DOI: https://doi.org/10.31073/mivg202402-390
Available at (PDF): https://mivg.iwpim.com.ua/index.php/mivg/article/view/390

UDC 631.811.982

EVALUATION OF THE POSSIBILITY OF FLUSHING OF DRIP IRRIGATION SYSTEMS WITH ELECTROCHEMICALLY ACTIVATED LOW-CONCENTRATION SALT SOLUTIONS

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Abstract. *The practice of using drip irrigation systems shows that contamination of drip outlets, including products of organic origin, is a serious threat to their reliable operation. In Ukraine, to combat such contamination, drip irrigation pipelines are flushed with environmentally hazardous 15 % sodium hypochlorite AquaDoctor made in China. At the same time, there is evidence in the world practice of the possibility of effective use of environmentally friendly electrochemically activated low-concentrated saline solutions, in particular, anolyte, for such purposes. The analysis of the domestic market of disinfectants, bactericidal agents and antiseptics suggested that the anolyte "Crystal" produced by PE "Personnel Lux" (Kharkiv), which has a high biocidal effect. Kharkiv), which has a high biocidal activity at a mass total concentration of 0.1 % of ADR, and electrochemically activated low-concentrated sodium hypochlorite "Secobren" with a hypochlorite content of up to 0.06 % produced by "UKRTEK PRODUCT" LLC (Kyiv), which may have similar properties, can be used for flushing drip outlets.*

Laboratory and field studies have been conducted to determine the possibility of flushing drip irrigation pipelines with electrochemically activated low-concentrated saline solutions to remove contamination of drip irrigation outlets with products of organic origin. The study was conducted during the flushing of drip irrigation pipelines with integrated drippers from ASSIF (METZER, Israel) with AquaDoctor, Crystal and Secobren disinfectants. Laboratory studies were conducted in the laboratory of the Institute of Plant Industry and Mechanics of the National Academy of Agrarian Sciences of Ukraine, accredited in the UkrSEPRO system, and field studies were conducted on subsurface drip irrigation systems in Cherkasy and Kyiv regions. For flushing in the field, the "Forced installation of supply and mixing of PUPS" developed by IRRIGATOR UKRAINE LLC was used.

The results of laboratory and field studies have shown that the washing capabilities of environmentally safe products "Kristal" and "Secobren" are comparable to those of environmentally hazardous hypochlorite "AquaDoctor". This makes it expedient to conduct further research to develop the technology of washing drip outlets depending on the nature and intensity of their pollution.

Keywords: *irrigated agriculture, drip irrigation systems, drip outlets, biological pollution, flushing, electrochemically activated low-concentration salt solutions, anolyte, sodium hypochlorite*

Relevance of the study. Information sources and the practice of using drip irrigation systems indicate that the development and use of advanced water treatment systems and filters, as well as the use of labyrinthine drip outlets with self-cleaning functions and anti-siphon systems, have largely eliminated the issue of drip irrigation contamination with inorganic particles. At the same time, there is a growing problem in the world of contamination of drip irrigation systems with various kinds of pollutants of organic origin, primarily the remains of microbial waste products in the form of biofilm in the labyrinths of drip outlets. As a rule, chlorine-containing substances are used to combat such pollution. In Ukraine, foreign-made sodium hypochlorite with 15 % chlorine content is used, which, when dissolved in water, forms by-products that are very dangerous for humans, animals and plants, such as trihalomethanes and halogenated acetic acids. This creates significant environmental risks for the soil and products grown on irrigated land.

At the same time, there are environmentally safe, electrically activated low-concentration substances with a low chlorine content that have powerful bactericidal properties and can be used to clean pipelines and drip outlets from biological contaminants. Identifying and testing the possibility of using such domestically produced substances that can effectively clean drip irrigation pipelines and drip outlets is an important practical task, the solution of which will improve the reliability of drip irrigation systems, ensure the preservation of soil fertility and reduce the environmental risks of negative environmental impact.

