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REAGENT PURIFICATION OF THE PROCESSING INDUSTRY ENTERPRISES EFFLUENTS

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Abstract. The article represents the results of research of the effluents purification by the reagent methods. The effluents were polluted by organic compounds of processing enterprises with small productivity. The analysis of pollution of the hydrosphere caused by the processing enterprises is carried out and the promising methods of cleaning wastewater from pollution are given. As an object of research, the streams of the production site of the fruit and vegetable juices of the Buzky Canning Factory were used. As a reagent-oxidant, sodium hypochlorite was studied. The mechanism of purification of contaminated wastewater with sodium hypochlorite is considered in detail.

The task of experimental studies was to determine the flow of sodium hypochlorite where wastewater treatment is carried out to a level lower than that regulated by standards. The criterion for cleaning efficiency was two indicators of water quality: chemical oxygen consumption (COC) and dry residue. The results of the conducted studies allow us to conclude that the use of sodium hypochlorite for purification of fruit and vegetable juice from organic pollutants is promising. It is established that for effluents of the Buzky canning plant, optimal use is made for purification of effluents of hypochlorite in the ratio of 0.5 dm^3/m^3 of wastewater that is being purified. To ensure environmental safety from possible contamination of unreacted hypochlorite of treated wastewater, an estimation of the cost of hyprochlorite for purification and comparison of residual concentrations with normalized parameters was carried out. The kinetics of oxidation of organic impurities in effluents was also studied, which was expressed by the degree of reduction of the COC solution in the process of reacting it with sodium hypochlorite. It is proved that the kinetics of the process of oxidation of organic contaminants is described by the equation valid for monomolecular reactions. For the system under study, the rate constant of the oxidation process of organic contaminants is 0.074 1/s. The principal scheme of purification of the effluents of the Buzky canning plant by sodium hypochlorite is proposed.

Key words: sodium hypochlorite, effluents, organic contamination, fruit and vegetable juices, reagent methods, oxidation.

РЕАГЕНТНЕ ОЧИЩЕННЯ СТІЧНИХ ВОД ПІДПРИЄМСТВ ПЕРЕРОБНОЇ ПРОМИСЛОВОСТІ

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Анотація. У статті представлено результати дослідження реагентних методів очищення забруднених органічними сполуками стоків невеликих за продуктивністю переробних підприємств. Проведено аналіз забруднень гідросфери переробними підприємствами та перспективні методи очищення стоків від забруднень. Як об'єкт досліджень використовували стоки ділянки виробництва плодово-овочевих соків Бузького консервного заводу. Як реагент-окислювач досліджувався гіпохлорит натрію. Детально розглянуто механізм очищення забруднених стоків гіпохлоритом натрію.

Завданням експериментальних досліджень було встановлення витрати гіпохлориту натрію, за якої здійснюється очищення стічних вод до рівня нижче, ніж регламентується нормативами. Критерієм ефективності очищення служили два показники якості води: хімічне споживання кисню (ХСК) та сухий залишок. Результати проведених досліджень дозволяють зробити висновок про перспективність використання гіпохлориту натрію для очищення стоків виробництва фруктових та овочевих соків від органічних забруднень. Встановлено, що для стоків Бузького консервного заводу оптимальним є використання для очищення стоків гіпохлориту у співвідношенні 0,5 $дм^3/м^3$. Для гарантування екологічної безпеки від можливого забруднення непрореагованим гіпохлоритом очищених стоків, проводилась оцінка витрати гіпрохлориту на очищення та порівняння залишкових концентрацій із нормованими показниками. Досліджувалась також кінетика окиснення органічних домішок в стоках, яка виражалась ступенем зниження ХСК розчину в процесі реагування його із гіпохлоритом натрію. Доведено, що кінетика процесу окиснення органічних забруднень описується рівнянням, дійсним для мономолекулярних реакцій. Для досліджуваної системи константа швидкості процесу окиснення органічних забруднень складає 0,074 1/с. Запропоновано принципова схема очищення стоків Бузького консервного заводу гіпохлоритом натрію.

Ключові слова: гіпохлорит натрію; стоки, органічні забруднення, плодово-овочеві соки, реагентні методи, окиснення.

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Introduction. Formulation of the problem

Contamination of surface waters with untreated effluents results in anthropogenic activity becoming threatening and, along with uncontrolled accumulation of domestic waste, industrial (in particular, mineralogical) massive atmospheric pollution threatens the preservation of biodiversity [1-4] and the subsequent existence of civilization in general. The most common pollutants of the hydrosphere are organic pollution, phosphorus and nitrogen compounds. As for the latter, they are the reason for mass eutrophication of surface water bodies.

