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HYDROPHYTE WATER PURIFICATION UNDER CONDITIONS OF “ZHYTOMYRVODOKANAL” COMMUNAL ENTERPRISE

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The aim of the research was the hydrophyte water purification method testing, water purification effect determination, also of the allowable loads of the most toxic pollutants on higher aquatic plants under conditions of modeling laboratory systems and advanced ways of processed phytomass use.

The results of hydrophyte water purification are presented, different types of higher aquatic plants under laboratory systems of water quality formation impact are analyzed, the water purification effect and the prospective ways of phytomass waste use are determined. The hydrophyte load use according to all studied variants showed a positive trend concerning the improvement of all the water quality indicators studied, and the cleaning from pollutants effect according to some indicators was more than 80%. The aquatic plants biomass can be used not only for obtaining from meliorant wastewater but also in various economic sectors — as feed additive for farm animals.

Key words: phytomelioration, hydrophytes, purification effect, chemical pollution, domestic waste water.

Biological purification is the most common way for removing organic substances from municipal wastewater [1]. Biological wastewater treatment plants are about 55% of the total number of treatment facilities [2]. In recent decades, there is a tendency of the urban wastewater quality changes due to the increase of nitrogen and phosphorus containing organic substances proportion, of heavy metals concentrations, synthetic surfactants, etc. Many biological sewage treatment plants were designed in 50 years of the last century and meet the environmental standards of that time, thus at present time for technical reasons they cannot provide the compliance of maximum allowable discharges of pollutants into natural water bodies [2]. The actual effectiveness of treatment of urban wastewater from nutrients in biological treatment plants does not exceed 20–40% for phosphates and 30–90% for ammonia nitrogen [1]. Revenues of biogenic elements into the natural reservoir in concentrations that exceed the maximum allowable ones cause the water body’s europhication and death of aquatic flora and fauna.

In this context the development of methods and technologies aimed at the reduction of biogenic elements content during the municipal wastewater biological purification process becomes relevant. According to the literature data the higher aquatic plants (HAP) use is the biogenic elements removal effective method [3–5]. There is information about the use of separate HAP in technological process of municipal wastewater biological purification [6–9]. The significant amount of aquatic and coastal aquatic plants is characterized by high phyto-meliorative effects, as well as they are an excellent juicy fodder for animal nutrition [10].

At the same time the removal patterns of pollutants based on technical parameters are not provided by literature, there is no information about HAP selection and their use under climatic conditions of Zhytomyr region, there is not enough information about technical devices for HAP placement on the biological wastewater treatment plants. Therefore the research of growth conditions, the issue of number regulation and *Eichhornies* practical application use opportunities causes significant economic interest. Considering high nutrients content these plants can be included into the farm animals' nutrition actions as valuable nutritional feed.

The aims of the conducted research are hydrophyte water purification method testing, water purification effect determination, determination of the allowable loads of the most toxic pollutants on higher aquatic plants under conditions of modeling laboratory systems and determination of advanced ways of processed phytomass use.

Materials and Methods

Representatives of various HAP groups belonging to different plant divisions were selected as test objects for research. There are water surface free-floating representatives among them: *Eichhornia crassipes (Mart.) Solms* (fam. *Pontederiaceae*) and *Pistia stratiotes L. (*fam. *Araceae).* The object choice was caused by *in vitro* and *in vivo* cultivation opportunity. All listed test facilities were previously successfully used for phyto-meliarative purposes [3, 5–8]. Plants were selected from populations fed in artificial reservoirs of the Botanic garden of Zhytomyr National Agroecological University (Fig. 1).

The industrial experiment planning was conducted according to the methodology of Gorski [11]. Plants were placed into the model installations (with 0.25 m^3 capacity), in which the water coming on the pumping station of the first lifting of "Zhytomyrvodokanal" Communal Enterprise was loaded.

Laboratory model systems containing the hydrophilic load were used by conducting of the experiments. Each model system contained plants of one HAP species and one variant with the mixed phytocoenoses of two types. The total biomass of the plants placed (raw weight) was 30–50 g (*E. crassipes*) and 10–20 g (*P. stratioites*) for 1.5 l of water. In the experiments with hydrocoles use the water amount was 200 l. In the experiments the plants number was calculated so that the phytomass amount in all the variants was approximated. Each model system contained plants of one HAP species as well as of their grouping. The variant without plants was taken as for control (Fig. 2).