Analysis of recent research and publications. The main limiting factor that determines the efficiency, reliability and durability of drip irrigation systems is the issue of the reliability of drip outlets, which was noted by researchers in the late 70s of the last century [1] . It was also determined that the reliability of drip irrigation outlets is primarily related to the state of their clogging and the main types of pollution were identified – physical, salt and biological [1–4]. Clogging of drip irrigation outlets significantly reduces the uniformity of water distribution over irrigated areas, can lead to both excessive and insufficient moisture of plants, and negatively affects crop growth and yield [4–6]. The ever-increasing shortage of fresh water in the world and the aggravation of environmental problems associated with the need to dispose of wastewater have led to the widespread use of such water in drip irrigation systems over the past two decades [5, 7, 8] and have further exacerbated the need to clean drip irrigation pipelines and drip outlets from biological contamination. Until recently, the main method of combating biological pollution of water was its chlorination [9]. When chlorine comes into contact with water, it forms a mixture of hypochlorous (HClO) and hypochlorous (HCl) acids:

$$Cl_2 + H_2O \rightarrow HClO + HCl \ (1).$$

Hypochlorous acid is the main active ingredient formed when chlorine dissolves in water. It is a weak, environmentally safe acid and dissociates in water to form hypochlorous ion (ClO-) and hydrogen ion (H^+):

$$HClO \leftrightarrow H^+ + ClO^- \ (2).$$

HClO is a much more effective disinfectant than ClO because of its ability to penetrate the cell walls of microorganisms. It acts on microorganisms without damaging animal and plant cells [10]. But, in addition to it, chloramines, trihalomethanes, and halogenated acetic acids are also formed when chlorine dissolves in water [9]. These by-products of water chlorination are harmful to both humans and plants. In connection with these possible negative consequences of using chlorinated water for cleaning drip irrigation pipelines and drip outlets, in recent years, sodium hypochlorite (NaClO), which is also an effective disinfectant, has been used to flush drip irrigation pipelines [11]. When dissolved in water, hypochlorite forms hypochlorous acid (HClO), which, as in the case of chlorination, is the main bactericidal agent:

$$NaClO + H_2O \leftrightarrow HClO + Na^+ + OH^- \ (3),$$

According to the practice of using sodium hypochlorite in Ukraine, it can effectively neutralize organic formations in drip irrigation pipelines and drip outlets [11], but at high concentrations of active chlorine, its use has the same disadvantages as chlorination.

An alternative to chlorine and sodium hypochlorite is chlorine dioxide (ClO_2), which is used as a disinfectant in various industries, including water treatment, food processing, healthcare, and catering [12–14]. There is also experience in its use for cleaning drip irrigation systems [15]. Chlorine dioxide dissolves in water to form various products, including chloric ($HClO_2$) and hypochlorous ($HClO_3$) acids. During the dissolution of chlorine dioxide, hypochlorous acid is not formed, and chlorite (ClO_2^-) and chlorate (ClO_3^-) ions are the active disinfectants. However, according to some recent studies [14, 16], **the disinfectant effect of hypochlorous acid HClO exceeds the similar properties of** chlorate and chlorite ions. In this regard, for example, to ensure effective drinking water treatment, it is envisaged, in some cases, that it should be treated with sodium hypochlorite after chlorine dioxide treatment [14]. In general, hypochlorous acid [10] is one of the most interesting, effective, and environmentally friendly substances. It is naturally formed in the human body – produced by our white blood cells to fight pathogens. Hypochlorous acid has been investigated as a possible wound care product, and in 2016, the FDA approved it as a primary active ingredient in the treatment of wounds and various infections in humans and animals [10]. In 2020, disinfectants based on an electrochemically activated solution of hypochlorous acid HClO as an active ingredient also appeared on the Ukrainian market. Such products have a wide range of effects and are used in various applications. The safety of these products has been proven by research by Ukrainian and international specialized institutions [10]. In 2021, hypochlorous acid in a concentration of up to 200 PPM was included in the Order of the Ministry of Health of Ukraine dated 28.03.2020 No. 722 "Organization of Medical Care for Patients with Coronavirus Disease (COVID-19)».