Among enterprises-polluters of the hydrosphere the processing industry occupies a leading place. Enterprises of this profile, whose performance is often quite small, are equipped with insufficiently effective systems of sewage treatment in Ukraine. And sometimes these cleaning systems generally work periodically or do not work at all. All processing companies use a significant amount of water consumed directly in the technology of the main product (brewing, alcohol, sugar), washing equipment and other purposes. After the use of water for technological and domestic purposes, an equivalent amount of waste water is formed, which for various types of enterprises of the processing industry is [5]:

- per 1 ton of beet in the production of sugar – 1.7 m^3;
- per 1 ton of bakery products – 2.9 m^3;
- per 1000 dal of beer – 76 m^3;
- per 1000 dal of alcohol – 1300 m^3.

Mostly, these sewage waters are characterized by a high degree of organic contamination (COC wastewater is in the range from 2000 to 60000 mg O_2/dm^3). The greatest negative impact on surface water is caused by the sugar, meat, yeast, alcohol and the fruit and vegetable processing industry. Organic pollution of sewage of these types of industries contains organic substances of plant and animal origin. The occurrence of such untreated wastewater in the surface water leads to a deterioration of the conditions of the water biota existence. The degradation of these organic contaminants consumes dissolved oxygen, which is one of the most important components of providing the living conditions of aquatic biocenosis. Therefore, it is important to study the treatment of sewage of processing industry from pollution and introduce innovative cleaning technologies (in particular, small processing enterprises), which will prevent pollution of surface water bodies and reduce the anthropogenic pressure on the environment.

Analysis of recent research and publications

Traditionally, wastewater treatment from nitrogen, phosphorus and organic contaminants is carried out at urban sewage treatment plants using biological (aerobic, anaerobic, and combined) purification methods. Studies are underway as to intensification, reduction energy intensity and increase the depth of purification from nitrogen compounds using nitrification processes – denitrification [6,7], method ANAMMOX [8,9], methods CANON, OLAND, SHARON [10-12] and other perspective tecnologies. However, while following the rules of sewage reception at urban wastewater treatment plants, the concentration of these pollutants is limited, which requires the installation of additional local treatment facilities at the sites where these drains are produced.

One of these sites is the infiltration of solid domestic waste landfills, which are characterized by significant concentrations of ammonia and organic pollutants. For such conditions, authors [13] propose the use of sequential anaerobic (reactor UASB) and aerobic (aerated lagoon) stages infiltration purification. A comparative assessment of the various methods for the implementation of anaerobic and aerobic filtration purification technologies (UASB technology, ASBR technology, MBBR technology, MBR technology, aerated lagoon) is presented by authors [14]. According to this analysis, the greatest decrease in the "chemical oxygen consumption" (COC) rate from the filtrate of dumps (95%) was achieved in the aerated lagoon. We propose the technology of two-stage cleaning of filtrate of landfills of solid household waste in aerated lagoons and urban sewage treatment plants [15].

In our opinion, it is promising to use untreated sewage, saturated with phosphorus and nitrogen compounds as feedstocks for the cultivation of biomass cyanobacteria. The resulting biomass can be used to produce energy (biogas, bioethanol or biodiesel). This would ensure minimization of the ecological danger of surface water from uncontrolled development of cyanobacteria in combination with the use of biomass as raw material for energy production (which achieves an increase of energy degree of independence of Ukraine) [16,17].

The pollution of hydro ecosystems by sinks of small enterprises of the processing industry, containing mainly organic pollution, should be minimized by establishing local treatment plants that would provide effective cleaning of organic contaminants, and at the same time would meet a number of additional criteria:

- be inexpensive in execution and operation;
- be relatively simple in management;
- permit the effective cleaning of polluted by organic pollutants of wastewater, in condition there will be the change of the widespread concentration of pollution.

Generally, the most effective method for the treatment of such waste would be biological methods, but they do not meet the above criteria, therefore, as the experience shows, their application for the purification of such waste in a number of small-scale enterprises, where there is no corresponding level of technological culture of sewage treatment ("Nidan+" Ltd., "Oliyar" company and others), resulted in the loss of bioculture, resulting in a reduction of the purification efficiency to a zero.In our opinion, an effective method for cleaning such waste products can be reagent methods that meet the above criteria and allow the efficient cleaning. The most common reagents that can be used for these purposes are: chlorine or its compounds; potassium permanganate and manganese dioxide;hydrogen peroxide.

Disposal of sewage with chlorine or its compounds is one of the most widespread oxidation methods for water treatment, which is used as gaseous chlorine and its compounds containing active chlorine: chlorine dioxide, hypochlorites, chloramines. In all cases, calculations are made for "active" chlorine. "Active" chlorine is that chlorine that at a certain pH value is capable of displacing equivalent amounts of iodine from aqueous solutions of potassium iodide.

The most affordable, cheap and safe reagent that can be used for the oxidation of organic compounds is sodium hypochlorite – a multi-tonnage waste from the production of metallic sodium.

