IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

Treatment of liquid fertilizer solutions by electrohydraulic effect and assessment of increasing the efficiency of plant nutrition

To cite this article: Abduvali Turdiboyev *et al* 2024 *IOP Conf. Ser.: Earth Environ. Sci.* **1420** 012001

Treatment of liquid fertilizer solutions by electrohydraulic effect and assessment of increasing the efficiency of plant nutrition

Abduvali Turdiboyev[1], Dilmurod Akbarov[1*], Anvar Norboev[2], Kholiyor Sayyid Safarov[2] and Muxammedgaliy Mamutov[3]

[1]Department of Electrical Technology and Operating of Electrical Equipment, National Research University "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers", 100000 Tashkent, Uzbekistan
[2]Department of Electrical Engineering, Karshi Engineering and Economics Institute, 180100 Karshi, Uzbekistan
[3]Karakalpak State University, Sh.Abdirov street №1, 230112 Nukus city, Republic of Karakalpakstan, Uzbekistan

[*]E-mail d_akbarov@tiiame.uz

Abstract. The article discusses the issue of increasing the efficiency of plant nutrition by treating liquid organic and mineral fertilizers with an electro-hydraulic effect. The amount of nitrates in water is reduced to 1.1 mg/l due to electro-hydraulic treatment. This creates the possibility of feeding plants and at the same time eliminating E. coli bacteria in liquid fertilizers from 2.23 mg/l. up to 102.7%, i.e. 82.55% compared to the control in exchange for its neutralization, which can prevent it from passing through the plant into the human and animal body, resulting in human health being maintained. As a result of the research, a process for electrohydraulic processing of liquid fertilizers was established, where the following processing modes and parameters were established to ensure the degree of grinding of solid particles in the liquid, processing voltage: U = 24 kV, capacitor capacity: C = 0.8 μF. , number of pulses: n=175 pulses, which turned out to be sufficient. Due to electro-hydraulic processing the rate of fertilizer uptake by plants has been improved over existing technology by optimizing the breakdown of coarse fertilizers into liquid solution through electro-hydraulic treatment of liquid fertilizer solutions. As a result, it was possible to increase the yield to 33 g for tomatoes and 37 g for cucumbers per 1 hectare owned by the farm using the method of electro-hydraulic treatment of liquid fertilizers.

1. Introduction

In the conditions of global climate change, all actions aimed at the purposeful and effective use of natural resources - land and water, as well as material resources - are ultimately aimed at increasing the efficiency of production in the field. In the agricultural sector of our country, important decisions and "Roadmaps" have been adopted on the introduction of modern resource-efficient technologies and innovative developments into production processes [1].

The situation that the problem is in right now. Plants absorb just 30–40% of the nutrients included in organic and mineral fertilizers. Because mineral fertilizers are mostly employed in dry, automated form in Uzbekistan's agro-industrial complex. Liquid fertilizers are more efficient than dry fertilizers in terms of plant nutrition, but they come with a high cost and labor need [4,5].

Although aqueous fertilizer solutions contain various minerals, their availability in a plant-absorbable form is often limited. A critical factor in boosting agricultural productivity is disrupting the cellulose and lignin cell membranes to release beneficial organic and mineral substances into a readily absorbable form for plants. This involves delivering these essential nutrients into the plant cells. [6,7,8]

2. Materials and methods

Presently using local fertilizers to feed plants is especially important when it comes to electrohydraulic processing. Local fertilizer is a special raw resource for the agricultural industry and the national economy since it comprises a complex of organic elements. Because they include chemical acids and organic materials from the local fertilizer, which are sources of physiologically active compounds that support living things' essential functions, soil fertility is increased. These qualities, however, do not appear until the organic fertilizer has undergone the correct breakdown processes and some of its constituents have been accessible for plant absorption. Using local fertilizer in its purest form is useless since this process moves very slowly in its natural condition. Several techniques are employed to activate the organic materials and nitrogen in animal dung for use as fertilizer, including thermal, chemical, and biological techniques [9, 10].

A possible method for activating complex organic structures with a multifactorial physicochemical effect is electrohydraulic treatment.

The primary challenge when using local fertilizer juice to irrigate crops is to produce a nutrient solution that meets certain requirements. Chemical components are soluble in water and, through root system absorption, contribute to plant nourishment. Different nutrients are needed depending on the stage of plant growth, however when using local fertilizers, they should be recycled [11].

The study included field, theoretical, and statistical data processing techniques.

3. Results and discussion

To evaluate the effectiveness of electrohydraulic treatment on liquid feed, the degree of decomposition is a key indicator of product quality.