Some authors, noting the extreme importance of biofilm control as one of the most dangerous types of biological contamination of pipelines and drip water outlets [17], emphasize that **an** effective substance for biofilm control can be **anolyte**, one of the environmentally safe components of electrochemically activated water, which also contains hypochlorous acid [18].

The use of anolyte is considered as an alternative to chlorine for disinfection of decentralized water supply systems and prevention of biofilms. There are significant advantages of such disinfection compared to chlorination: anolyte effectively reduces the formation of biofilms (the biomass of fixed biofilms is reduced by 37.5–79.9 %) [19]. Studies of the process of biofilm formation. call the reason for this – the vital activity of bacteria. **Anolyte** prevents the formation of biofilms better than other disinfectants by counteracting the attachment of inactivated microorganisms to the walls of pipes and emitters and removes existing microorganisms from surfaces [20]. Today, within the framework of the European Union's Horizon 2020 research and innovation program, in accordance with grant agreement No. 6, research is being conducted abroad on the use of anolyte for water disinfection in horticulture [21]. It is noted that heaters and UV installations do not affect the formation of biofilm, but anolyte effectively copes with this task. It can be used to destroy microorganisms in irrigation pipelines during the growing season, taking into account its environmental safety [22].

The aim of the study is to investigate the possibility and feasibility of flushing drip irrigation systems with electrochemically activated low-concentration saline solutions.

Research methods and materials. Theoretical and empirical methods of scientific research are used: analysis and synthesis, deduction and induction, comparison, as well as laboratory and field methods.

Research results and discussion. To achieve this goal, we analyzed the availability of anolites on the Ukrainian market, which are produced in industrial volumes and have high bactericidal properties. Literature sources state that all anolites demonstrate high antiseptic properties and environmental safety at low concentrations of their components, and some differences in the ratio of their components make it almost impossible for the vast majority of pathogens to develop resistance to them [22]. According to their characteristics, anolites are divided into acidic (pH 1 to 5,2), neutral (pH + 7,0 ± 1,5) and alkaline (pH = 9 or more). Neutral anolyte (NA), which is produced using catholyte, is the main type of anolyte widely used as a disinfectant today. There are anolyte production plants of various designs around the world with capacities ranging from 5 to 500 liters per hour. Before the war with Russia, the Ukrainian market offered a variety of anolites from foreign and domestic producers, which were used as disinfectants and decontaminants. Since the beginning of the war, this market has shrunk significantly. The main reason for this is the absence of domestic industrial facilities for the production of anolites in Ukraine. At the same time, anolites are present on the Ukrainian market and are produced at foreign facilities according to technical documentation approved in Ukraine. One of the largest producers of neutral anolyte in Ukraine is Personnel Lux PE (Kharkiv). The anolyte "Crystal" (Fig. 1, a) it produces has high biocidal properties and contains hypochlorous acid and highly active oxygenated chlorine compounds, chlorine free radicals, and oxygen: $HClO$; ClO_2; ClO^-; O_3; $H\ O_3{}^+{}_2$; $H\ O_3{}^+$; O_2 ; Cl^0. At the same time, their mass concentration in terms of active chlorine is only 0.1 %, which makes this reagent safe for humans, plants and animals. Most of the anolyte components relax into ordinary weakly mineralized water after some time (maximum several days) and do not accumulate in plants and soil. According to TU U24.2-3736315-001:2011, which is used to produce this anolyte, its alkalinity can range from 6 to 8. Studies of the Ukrainian market of disinfectants also revealed the presence of electrochemically activated, environmentally safe hypochlorite Secobren manufactured by UKRTEK PRODUCT LLC (Kyiv). In accordance with TU U 20.2-43534135-001:2020, chlorine-containing compounds in it are no more than 0.6 % (sodium hypochlorite – up to 0.06 %, sodium chloride – up to 0.5 %) (Fig. 1, b).