The method has several advantages, namely:

- easy to implement, inexpensive for reagent support;
- available reagent (sodium hypochlorite);
- small amounts of reagent, a small amount of waste generated (only oxidized, disinfected organic contamination);
- possibility of use after modernization of existing treatment facilities;
- the possibility of using waste as an effective organo-mineral fertilizer.

Chlorination is the most common, and sometimes the only process used in our country for water purification. Water for the purpose of decontamination is chlorinated not only on water pipes that consume water from open sources, but also from all artesian water pipes. For chlorination, water is treated with gaseous chlorine or preparations containing active chlorine - calcium hypochlorite or sodium, chlorine lime, chlorine oxide (IV), chloramines. The most inexpensive and suitable for the developed method of treatment of wastewater from organic substances is the use of sodium hypochlorite, which in large quantities forms as a production waste in the process of production of magnesium.

When dissolved in water, sodium hypochlorite dissociates with the formation of hypochlorite ion and hypochloric acid in proportions that depend on pH of the medium.

$$NaClO \leftrightarrow Na^+ + ClO^-$$

$$ClO^- + H^+ \leftrightarrow HClO$$

The dependence between the concentrations of chlorine Cl_2, non-dissociated hypochloric acid HClO and hypochlorite ClO in water at various pH values is presented in Fig.1. From Fig. 1 it is evident that at pH=7–8 the main disinfectant is hypochloric acid.

If ammonia, ammonium salts or organic substances containing amino groups are present in water, chlorine, hypochloric acid and hypochlorites are reacted with them, forming mono- and dichloramines.

$$HClO = NH_3 \rightarrow NH_2Cl + H_2O$$

$$HClO + NH_2Cl \rightarrow NHCl_2 + H_2O$$

These compounds also have a bactericidal effect, since active chlorine is released during hydrolysis [18].

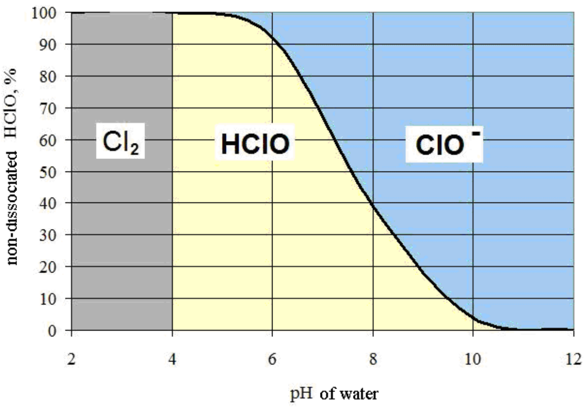

Fig.1. Chlorine compounds under different pH conditions.

Molecular chlorine, hypochloric acid and hypochlorite ions are commonly called free chlorine, as opposed to chlorine bound. The bactericidal action of free chlorine is 20–25 times more potent than the bound one.

The correlation between mono- and dichloramines, which are formed when chlorine is introduced into water in the presence of ammonia, depends on the pH of water. As the pH of the water increases, the amount of bound chlorine in dichloramines decreases and its residue is increased in the form of monohloramines, the bactericidal action of which is 3–5 times less than that of dichloramines. The bactericidal action of chloramines is 8–10 times higher than chlorinated organic amines and imines.

The process of decontamination of organic compounds by chlorine takes place in two stages: first, chlorine diffuses through the cell of the microorganism, than reacts with enzymes. The process speed is determined by the kinetics of chlorine diffusion inside the cell and the kinetics of cell death due to metabolic abnormalities. As the concentration of chlorine in water increases, its temperature increases and chlorine is converted into non-dissociated form, the overall speed of disinfection increases.

The bactericidality of chlorine in water decreases with pH increasing. Therefore, water should be disinfected by chlorine before the introduction of alkaline reagents in it. In the case of the presence of organic compounds in water that can oxidize, or reducing agents, as well as colloidal and suspended particles that can envelop bacteria, the process of disinfecting water is slowed down. For the guarantee of disinfection, various residual concentrations of free or bound chlorine maintain in water.

At the constant concentration of chlorine in water, the kinetics of the disinfection process can be expressed by the equations valid for monomolecular reactions [18]:

$$\frac{dy}{dt} = AN = a(N_0 - y) \quad (1)$$

$$\frac{N}{N_0} = \exp(-At) \quad (2)$$

where y is the number of microorganisms that died from the action of chlorine per unit time,

t is the time of action of the reagent;

N is the number of microorganisms remaining in water at the end of period t;

A is the speed constant of the water disinfection process (t^{-1} dimension);

The influence of chlorine concentration on the time required to destroy bacteria from the initial to the given amount can be expressed by the equation [18]:

$$C^n t = K \quad (3)$$

where C is concentration of chlorine, mg/l;

t is time of contact of chlorine with water, min;

n is index of degree (at pH close to 7 it is equal to 1.3);

K is constant of resistance of microorganisms to the action of chlorine, which depends on the type of microorganisms and pH of the environment.