The research experiments were carried out at the "Kabil Agzam Fayz" farm specializing in farming in the Akkorgan district of the Tashkent region.[12] We used the "Khonariq" (Margunenko) canal to irrigate plants on the farm. Water quality indicators are listed in Table 1 below.

Table 1. Water salinity levels (mg/l).

The name of the elements	Dry residue of salts in water
Ca	241
HCO_3	3-4 mmol/l
Cl	65-90
Na	91-110
Fe	4
Mn	0.89
B	0.62
Zn	0.73
S(SO4)	82 (250)

The level of salinity of the water samples taken from the "Khonarik" (Margunenko) channel fully meets the above requirements [13].

The time of processing liquid fertilizer with electrohydraulic effect is extended for 3-4 minutes.

After the liquid fertilizer is treated with the electrohydraulic effect, most of the effluents are broken down to particles with a diameter of 0.002 mm.

The dependence of the treatment wattage on the number of nitrates in water when treating liquid fertilizer with the electrohydraulic effect is summarized in Figure 1.

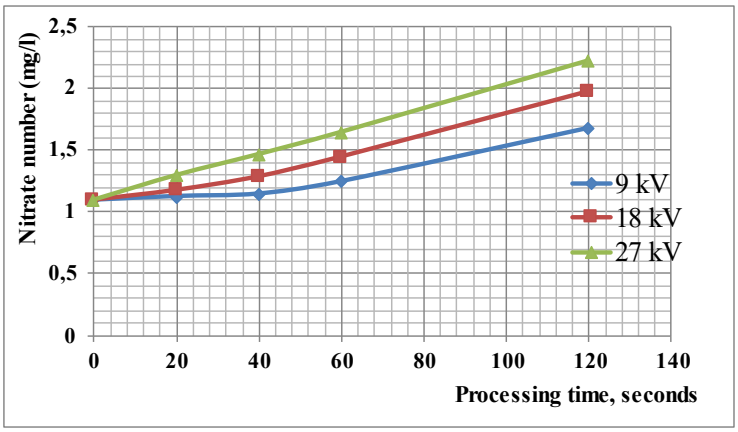

Figure 1. Dynamics of changes in the amount of nitrates in treated water at discharge voltages of 9, 18, 27 kV depending on treatment time.

The experimental results indicate that solely increasing the discharge voltage is insufficient to significantly elevate nitrate concentrations in water. Moreover, the duration of treatment significantly influences nitrate levels. To optimize the process, adjusting the discharge gap in air and the working gap between electrodes is crucial based on the desired discharge voltage. [14]

The electrohydraulic effect in water generates ultrasound and ultraviolet radiation, which collectively contribute to bacterial destruction. [15] The study revealed a correlation between bacterial mortality and both voltage magnitude and processing time (Figure 2).

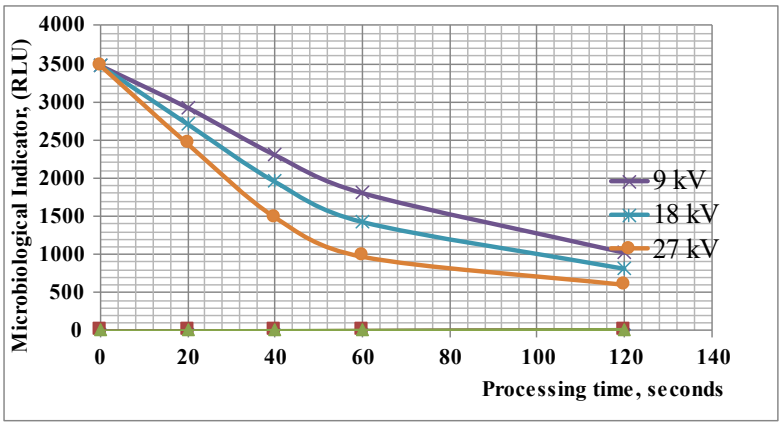

Figure 2. Dynamics of change of microbiological indicators depending on discharge voltage and processing time.

The experiments assessed the neutralization of E. coli bacteria in water. The results demonstrate that both processing time and discharge voltage significantly influence E. coli mortality. A higher discharge voltage correlates with increased ultrasound and ultraviolet radiation levels. [16]

Laboratory tests conducted at the Tashkent water supply company measured nitrate levels using a pH meter and ionometer, following standard procedures. [17] Electrohydraulic treatment effectively reduced nitrate concentrations from 2.23 mg/L to 1.1 mg/L, representing a 102.7% decrease. This reduction could potentially eliminate the need for additional plant fertilizer. In liquid fertilizers, E.coli (intestinal bacilli) bacteria are neutralized, i.e. up to 82.55% neutralization compared to the control.[18]

An improved electrical scheme of the electrohydraulic effect processing device was developed.