The analysis of the characteristics of the anolyte "Crystal" according to the indicators standardized by DSTU 7591:2014 "Water quality for drip irrigation systems. Agronomic, environmental and technical criteria" [23], shows that its use (even without dilution) does not pose environmental risks.

a) b)

Fig. 1. Domestic environmentally safe, electrochemically activated low-concentration substances in commercial containers and permits for their production:
a – Crystal anolyte; b – Secobren hypochlorite

Thus, the increase in the permissible values of toxic ion concentrations by soil groups given in Table 1 of DSTU 7591 "Assessment of irrigation water quality for the risk of secondary soil salinization (according to DSTU 2730)» when applying the anolyte "Crystal" even without dilution with water can be from 0.6 to 4 %. When diluted with water for washing in a ratio of 1:100, the increase in indicators can be only 0,006…0,04 %, i.e., there will be no practical impact.

Table 2 of DSTU 7591 "Assessment of irrigation water quality for the risk of soil alkalization (according to DSTU 2730)» shows that the introduction of the anolyte "Crystal", whose pH is 7.2, will not change the water quality class. The same applies to the impact on the risk of soil salinization (Table 3 of DSTU 7591 "Assessment of irrigation water quality for the risk of soil salinization (according to DSTU 2730)»).

The analysis of the environmental safety of anolyte (Tables 5, 6 and 7 of DSTU 7591) shows that it cannot pose a threat according to the indicators given in these tables, as it does not contain trace elements and heavy metals, pesticides, phenols, cyanides, oil products, etc. Due to its extremely low degree of mineralization, it will not affect the suitability of irrigation water in terms of the degree of impact on the elements of drip irrigation systems (Table 8 of DSTU 7591).

The same conclusions can be drawn from the analysis of the characteristics of electrochemically activated low-concentration sodium hypochlorite "Secobren"

The effectiveness of the use of Crystal and Secobren for cleaning drip irrigation pipelines and drip outlets in comparison with AquaDoctor anolyte (China) with 15 % active chlorine content, which is currently used for these purposes, was tested in the laboratory and in the field. Laboratory studies were carried out on three samples of pipelines (METZER Israel) 1,5, 2,3 and 2,4 m long with compensated drippers with a nominal flow rate of 0,85 l/h (≈ 14 ml/min) with a distance between drip outlets of 0,5 m. The samples were taken from the underground irrigation system installed by Irrigator Ukraine LLC in the POA "UKRAINE" of Boryspil district, Kyiv region, near Velyka Karatul village. Water is supplied to the system from the Dnipro River, which is why there was little sand and silt in the water during the irrigation period, but a significant amount of algae. To preserve the vital activity of the pathogenic biota, the samples were delivered to the laboratory filled with water. The research was carried out at the stand for testing drip irrigation pipelines at the Laboratory for Testing Irrigation and Drainage Facilities of the Institute of Water Resources and Management of NAAS (Certificate of Measurement Capabilities No. PT-8/24 of 11.01.2024). The research was carried out according to the test methodology for microirrigation technical means developed at IWPIM NAAS [24].

During the tests, the flushing capacity and efficiency of cleaning drip outlets from contaminants were determined by the following agents: AquaDoctor sodium hypochlorite (China) with an active chlorine content of 15 %, Crystal anolyte and Secobren hypochlorite.

Results of laboratory tests. Flushing of drip outlets was carried out in two stages. At the first stage, the concentration of the solutions was 1‰, measurements of the change in the capacity of the drip outlets were carried out at operating pressures from 0,025 to 0.1 MPa with a step of 0,025 MPa *(nominal operating flow rate of the drip outlet is 0,85 l/h (14 ml/min)* (Table 1):

1. Evaluation of changes in the flow characteristics of drip outlets depending on the impact of different types of detergents