The value of the constant K is determined by the presence in the water of certain forms of active chlorine for a given pH. For water that does not contain ammonium salts, provided that the number of *Coli bacteria* is reduced by 95%, K=0.15 for pH=7.0; 0,45 for pH=8.5 and 4,0 for pH=9.8. In the presence of ammonium salts in water, when active chlorine in water is present in the form of mono- and dichloro-amines, K varies from 3.5 for pH=7.0 to 400 for pH = 9.5.

The influence of temperature on the speed of water disinfection process is expressed by the equation [18]:

$$\lg\frac{t_1}{t_2} = \frac{E(T_2 - T_1)}{RT_1T_2} \quad (4)$$

where t_1 and t_2 are the time required to reduce the water content of microorganisms at a given percentage, min;

T_1 and T_2, K, E are the activation energy, J/mol,

R is the gas constant equal to 8.33 J/ mol$\cdot$K).

Particularly speed of the disinfection process of water changes at temperature while using chloramines. The bactericidal effect of chlorination largely depends on the initial dose of chlorine and the duration of preservation in water of some of its residual concentration. The amount of required bactericidal concentration of residual chlorine depends on the ability of the water to absorb chlorine, that is inextricably linked with the general need for chlorine in the water to be purified. This indicates the proportionality of the rates of disinfection and oxidation processes of organic and inorganic substances contained in water. An increase of the absorption of chlorine by water improves the bactericidal effect of chlorination at equal concentrations of residual chlorine, since the initial dose of chlorine in this case is always higher.

The purpose of this research was to study the feasibility of using reagent methods for the purification of polluted by organic compounds of effluents of small in performance processing enterprises.

In the course of this study, the following **tasks** had to be performed:

1) to determine the chemical composition of sewage production of vegetable and fruit juices;

2) to investigate optimal parameters of purification of effluents from organic contaminants by sodium hypochlorite;

3) to identify experimental results of purification of effluents from organic contaminants by sodium hypochlorite in theoretical model;

4) to develop a technological scheme of the treatment of waste water from vegetable and fruit juices from organic contaminants by sodium hypochlorite.

Research materials and methods

The effluents of the Buzky Cannery were investigated, which were selected from the sewage system at the outlet after the production site of vegetable and fruit juices. The values of the indicators were established in the waste water, given in Table 1 using the techniques, described in details in [19].

Studies of the treatment of small waste water at the small in performance processing industries were carried out in the laboratory using a thermostatically reactor having volume of 3 liters with a turbine mixer, whose angular velocity was 31.4 1/s, where the studied drains were loaded. When the mixer was on, a certain amount of sodium hypochlorite was poured into the solution by a measurable burette. Since the kinetics of the interaction of sodium hypochlorite with organic contamination under these conditions was difficult to establish, the solution was stirred for 30 minutes, after that a sample was taken from it for the determination of the COC and the amount of dry residue.

Results of the research and their discussion

The results of the determination of the chemical composition of the effluent of the Buzky canning plant and its comparison with the MPC (maximum permissible concentration) for the reservoirs of commercial drinking water supply are given in Table 1.

Table 1 – Chemical composition of drains of the production site of vegetable and fruit juices at Buzky cannery plant

№	Name of metrics	Unit	Concentration	
			Sample	MPC
1	Scent	mark	5	< 3
2	Transparency	sm	4.00	10
3	Active pH reaction	-	11.72	6–9
4	Sulphates	mg/dm^3	155.55	500
5	Sodium + Potassium	mg/dm^3	980.75	200
6	Chlorides	mg/dm^3	443.12	350
7	Dry residue	mg/dm^3	3112.50	1000
8	Suspended matter	mg/dm^3	152.00	-
9	Ammonium nitrogen	mg/dm^3	24.10	2
10	Nitrite	mg/dm^3	0.09	3.3
11	Nitrates	mg/dm^3	0.57	45
12	Phosphates	mg/dm^3	2.88	3.5
13	BOC_5 (biological oxygen consumption)	mg/dm^3	375.60	15
14	COC (chemical oxygen consumption)	mg/dm^3	1056.90	80
15	Ferum total	mg/dm^3	0.67	0.3

The results of studies indicate a hard pollution of wastewater with organic compounds. The task of experimental studies was to determine the expenditure of sodium hypochlorite, which provides wastewater treatment to a level lower than that regulated by standards. This is necessary to ensure, on the one hand, the most complete purification of effluents from organic matter, and on the other hand to avoid over expenditure of sodium hypochlorite. It should be taken into consideration that the dose of active chlorine for decontamination of sewage in a solution of sodium hypochlorite, which is dosed into the system after mechanical treatment should not exceed 10^{-2} kg/m^3 [20]. To do this, a series of studies was conducted to clear wastewater with different dosages of sodium hypochlorite. The criterion for cleaning efficiency was two indicators of water quality: COC and dry residue. The results of experimental studies are presented in Figures 2 and 3.