These studies were carried out to obtain information concerning the resistance of the HAP species used to pollutants contained in natural waters coming on the pumping station of the first lifting of "Zhytomyrvodokanal" Communal Enterprise, as well as to determine the influence of hydrocoles on physical and chemical properties of the quality of the water studied.

The duration of the experiments ranged from 0 to 40 days depending on the timing of influence signs of substances on the plants vitality. Every 10 days during the research period the water samples were selected in accordance with the methodology [11, 12] to determine their physical and chemical composition.

Physical properties and chemical composition of wastewater before and after the cultivation of *P. stratiotes* and *E. crassipes* were determined by unified Y. Lurie methodology (1984) [13], as well as generally accepted methods. The water temperature was measured by a thermometer at the moment of sampling in situ. Color and smell

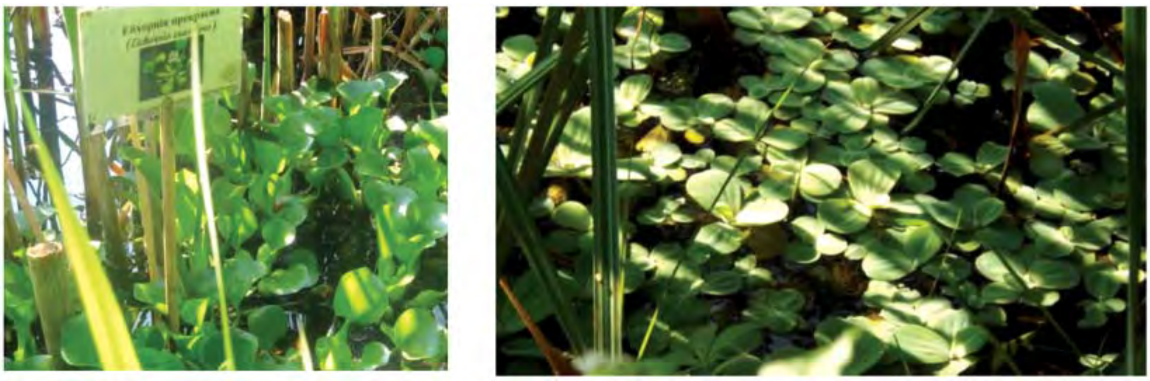


Fig. 1. **Places for selection of plant material for conducting plants phyto-meliarative properties research:** lake of the Botanic garden of Zhytomyr National Agroecological University

Fig. 2. **Research scheme of hydrophyte systems operating regimes (from left to right):**
1 — E. crassipes (Mart.) Solms — 100%; *2 — P. stratiotes L.* — 100%; *3 — E. crassipes (Mart.) Solms* — 50% + *P. stratiotes L.* — 50%; *4* — Control (without hydrocoles)

were determined with the organoleptic water characteristics.

All analysis of water quality determination was carried out in accordance with current normative documents guidelines and methodical developments in the department of instrumental and laboratory monitoring of Zhytomyr region State Environmental Inspection. The hydrocoles phytomass composition was determined in State Enterprise "Design and Technology Centre for Soil Fertility and Product Quality" laboratory.

