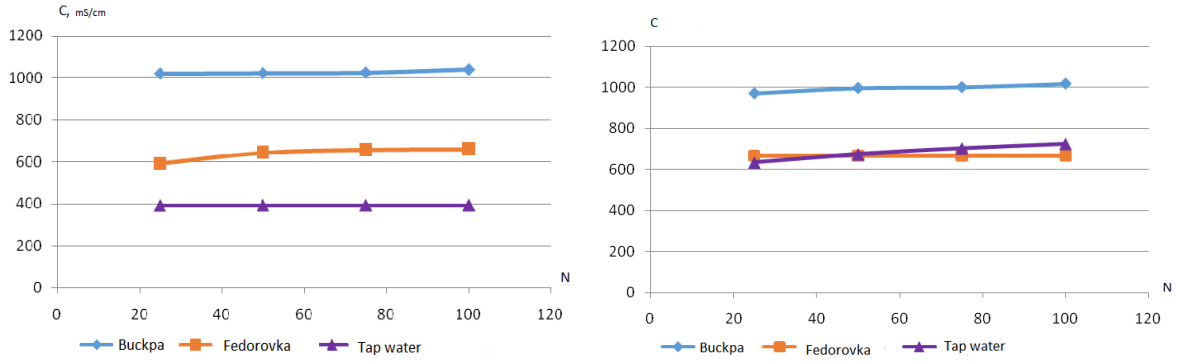
a) b)

Fig.1. Dependence of the salinity of tap and natural water on time:
a) C=0.25 μF, l_p=6 mm; b) C=0.5 μF, l_p=7mm



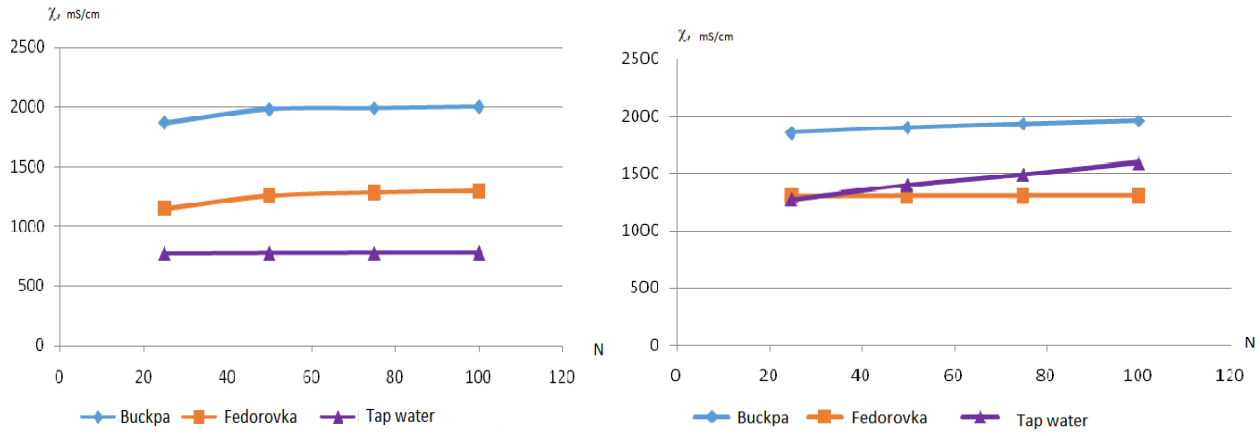
a) b)

Fig.2. Dependence of electrical conductivity of tap and natural water on time: a) C=0.25 μF, l_p=6 mm; b) C=0.5 μF, l_p=7mm



a) b)

Fig.3. Dependence of the salinity of tap and natural water on the number of discharges: a) C=0.25 μF, l_p=6 mm; b) C=0.5 μF, l_p=7mm



a) b)

Fig.4. Dependence of electrical conductivity of tap and natural water on the number of discharges: a) C=0.25 μF, l_p=6 mm; b) C=0.5 μF, l_p=7mm

The salinity of the water of the Fedorovsky reservoir and the Bukpa River is characterized by large temporal and spatial variability and represents an extensive area of close interaction between developed agro-industrial complexes and the stream ecosystem [4]. Due to the small size of the water storage basins and their small depths, the main elements of the hydrological and hydrochemical regime of the basins and the state of the ecosystem are subject to significant anthropogenic changes.

Due to the hydraulic effect caused by a pulse discharge in a liquid, an instantaneous release of energy accumulated in the capacitor battery takes place. During discharge, a plasma channel is formed. In the channel with a small cross section, there is an intense local heating of the liquid. When the temperature rises by 1°C, the electrical conductivity increases by approximately 2%. In this connection, when measuring the electric conductivity of the treated by the electric discharge method water, its increase is observed. Electrical conductivity is directly proportional to salt concentration.

Conclusion

The application of the electric-pulse device for water purification makes it possible to solve the issues of protecting water resources from depletion and pollution and their rational use for the needs of the national economy, which is one of the most important problems requiring urgent solutions. Electric hydropulse treatment for water purification makes for:

- reagent-free disinfection of water;
- elimination of all types of microorganisms, including viruses and spores;
- carrying out water treatment regardless of the amount of suspended solids and impurities.

During the study, experimental engineering activities on the development and design of an environmentally-friendly electric pulse water treatment technology were carried out. Thus, these studies demonstrate the advantages of applying a pulsed discharge for decontaminating water with high initial contamination [6].

The obtained results confirm that the application of electric discharge treatment makes it possible not only to carry out water decontamination more efficiently, but also to purify it with a higher initial degree of contamination.

REFERENCES

1 Kussaiynov K., Bulkairova G.A., Shaimerdenova K.M., Kutum B.B. et al.; *Patent No. 1794 Republic of Kazakhstan. Installation for electrohydropulse disinfection of running water*. No. 2015/0412.2; publ. 11/15/16, 5 p. [in Kazakh]

2 Kussaiynov K., Shaimerdenova K.M., Kutum B.B., Bulkairova G.A., Ranova G., Kivrin V. Effect of electrical discharges on the structure and properties of the electrode system during hydroimpulse treatment of water. Bulletin of KarSU. Physics series. 2015, No.3 (79), pp. 49 - 54. [in Russian]

3 Vilkov K.V., Grigoriev A.L., Nagel Yu.A., Uvarova I.V. Decontaminating action of a powerful pulsed electric discharge in water. PZhTF, 2004, Vol. 30, Issue 7, pp. 48 - 54. [in Russian]

4 Program for the development of the agro-industrial complex in the Republic of Kazakhstan for 2013-2020 (Agribusiness 2020), Astana 2012. Available at: http://www.government.kz/ru/programmy/2246-proekt-razvitiya-eksportnogo-potentsiala-myasa-krupnogo-rogatogo-skota.html [in Russian]

Article accepted for publication 10.12.2018

.