As can be seen from Figures 2 and 3, it is optimal to use purified sewage for treatment of sodium hypochlorite effluents in the ratio of 0.5dm^3/1m^3. Such a dosage of hypochlorite in the drains reduces the dry residue in the effluents and COC to the normalized levels. It should be noted that the reduction of the dry residue is due to the oxidation of organic contaminants and their conversion into insoluble form, which ensures the further conglomeration of tumors and separation from purified sewage. To ensure environmental safety from possible contamination of unreacted hypochlorite of treated wastewater, an estimation of the expenditure of hyprochlorite for purification and comparison of residual concentrations with normalized values was carried out [20].

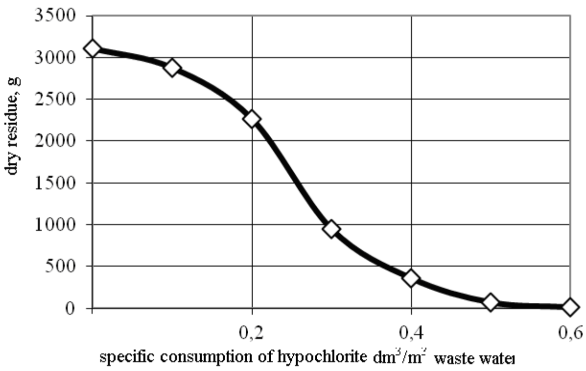

Fig. 2. Dependence of the mass of dry residue on the specific consumption of sodium hypochlorite

According to [21], during the reaction of hypochlorite with organic substances, the reaction time is spent up to (90–95)% of hypochlorite. Based on the experimental data found in the process of optimal dosage of hypochlorite used for wastewater treatment (0,5 dm^3/1 m^3 of waste water), the residual concentration of hypochlorite should not exceed 0.05 dm^3/1m^3 of waste water. Taking into account that the content of active chlorine in 1 dm^3 of hypochlorite is 140 g [20], the content of active chlorine in effluents will not exceed 7 kg/m^3. This is less than the allowable value, and given that additional hypochlorite will be spent on disinfecting drains, the proposed technology can be considered environmentally safe.

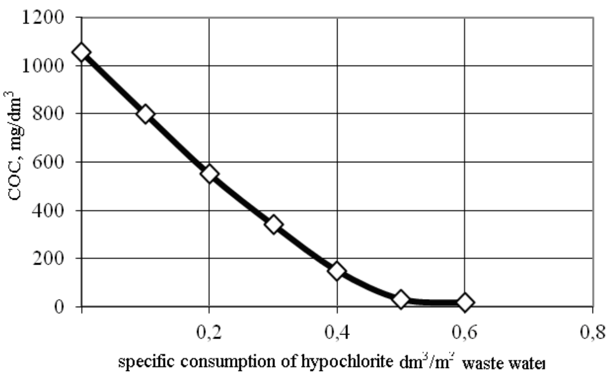

Fig. 3. Dependence of COC in purified effluents on the specific consumption of sodium hypochlorite

We recommend the dosage of hypochlorite 0,5dm^3/1m^3 of wastewater, which is cleaned, to introduce the industrial technology of sewage treatment at the Buzky canning plant.

The kinetics of oxidation of organic impurities in effluents was also studied, which was expressed by the degree of reduction of the COC solution in the process of reacting it with sodium hypochlorite. It was assumed that by analogy with disinfection [18], the kinetics of the process of oxidation of organic substances in the effluents can be expressed by the equation valid for monomolecular reactions:

$$COC=P\exp(-Bt) \qquad (5)$$

where *COC* is the chemical oxygen consumption at the end of period *t*,
t is the time of reactant,
C is the static coefficient,
B is the constant of the rate of oxidation of organic impurities (the dimension of t^{-1}).

To establish the adequacy of the hypothetical equation (5), the kinetics of the process of oxidation of organic impurities to the real process were carried out experiments, the results of which are presented in Fig. 4.