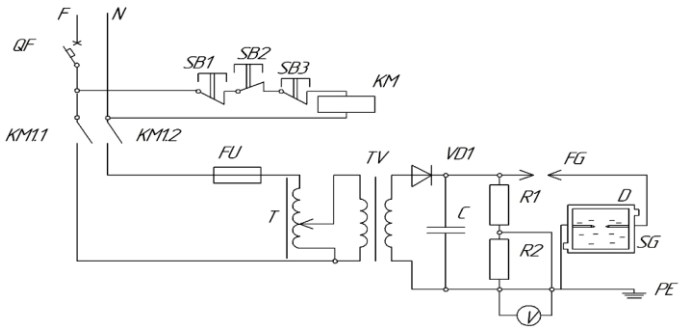

Figure 3. Electrical schematic diagram of the electro-hydraulic solution cleaning device.

To connect the device to the network in this scheme, the magnetic coil KM connects the contacts KM1.1 and KM1.2. A QF circuit breaker is used to protect the device from high current. The control system has a start button SB1, which gives a signal to the magnetic coil connecting the contacts KM 1.1 and KM 1.2. In turn, the SB2 "stop" button is used to disconnect the device from the network [19, 20, 21].

Electrohydraulic effect treatment device also includes: phase step-up transformer; VD-diodes (KTs-1007); High voltage capacitors (K-70-15); R1, R2 - resistors; High voltage voltmeter; electric shock protection device; FU- discharge interval.

The working principle of the generator is based on collecting the electric energy generated by the semi-sinusoidal charge current Iz passing through the primary windings of the pulse transformer and considered as the I stage of generation. The generator generates electricity.

As soon as the charging current reaches the value O, stage II begins. At this stage, the energy collection in the pulse transformer takes place due to the Electromotive Force. The angular frequency is calculated using the following formula [22,23].

$$\omega = \frac{1}{\sqrt{LC}} \quad (1)$$

where: L is the inductance of the secondary winding of the pulse transformer;

C - capacitor capacity;

The charging process of the capacitor occurs until the intermediate discharge FU is short-circuited. After the FU short circuit, the energy of the capacitor S and the energy remaining in the pulse transformer discharges the processed product [24].

As a result of research, the process of electrohydraulic effect treatment of liquid fertilizers, the following treatment modes and parameters ensuring the level of crushing of solid particles in the liquid were determined:

processing voltage: U = 24 kV;

capacitor capacity: C = 0.8 μF;

number of pulses: n = 175 imp;

Table 2. Primary technical parameters of the electrohydraulic treatment device for liquid fertilizers.

№	Technical indicators	Value
1	Productivity, m^3/h	6.0-7.5
2	Electropulse treatment time, sec	3-4
3	Mains voltage, V	28-85
4	Discharge voltage, kV	9-27
5	Total installed capacity, kW	8.1

The primary factors influencing the electrohydraulic effect were discharge voltage (U), capacitance (C), and the number of pulses (n). To assess the effectiveness of the electrohydraulic treatment method and characterize the processed product, particle size reduction (h) was used as a metric.

In order to achieve the maximum level of grinding of solid particles in the electrohydraulic treatment of liquid fertilizer, the following parameters were adopted: U=24 kV; C = 0.8 μF; n = 175-200 pulses.

In the preparation of fertilizer with a liquid solution: the solution is treated with an electrohydraulic effect.

By electrohydraulic treatment of liquid fertilizer, most of the solid particles are crushed to 0.005-0.002 cm. The duration of electric treatment, the size of the working chamber, the amount of concentration of water and fertilizer, the thickness of the seed layer, the amount of silage in the solution, electrodes range, water content, electric field strength and duration of electric pulses. After electrohydraulic treatment, the finished liquid solution is given to plants by drip irrigation.

Tomato and cucumber plants, destined for greenhouse cultivation, were chosen for research aimed at enhancing plant nutrition through the application of electrohydraulically treated liquid fertilizer.

Table 3. The composition of the liquid solution fertilizer taken for the test (in %).

Fertilizer type	The percentage of pure manure in liquid solution is in %	Percentage of discharges larger than 1 cm in %	Amount of various impurities in %	The amount of mineral fertilizer in the mixture is in %
Cattle manure	35	68	4,2	7,5

Table 4. Indicators of water used for the preparation of liquid fertilizer.

Indicator name	Value
Salinity level, 100-150 mg/liters	100-150 mg/l
Sodium	30-60 mg /l
water temperature	20^{o}C
Ph	4,5

Table 5. Effects of electrohydraulic treatment of liquid fertilizers on plant productivity.