Active ingredient	%, drip water outlets	***Pressure, MPa***											
		0,15			**0,2**			**0,25**			**0,3**		
		Flow rate depending on pressure, ml/60s											
		to	**after**	**%, changes from nominal**	**to**	**after**	**%, changes from nominal**	**to**	**after**	**%, changes from nominal**	**to**	**after**	**%, changes from nominal**
Aqua Doctor	33	0	7	50	0	11	79	0	14	100	12	14	100
	33	0	0	0	0	0	0	0	0	0	0	0	0
	34	1	0	0	2	0	0	4	0	0	3	0	0
Secobren	25	8	10	71	13	13	93	12	13	93	12	13	93
	25	7	8	57	10	10	71	10	11	79	10	12	86
	25	6	8	57	9	9	64	10	10	71	11	10	71
	25	5	1	7	4	4	29	12	12	86	13	13	93
Crystal	20	7	7	50	9	10	71	11	11	79	12	12	86
	20	7	8	57	6	10	71	9	10	71	7	8	57
	20	6	7	50	8	10	71	11	11	79	11	12	86
	20	7	7	50	8	10	71	11	12	86	12	13	93
	20	0	0	0	0	0	0	0	0	0	0	0	0

At both stages, after draining the water that filled the samples during transportation to the laboratory, one of the samples was filled with AquaDoctor, the second with Crystal, and the third with Secobren.

The samples filled with reagents were kept for 48 h, after which the washing agents were drained and the flow rates of the drip outlets were determined. Drip flow rates were measured after pressure stabilization for 10 min at a given gradation: at the first stage – 0,025, 0,05, 0,075, 0.1 MPa, at the second stage – 0,15, 0,2, 0,25, 0,3 MPa. The flow rates of the droppers were determined by the volumetric method using 25 ml measuring cups and a stopwatch. The determination time at each pressure was 60 seconds. The pressure was created by the test bench pump, controlled by a manometer, and regulated by a valve.

Sampling of underground drip irrigation pipelines for research was associated with the difficulty of digging them out and transporting them with water to the laboratory. This made it impossible to select long sections of pipelines with a number of drip outlets that could provide statistical processing of the results in accordance with the methodology [24]. Therefore, it can be assumed that the results obtained give a general idea and trends about the phenomena under study, in our case, the possibility of flushing drip irrigation systems with electrochemically activated low-concentrated saline solutions without quantifying them using mathematical statistics. Next year, the study is planned to continue to obtain statistically reliable results of flushing efficiency and to develop elements of the technology for flushing drip irrigation systems with environmentally friendly electrochemically activated saline solutions.

As can be seen from Table 1, 30 % of the drip outlets were flushed with AquaDoctor hypochlorite with a flushing solution concentration of 1 ppm and pressures of 0,025, 0,05, 0,075, 0,1 MPa, and the flow rate of only 33 % of the flushed drippers was restored to the nominal value. 67 % were not flushed. All 100 % of the drips washed with Secobren hypochlorite restored their throughput to values close to the nominal value. 60 % of the drips washed with Kristall anolyte restored their capacity almost completely, 20 % restored partially, and 20 % were not washed.

At the second stage, the concentration of solutions was 5‰, and measurements of changes in the throughput of drip water outlets were carried out at the following operating pressures from 0,15 to 0,3 MPa with a step of 0,025 MPa (Table 2).

2. Evaluation of changes in the flow characteristics of drip outlets depending on the impact of different types of detergents

Active ingredient	**%, drip water outlets**	***Pressure, MPa***											
		0,15			**0,2**			**0,25**			**0,3**		
		Flow rate depending on pressure, ml/60s											
		to	**after**	**%, changes from nominal**	**to**	**after**	**%, changes from nominal**	**to**	**after**	**%, changes from nominal**	**to**	**after**	**%, changes from nominal**
Aqua Doctor	33	14	13	93	14	14	100	14	14	100	14	14	100
	33	0	0	0	0	0	0	0	0	0	0	0	0
	34	0	0	0	0	0	0	0	0	0	0	5	36
Secobren	25	13	14	100	13	14	100	13	14	100	13	14	100
	25	12	10	71	12	12	86	12	12	86	12	12	86
	25	10	13	93	10	11	79	10	11	79	10	11	79
	25	13	10	71	13	14	100	13	13	93	13	14	100
Crystal	20	12	12	86	12	13	93	12	13	93	12	13	93
	20	8	9	64	8	9	64	8	7	50	8	11	79
	20	12	13	93	12	12	86	12	14	100	12	14	100
	20	13	13	93	13	13	93	13	14	100	13	14	100
	20	0	13	93	0	13	93	0	14	100	0	14	100