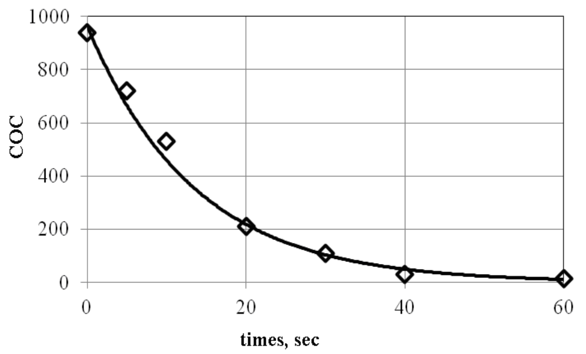

Fig. 4. Kinetics of the process of oxidation of organic substances in waste waters by sodium hypochlorite

As can be seen from Fig. 4, the experimental points are really satisfactorily approximated by the exponential dependence (correlation coefficient R^2 = 0,9762), the approximation equation has the form:

$$COC=964.42P\exp(-0.074t) \qquad (6)$$

As follows from equation (6), the rate constant of the oxidation process of organic impurities B is 0,074 / s. The basic scheme of the treatment of drains of the production site of fruit and vegetable juices of the Buzky canning factory is presented in Fig. 5. In accordance with the scheme, wastewater enters concrete structures, 3 such structures remain from the biological purification scheme that operated at the plant in the 90's of the last century.

To that place by dosing-pump 2 from the collector 1 is given a certain amount of sodium hypochlorite, which is dispensed directly into the stream of sewage. Therefore, the reaction of oxidation of organic impurities begins directly in the pipeline. Subsequently, the reaction mixture enters directly into concrete structures with the submerged pipeline. In these structures, the reaction is completed and the sediment is released, which precipitates in the volume of the reactor. At certain intervals, as the sediment is accumulated at the bottom of the reactor, it is pumped off by the sludge pump 6 through the inhaled pipeline 5 into road transport 7. Pulp is used in agriculture as a liquid organic fertilizer.

Conclusion

Thus, the results of the conducted studies allow us to conclude that the use of the reagent methods is perspective for the purification of polluted by organic compounds of effluents at small in productivity processing enterprises. As a reagent-oxidant, the most promising is the use of sodium hypochlorite that is the production waste of metallic sodium.

As a result of experimental studies, it is stated that for sewage at the Buzky canning plant the optimal use of hypochlorite for purification of effluent is in the ratio of 0.5 dm^3/1m^3 of cleared wastewater. It is proved that the kinetics of the process of oxidation of organic contaminants by sodium hypochlorite is described by the equation valid for monomolecular reactions. For the system under study, the rate constant of the oxidation process of organic contaminants is 0.074 1/s. The principal technological scheme of purification of the effluent at the Buzky canning plant by sodium hypochlorite is proposed.

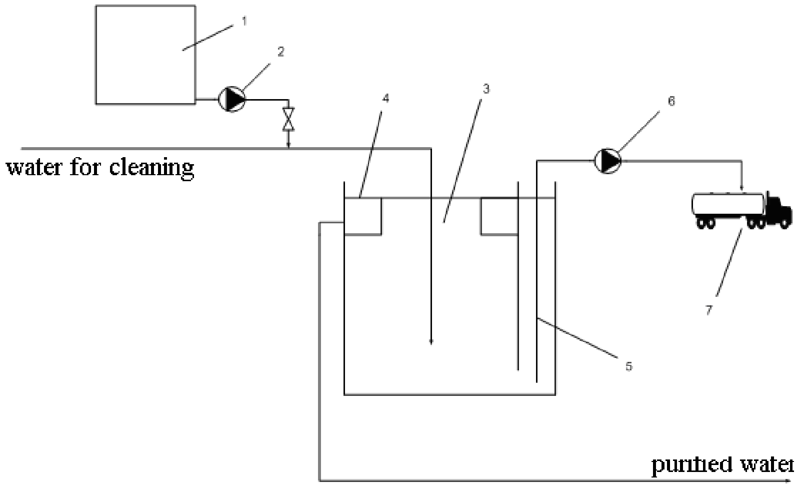

Fig. 5. Principal scheme of sewage treatment at the Buzky canning plant

List of references:

1. May R.M. Ecological science and tomorrow's world // Phil. Trans. Royal Soc. B. 2010. V.365. P.41-47. DOI:10.1098/rstb.2009.0164.
2. Mudrak O.V., Mudrak H.V., Razanov S.F., Kavun Zh.A. Ecological-cohenological analysis of the flora Eastern Podillya as a basis for the conservation of biodiversity // Ukrainian Journal of Ecology. 2018. 8(2). P.204-209. DOI:10.15421/2018_328
3. Mooney H.A. The ecosystem-service chain and the biological diversity crisis // Phil. Trans. Royal Soc. B. 2010. V.365. P.31-39. DOI: 10.1098/rstb.2009.0223
4. Lavrik M. O., Pavlichenko A.V., Trepachova K. V. Study of character and degree of impact of mine drainage ponds on the environment // Mining of mineral deposits. 2015. V. 9(4). P.477-483. DOI: 10.15407/mining09.04.477
5. Левандовський Л.В. Вплив відходів харчової промисловості на довкілля/ Л.В.Левандовський, Є.А.Лукашевич, Г.О.Нікітін, А.О.Диба // І-й Всеукраїнський з'їзд екологів: зб.тез міжнар. наук.-техн. конф. м.Вінниця, 2006 р./ Вінниця, 2006. С. 264.
6. Khin T. Novel microbial nitrogen removal processes // Biotechnology Advances. 2004. № 225. P. 19-532. DOI:10.1016/j.biotechadv.2004.04.003
7. Калюжный С.В. Высокоинтенсивные анаэробные биотехнологии очистки промышленных сточных вод // Катализ промышленности. 2004. №6. С. 42-50.
8. Mulder A., Van de Graaf A.A., Robertson L.A., Kuenen J.G. Anaerobic ammonium oxidation discovered in a denitrifying fluidized bed reactor // FEMS Microbiology Ecology. 1995. № 16. P. 177-184. DOI:10.1111/j.1574-6941.1995.tb00281.x
9. Malovanyy A. Concentration of ammonium from municipal wastewater using ion exchange process/A. Malovanyy, H. Sakalova, Y. Yatchyshyn, E. Plaza, M. Malovanyy // Desalination. 2013. V.329. P.93-102. DOI:10.1016/j.desal.2013.09.009
10. Malovanyy A., Plaza E., Trela J., Malovanyy M. Combination of ion exchange and partial nitritation/Anammox process for ammonium removal from mainstream municipal wastewater // Water Science & Technology. 2014. V.70, №1. P.144-151. DOI:10.2166/wst.2014.208
11. Szatkowska B., Płaza E., Trela J. Partial nitritation/anammox and CANON – Nitrogen removal systems followed by conductivity measurements // Department of Land and Water Resources Engineering, Sweden. 2005. № 13. P.109-117.
12. Windey K., De Bo I., Verstraete W. Oxygen-limited autotrophic nitrification–denitrification (OLAND) in a rotating biological contactor treating high-salinity wastewater // Water Research. 2005. № 39. P.4512-4520. DOI:10.1016/j.watres.2005.09.002
13. Govahi S., Karimi-Jashni A., Derakhshan M. Treatability of landfill leachate by combined upflow anaerobic sludge blanket reactor and aerated lagoon //International Journal of Environmental Science and Technology. 2012. №9. P.145–151. DOI: 10.1007/s13762-011-0021-7
14. Payandeh P.E., Mehrdadi N., Dadgar P. Study of Biological Methods in Landfill Leachate Treatment //Open Journal of Ecology. 2017. №7. P.568-580. DOI: 10.4236/oje.2017.79038
15. Malovanyy M., Zhuk V., Sliusar V., Sereda A. Two stage treatment of solid waste leachates in aerated lagoons and at municipal wastewater treatment plants //Eastern-European Journal of Enterprise Technologies. 2018. № 1(10). P.23 - 30. doi.org/10.15587/1729-4061.2018.122425
16. Malovanyy M.S., Soloviy Kh.M. Conditions for cyanobacteria biomass development and selection for further processing// 7th International Youth Science Forum «Litteris et Artibus»: Conference Proceedings, Lviv, 23-25 November 2017y. / Lviv, 2017. P.122-123.
17. Соловій Х., Мальований М., Никифоров В. Збір та концентрування мікроводоростей з ціллю їх подальшого використання для виробництва енергоносіїв// Міжнародний науковий симпозіум «Сталий розвиток – стан та перспективи: Збірник матеріалів, Львів-Славське:, 28 лютого – 3 березня, 2018 р./ НУ «Львівська політехніка. Львів, 2017. С.174-176.
18. Vogt H. Chlorine Oxides and Chlorine Oxygen Acids // Ullmann's Encyclopedia of Industrial Chemistry. 6th. Weinheim: Wiley-VCH, 2005. P.5-6. DOI:10.1002/14356007.a06_483.pub2.
19. Лурье Ю.Ю. Унифицированные методы анализа вод. М.: Химия, 1973. 376 с.
20. Законодавство України [Веб-сайт]. Київ, 2007. URL: http://zakon.rada.gov.ua/laws/show/z0853-07 (дата звернення: 16.09.2018).
21. Знак З.О., Гнатишин Н.М. Дослідження взаємодії натрію гіпохлориту з олефінами у кавітаційних полях // Восточно-Европейский журнал передовых технологий. 2015. 2/6(74). С.49-54. DOI: 10.15587/1729-4061.2015.38783

References:

1. May RM. Ecological science and tomorrow's world. Phil. Trans. Royal Soc. B. 2010; 365 :41-47. DOI:10.1098/rstb.2009.0164.
2. Mudrak OV, Mudrak HV, Razanov SF, Kavun ZhA. Ecological-cohenological analysis of the flora Eastern Podillya as a basis for the conservation of biodiversity. Ukrainian Journal of Ecology. 2018; 8(2): 204-209. DOI:10.15421/2018_328
3. Mooney HA. The ecosystem-service chain and the biological diversity crisis. Phil. Trans. Royal Soc. B. 2010; 365: 31-39. DOI: 10.1098/rstb.2009.0223
4. Lavrik MO, Pavlichenko AV, Trepachova KV. Study of character and degree of impact of mine drainage ponds on the environment. Mining of mineral deposits. 2015; 9(4): 477-483. DOI: 10.15407/mining09.04.477

5. Levandovskyi LV, Lukashevych YeA, Nikitin HO, Dyba AO. Vplyv vidkhodiv kharchovoi promyslovosti na dovkillia. I-y Vseukrainskyi zizd ekolohiv. Vinnytsia; 2006: 264
6. Khin T. Novel microbial nitrogen removal processes. Biotechnology Advances. 2004; 225: 19-532. DOI:10.1016/j.biotechadv.2004.04.003
7. Kaliuzhnyi SV. Vysokointensivnye anaerobnyie biotiekhnolohii ochistki promyshliennykh stochnykh vod. Kataliz promyshliennosti. 2004; 6: 42-50.
8. Mulder A, Van de Graaf AA, Robertson LA, Kuenen JG. Anaerobic ammonium oxidation discovered in a denitrifying fluidized bed reactor. FEMS Microbiology Ecology. 1995; 16: 177-184. DOI:10.1111/j.1574-6941.1995.tb00281.x
9. Malovanyy A, Sakalova H, Yatchyshyn Y, Plaza E, Malovanyy M. Concentration of ammonium from municipal wastewater using ion exchange process. Desalination. 2013; 329: 93-102. DOI:10.1016/j.desal.2013.09.009
10. Malovanyy A, Plaza E, Trela J, Malovanyy M. Combination of ion exchange and partial nitritation/Anammox process for ammonium removal from mainstream municipal wastewater. Water Science & Technology. 2014; 70 1: 144-151. DOI:10.2166/wst.2014.208
11. Szatkowska B, Płaza E, Trela J. Partial nitritation/anammox and CANON – Nitrogen removal systems followed by conductivity measurements. Department of Land and Water Resources Engineering, Sweden. 2005; 13: 109-117.
12. Windey K, De Bo I, Verstraete W. Oxygen-limited autotrophic nitrification-denitrification (OLAND) in a rotating biological contactor treating high-salinity wastewater. Water Research. 2005; 39: 4512-4520. DOI:10.1016/j.watres.2005.09.002
13. Govahi S, Karimi-Jashni A, Derakhshan M. Treatability of landfill leachate by combined upflow anaerobic sludge blanket reactor and aerated lagoon. International Journal of Environmental Science and Technology. 2012; 9: 145-151. DOI: 10.1007/s13762-011-0021-7
14. Payandeh PE, Mehrdadi N, Dadgar P. Study of Biological Methods in Landfill Leachate Treatment. Open Journal of Ecology. 2017; 7: 568-580. DOI: 10.4236/oje.2017.79038
15. Malovanyy M, Zhuk V, Sliusar V, Sereda A. Two stage treatment of solid waste leachates in aerated lagoons and at municipal wastewater treatment plants. Eastern-European Journal of Enterprise Technologies. 2018; 1(10): 23-30. doi.org/10.15587/1729-4061.2018.122425
16. Malovanyy MS, Soloviy KhM. Conditions for cyanobacteria biomass development and selection for further processing. 7th International Youth Science Forum «Litteris et Artibus». Lviv; 2017:122-123.
17. Solovii Kh, Malovanyi M, Nykyforov V. Zbir ta kontsentruvannia mikrovodorostei z tsilliu yikh podalshoho vykorystannia dlia vyrobnytstva enerhonosiiv. Mizhnarodnyi naukovyi sympozium «Stalyi rozvytok – stan ta perspektyvy. Lviv; 2017: 174-176.
18. Vogt H. Chlorine Oxides and Chlorine Oxygen Acids. Ullmann's Encyclopedia of Industrial Chemistry. 6th. Weinheim. Wiley-VCH; 2005: 5-6. DOI:10.1002/14356007.a06_483.pub2.
19. Lurie YuIu. Unifitsirovannyie metody analyza vod. Moskva: Khymyia;1973.
20. Zakonodavstvo Ukrainy Available from: http://zakon.rada.gov.ua/laws/show/z0853-07.
21. Znak ZO, Hnatyshyn NM. Doslidzhennia vzaiemodii natriiu hipokhlorytu z olefinamy u kavitatsiinykh poliakh. Vostochno-Yevropeiskyi zhurnal peredovykh tekhnolohii. 2015; 2/6(74): 49-54. DOI: 10.15587/1729-4061.2015.38783

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