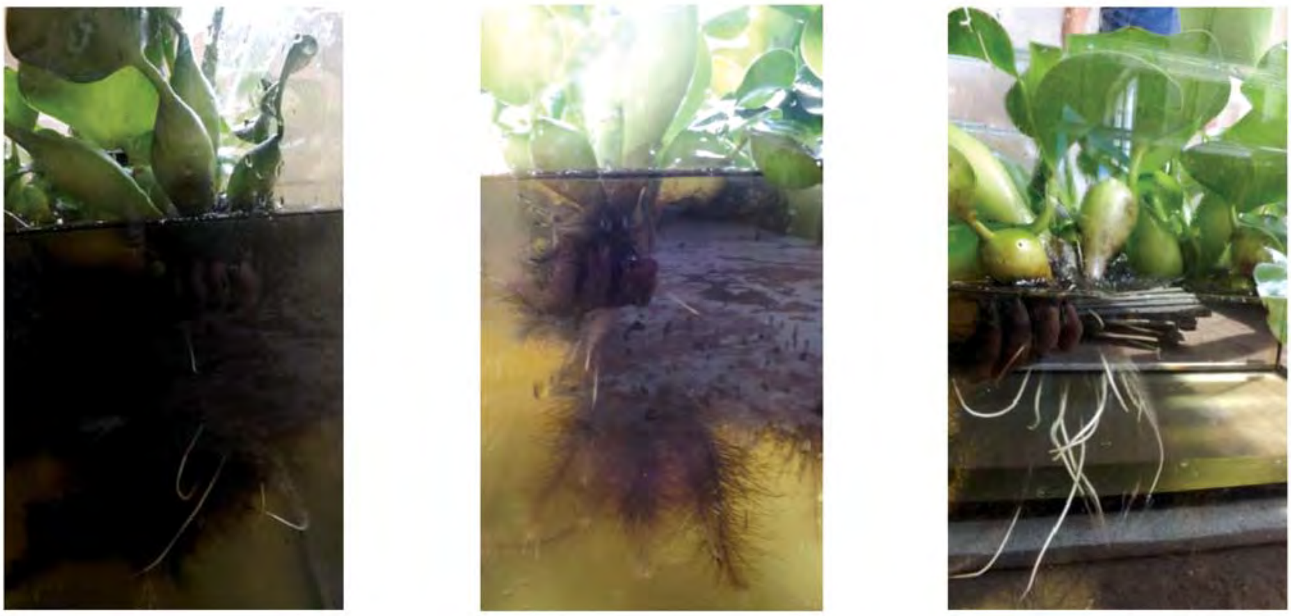
Results and Discussion

Significant seasonal temperature variations — from 0.1 to 30 °C in average are inherent for the Zhytomyr region water surface. During the research considering the relatively hot period (July–August 2015) the highest water temperature of the Teteriv River was recorded from 12th to 15th August at the 25 °C, the lowest during periods from 1st to 4th July, from 13th to 18th July and from 20th to 23rd August at the 19 °C. In such hot periods of the year, as July–August 2015, natural waters, especially surface ones, are seldom transparent. Given this in our opinion the most important water indicator index of turbidity and chrominance appeared, and its smell. The water turbidity control is very important and also from a toxicological point of view. So in the river waters with moderate turbidity the vast majority of aluminum is located in suspended condition, more than 90% of lead, 30–35% of arsenic and cadmium, and more than 20% of mercury [2].

Under research conditions when loading water in biofilters it was defined as "turbid". 10 days later the water turbidity reduced significantly and this water could be characterized as "little turbid". In the next weeks, water quality for this indicator improvement was observed and by the end of the experiment, water was characterized as "clear" (Fig. 3).

While water selection and before their loading wastewater was characterized by the IV score smell (distinctive smell that draws attention; can force to refrain from drinking). After 10 days of hydrocole in bioreactors residence, the smell decreased by two points to the II score. By the end of experiment, it was characterized as faint smell with the score — I, so the hydrophyte purification use had a positive trend on the turbidity and unpleasant smell indexes reduce.

The content of suspended particles (SP) under experimental conditions during the whole research period had a tendency to decrease, particularly in the first 10 days of the experiment their content in *N1* option cultivating hydrophytes *E. crassipes (Mart.) Solms* species, decreased by 10%; in option *N2* with growing hydrophytes *P. stratiotes L.* species by 13%; in mixed phytocoenoses (option *N3*) — only 3%. But during the next sampling after a 10-day period indicators



At the start of experiment | Through 10 days of the experiment | Through 20 days of the experiment

Fig. 3. **Water turbidity during the period of the experiment with hydrophyte purification dynamics**

for all options almost had been leveled and constituted 16–11% of their original content (Fig. 4). At the time of the experiment completion the greatest general suspended SP content decrease was shown by the option *N2* with *P. stratiotes L.* — 30%, slightly lower — on option *N1* — 27%, and even lower SP removal rate appeared on option *N3* — 22%. On the control check SP decrease almost was not recorded that constituted only 3% of its initial value.

Therefore the positive trend by the SP exclusion indicator when using the hydrophyte purification was observed, in particular their contents decreased by 22–30% compared with control check.

In addition to the organoleptic indicators basic groups (physical-organoleptic), while conducting research we paid attention to a group of chemical and organoleptic indicators. The active water reaction is one of the most important its quality indicators that determines the nature of chemical and biological in natural waters and wastewater treatment facilities processes implementation. While hydrocole on wastewater sewage treatment facilities cultivation water, pH in all the studied period was 7.0–7.9 that corresponds to the maximum permissible criteria values. However in options with hydrobionts use in first 10 days of experiment implementation we observed movement of the pH to the left to the waste water neutralizing direction (Fig. 5).