The results of laboratory tests show that of all the droppers that were washed with AquaDoctor hypochlorite solution, 33 % of the droppers recovered completely, 33 % partially, and 34 % did not recover at all. 50 % of the drips washed with Secobren recovered 100 %, 25–90 %, and 25–80 %. Of those washed with Kristall, 60 % restored their capacity by 100 %, 20 % by 93 %, and 20 % by 79 %.

The data obtained indicate that domestic environmentally safe electrochemically activated low-salt solutions of anolyte “Crystal” and sodium hypochlorite “Secobren” exceed the environmentally hazardous 15 % sodium hypochlorite “AquaDoctor” produced in China in terms of their washing capacity to clean drip outlets from contaminants of biological origin.

Results of field research.

Field studies were conducted jointly with IRRIGATOR UKRAINE LLC on two subsurface drip irrigation systems: in the fields of the PAO “UKRAINE” in Boryspil district of Kyiv region and LLC SPF “Urozhay” in Cherkasy region (near the village of Liplyave). The pumping stations of both systems take water from the Dnipro River.

The areas irrigated by drip irrigation systems created by Irrigator Ukraine LLC are divided into irrigation blocks. The systems of POA UKRAINE and Urozhay LLC have 10 of them (1–1 to 1–10). During the irrigation cycle, the irrigation blocks work in pairs, creating an irrigation shift. Bermad Turbo IR M water meters are used to record the flow rate in each pair of simultaneously operating units (Fig. 2).

a b c

Fig. 2. Fittings and equipment for flushing subsurface drip irrigation pipelines in the field:
a – Bermad Turbo IR M water meter; b – installation for flushing subsoil drip irrigation pipelines designed by IRRIGATOR UKRAINE LLC; c – end cranes of two adjacent pipelines

During the irrigation season, data on consumption is recorded in the irrigation log. When operating subsurface irrigation systems, they are flushed from mechanical contamination on a monthly basis, and flushed with chemicals during algae blooms and at the end of the season. An indicator for flushing the system is a reduction in the consumption of irrigation modules by more than 5 %. The quality of flushing is assessed by the following factors: a – the renewal of module consumption; b – the degree of transparency of drain water after preliminary flushing and keeping water with a chemical in the pipeline for 24 hours (the darker the color, the higher the quality of flushing); c – inspection of the condition of the components of the drippers.

Comparison of the flushing effect on the cleaning of drip irrigation pipelines and drip outlets from contaminants of biological origin with AquaDoctor, Crystal and Secobren substances was carried out using the flushing unit of the PUPZ LLC "IRRIGATOR UKRAINE" [25] (Fig. 2, b) . Three irrigation blocks of these subsurface irrigation systems with a length of irrigation pipelines of 300 m with compensated drippers ASSIF (METZER Israel) with a nominal flow rate of 0,85 l/h in each of the farms were first emptied through the end taps (Fig. 2, c), and then filled separately with solutions of "AquaDoctor", "Crystal" and "Secobren" and left for 24 hours. After that, the solutions were drained, and the pipelines and drip outlets were flushed with irrigation water under a pressure of up to 0,3 MPa. The concentration of solutions during flushing was: in SPF "Urozhay" – 1,5 liters of "AquaDoctor", "Crystal" and "Secobren" were dissolved in 3,1 m of^3 water (the concentration of solutions was equal to (about 0,5‰); in PJSC "UKRAINE" – 3 liters of "Crystal" and "Secobren" and 1 liter of "AquaDoctor" were dissolved in 2,6 m of^3 water (the concentration of solutions was equal to 1,15 and 0.38‰). Due to the fact that the flushing was carried out after the end of the irrigation season, water was delivered by tankers and the use of Bermad Turbo IR M water meters, which are equipped with the systems, was impossible. During the research, the transparency of the drain water after preliminary flushing and aging with water and chemicals in the pipeline for 24 hours was visually analyzed (Fig. 3).