#	Indicators of processed liquid fertilizer			Electrohydraulic effect processing indicators			Size of treated liquid fertilizer, cm.	Productivity: q.
	The proportion of pure manure in liquid solution is in %	The size of the liquid, cm.	Amount of different mixture in %	Voltage, kV	Capacitor capacity, μF	Processing time, min.		
Tomato "Gulband" - F1 variety								
1	35	67%/0.9	7.3	24	0.8	3-4	0.002	183
Cucumber "Sardor" - F1 variety								
2	35	68%/0.92	7.5	24	0.8	3-4	0.002	157

Table 5 shows that when liquid fertilizer is treated with electrohydraulic effect, the size of the fertilizer in the mixture is broken up to 0.002 cm, and the fertilizers of this size are easily absorbed by plants. This makes it possible to increase the productivity of plants up to 33-37 centners compared to the current fertilization technology.

4. Conclusion

In order to test the electrohydraulic effect processing device for liquid fertilizer under production conditions, plant cultivation and fertilization in the greenhouse belonging to the agricultural farm "Kabil Ag'zam Fayz" of the Okgorgan district of the Tashkent region. fermentation technology and technical indicators were analyzed. It was possible to place the device in the most effective way in accordance with the technical requirements and standards of the greenhouse and the technological stages of plant cultivation.

Through the electrohydraulic effect treatment of liquid fertilizer, the fertilizer absorption rate of plants has been improved compared to the current technology by optimally breaking down large fertilizers in liquid solution. As a result, it was possible to increase the productivity of tomatoes up to 33 centners and cucumbers up to 37 centners.

References

[1] Miroljub N et als 2021 *Industrija* **49** 25-42
[2] Bharati R 2022 *Eduzone: International Peer Reviewed/Refereed Multidisciplinary Journal* **11(1)** 223–41
[3] Nuralieva, N., Toshev, T., Beytullaeva, R., Khudaynazarov, A. 2024 *BIO Web of Conferences* **105** 06017
[4] Bokiev A, Nuralieva N, Sultonov S, Botirov A and Kholiknazarov U 2021 *E3S Web of Conferences* **264** 04022
[5] Khaliknazarov O, Turdiboyev A 2021 *International Journal of Advanced Research in Science, Engineering and Technology* **8(7)** 17621-5
[6] Oyewole A 2021 *International Journal of Advances in Engineering and Management* **3(2)** 780-7
[7] Ferreira J T E, Silva A M and Almeida A T 2018 *IEEE Transactions on Industry Applications*, **54(3)** 2071-84
[8] Ferreira J T E *2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe)*, (Palermo, Italy, 2018) pp 1-12, doi: 10.1109/EEEIC.2018.849388
[9] Laadjal K, Sahraoui M, Alloui A and Cardoso A J M 2021 *Machines* **9** 203
[10] Muhammadiev A, Yunusov R F, Bayzakov T M, Sattarov N E, Yusupov Sh B, Xaliqnazarov U A, Sattarov M N 2020 *IOP Conference Series: Earth and Environmental Science* **614** 012013
[11] Ibragimov M, Akbarov D, Tadjibekova I 2023 *E3S Web of Conferences* **365** 04019
[12] Liu X et al. 2023 Journal of Hazardous Materials **2023** 23-25
[13] Yunusov R, Imomnazarov A B, et al 2023 *IOP Conference Series: Earth and Environmental Science* **1142** 012019
[14] Kumar A and Gupta S K 2023 *Agricultural Reviews* **2023** 256-9
[15] Shreyner R T 2000 *Mathematical modeling of AC electric drives with semiconductor frequency converters* (Yekaterinburg: URO RAS)
[16] Ilinskiy N F, Rojanovskiy Yu V, Gornov D 2000 *Energy savings in the electric drive* (Moscow)
[17] Rakhmonov I, Berdishev A, Khusanov B, Khaliknazarov U, Utegenov U 2020 *IOP Conference Series: Materials Science and Engineering,* **883** 012104
[18] Danilov V N 1991 *Increasing the operational reliability of electric motors used in agricultural production by electronic means of protection* (Chelyabinsk)
[19] Zhang J, et al 2023 *Economic evaluation of electrohydraulic treatment for wastewater treatment. Environmental Science and Technology* (Elsevier)
[20] Eshpulatov N, et al 2023 *IOP Conference Series: Earth and Environmental Science* **1142** 012006
[21] Eshpulatov N, et al. 2021 *E3S Web of Conferences* **264** 04086
[22] Turdiboyev A, et al. 2023 *E3S Web of Conferences* **434** 01032
[23] Ibragimov M, Turdiboyev A, Akbarov D 2021 *IOP Conference Series: Earth and Environmental Science* **939** 012004
[24] Li Y, et al. 2023 Chemical Engineering Journal **2023** 258-63