This assessment showed comparable results of the quality of flushing with all three tested substances – hypochlorites "AquaDoctor" and "Secobren" and anolyte "Crystal". In addition, the quality of flushing of drip outlets with AquaDoctor, Secobren, and Crystal was assessed by opening the drip outlets and analyzing the condition of their components (filters, membranes, main and self-flushing labyrinths, and outlet chambers) before and after flushing (Fig. 4). In total, 5 drip outlets were opened for study on each of the three studied pipelines in each of the farms. That is, the quality of flushing with each of the substances (AquaDoctor, Secobren and Crystal) of ten drip outlets was investigated, and the components of the drip outlets were analyzed to determine which are most susceptible to clogging.

The main structural elements of the studied pipeline drippers are an inlet filter, a main labyrinth with a wide channel, a silicone membrane, a self-flushing pressure compensation labyrinth, and an outlet chamber. As can be seen from Figs. 4 and 5, the inlet filter is cleaned well enough during flushing and cannot be the reason why the drips cannot be restored to their capacity.

Figure 5 shows that the main labyrinth (No.1) is completely cleaned of contaminants after the droppers are washed. Some contaminants that do not affect the performance of the droppers may remain in the outlet chamber of dropper No. 2. It should be noted that, according to the observations of IRRIGATOR UKRAINE LLC specialists,

a b c

Fig. 3. Visual assessment of the quality of flushing of subsurface drip irrigation pipelines in the field: a – in 5-liter containers; b – at the beginning of the pipeline discharge after flushing; c – at the end of the pipeline discharge after flushing

Fig. 4. The appearance of the drippers from the side of the inlet filter:
a – before flushing; b, c – after flushing

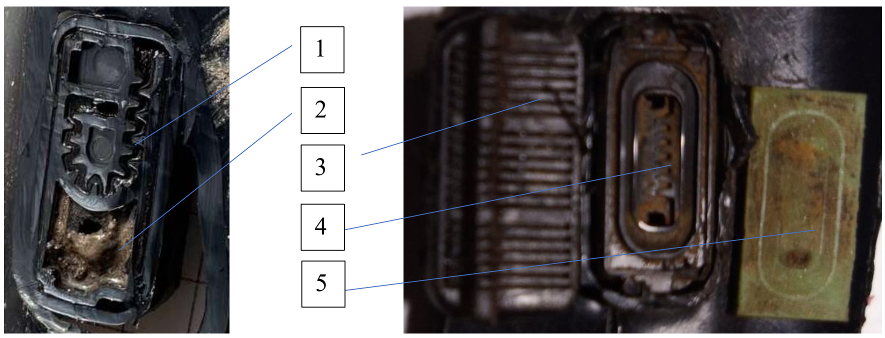

Fig. 5. View of the dropper components after flushing:
1 – main labyrinth; 2 – dropper outlet chamber; 3 – inlet filter; 4 – self-flushing labyrinth; 5 – silicone membrane

contamination of the outlet chamber occurs by dirt entering the dropper from the outlet side during the installation of pipelines when there is no water in them and the anti-siphon systems of droppers are not working. This is typical for underground pipelines. The silicone membrane (No. 5) in all the drippers tested was undamaged, flat and elastic, so it could not have caused the drippers to fail. The most vulnerable component of the droppers, in terms of contamination with particles of organic origin, is the self-flushing labyrinth (No. 4). It is significantly contaminated in all drips, which, in our opinion, is the main reason for the loss of drip capacity. Despite the fact that the studied drips are quite advanced systems with dense filters, pressure stabilizing mechanisms and anti-siphon systems, their design did not take into account the possibility of penetration and further development of a large number and variety of biological microorganisms This makes it necessary to periodically flush them when using recycled water or water from surface sources.

Field studies of domestic environmentally safe, electrochemically activated substances such as Kristal anolyte and Secobrand hypochlorite have confirmed that their cleaning capacity for drip irrigation pipelines and drip outlets from biological contaminants is comparable to the environmentally hazardous foreign product with a high chlorine content that is currently used in Ukraine for these purposes.

Conclusions. The results of laboratory and field studies have shown that the washing capabilities of environmentally friendly means of electrochemically activated low-concentrated saline solutions “Crystal” and “Secobren” are comparable to those of environmentally hazardous 15 % hypochlorite “AquaDoctor” and are promising for their further use in drip irrigation systems.

The working concentrations of solutions of “Crystal” and “Secobren” substances required for washing emitters of drip irrigation systems were preliminarily determined and the need for more detailed laboratory and field studies on this issue was substantiated (development of washing technology depending on the nature and intensity of contamination). Given that the use of “Crystal” and “Secobren”, due to their environmental safety, does not impose restrictions on the number and intensity of flushing, as is the case when using the highly toxic 15 % sodium hypochlorite “AquaDoctor”, it is possible to thoroughly clean drip irrigation systems and restore up to 100 % of the throughput capacity of drip outlets, even during the growing season.

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УДК 631.811.982

ОЦІНКА МОЖЛИВОСТІ ПРОМИВКИ СИСТЕМ КРАПЛИННОГО ЗРОШЕННЯ ЕЛЕКТРОХІМІЧНО АКТИВОВАНИМИ НИЗЬКОКОНЦЕНТРОВАНИМИ СОЛЬОВИМИ РОЗЧИНАМИ

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Анотація. *Практика використання систем краплинного зрошення свідчить, що забруднення краплинних водовипусків, у тому числі продуктами органічного походження, є серйозною загрозою їх надійної роботи. В Україні для боротьби з таким забрудненням використовують промивки трубопроводів краплинного зрошення екологічно небезпечним 15 % гіпохлоритом натрію "AquaDoctor" виробництва КНР. Разом з тим, в світовій практиці існують данні про можливість ефективного застосування для таких цілей екологічно безпечних електрохімічно активованих низькоконцентрованих сольових розчинів, зокрема – аноліту. Аналіз вітчизняного ринку дезінфікуючих та бактерицидних засобів і антисептиків дозволив припустити, що аноліт «Кристал» виробництва ПП «Персонал Люкс» (м. Харків), який має високу біоцидну активність при масовій сумарній концентрації АДР 0,1 %, та електрохімічно активований низькоконцентрований гіпохлорит натрію «Секобрен» з вмістом гіпохлориту до 0,06 % виробництва ТОВ «УКРТЕК ПРОДАКТ» (м. Київ), що має може аналогічні властивості, можуть бути використані для промивки краплинних водовипусків. Проведено лабораторні і польові дослідження щодо можливості промивки електрохімічно активованими низькоконцентрованими сольовими розчинами забруднень краплинних водовипусків продуктами органічного походження. Дослідження проведено при промивках трубопроводів краплинного зрошення з інтегрованими крапельницями фірми ASSIF (METZER, Ізраїль) дезінфікуючими засобами "AquaDoctor", «Кристал» та «Секобрен». Лабораторні дослідження проводились в акредитованій в системі УкрСЕПРО лабораторії ІВПіМ НААН, польові – на системах підґрунтового краплинного зрошення Черкаської та Київської областей. Для промивки в польових умовах використовувалась «Примусова установка подачі та змішування ПУПЗ» розробки ТОВ «ІРРІГАТОР УКРАЇНА».*
Результати лабораторних і польових досліджень засвідчили, що промивні спроможності екологічно безпечних засобів «Кристал» та «Секобрен» є співставні з можливостями екологічно небезпечного гіпохлориту "AquaDoctor". Це робить доцільним проведення подальших досліджень для відпрацювання технології промивки краплинних водовипусків в залежності від характеру та інтенсивності їх забруднення.

***Ключові слова**: зрошуване землеробство, системи краплинного зрошення, краплинні водовипуски, забруднення біологічного походження, промивки, електрохімічно активовані низькоконцентровані сольові розчини, аноліт, гіпохлорит натрію*