After 10-day periods overcome the pH value began to shift to the right and in 24–25 days (option *N1* and *N3*) crossed its initial value and began to shift to the right. However, it should be noted that at the end of the experiment this indicator in the studied waters meets the requirements that exist to the drinking water reservoirs points' water composition and properties (6.5–8.5). In option *N2*, unlike the other options, towards neutralization recession have not taken place (10 days period), but at the moment of experiment conclusion pH indicators were virtually identical to the value obtained in option *N1*. Such intensive indicators variation while control was not found, obviously this is related to the less intensive biochemical processes which took place there.

In addition to pH indicator we observed the general alkalinity indicators. As in the majority of natural waters including Communal Enterprise "Zhytomyrvodokanal" first water intake, carbonate compounds are dominating (mainly HCO_3^- ions), we took into account only hydrocarbonate and carbonate alkalinity (Fig. 6).

During the entire experiment conduction period water alkalinity had a tendency to minor fluctuations. Only in the first option this indicator fluctuations were the most

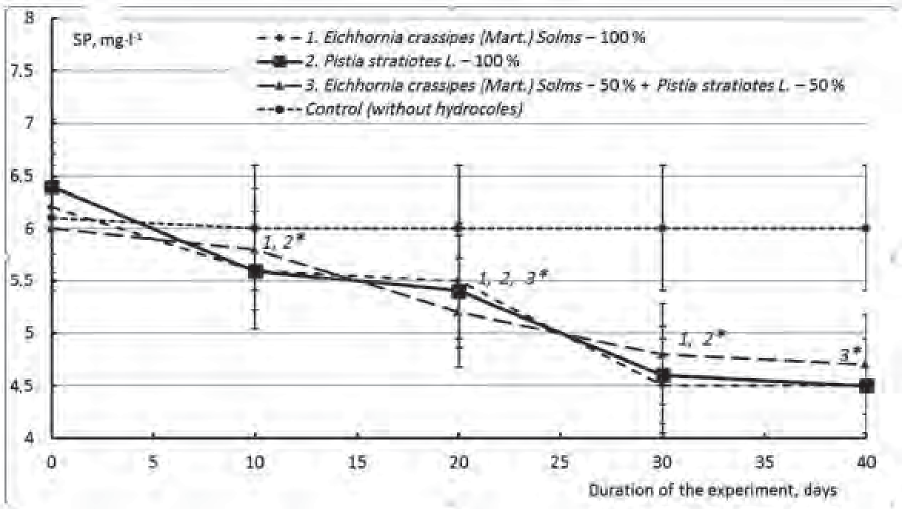


Fig. 4. **Suspended particles (SP) concentration change under hydrophyte purification conditions in the water content**

Hereinafter: * — differences are statistically significant as compared to the *control*, $P < 0.05$.

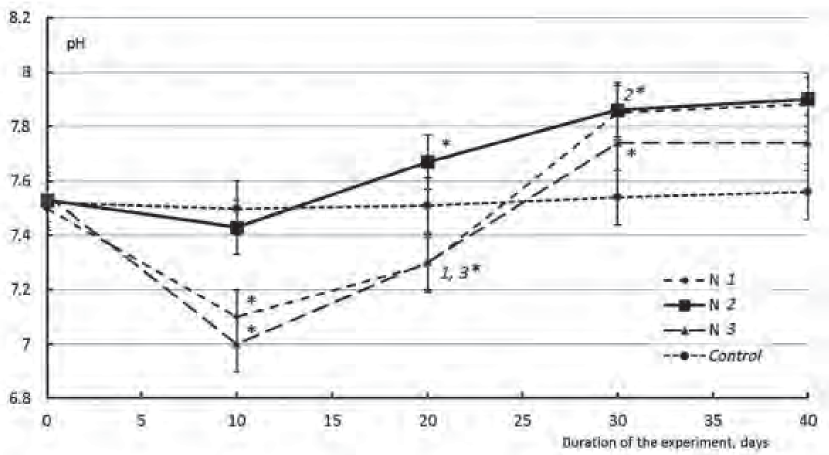


Fig. 5. **pH indicator concentration change under hydrophyte purification conditions**

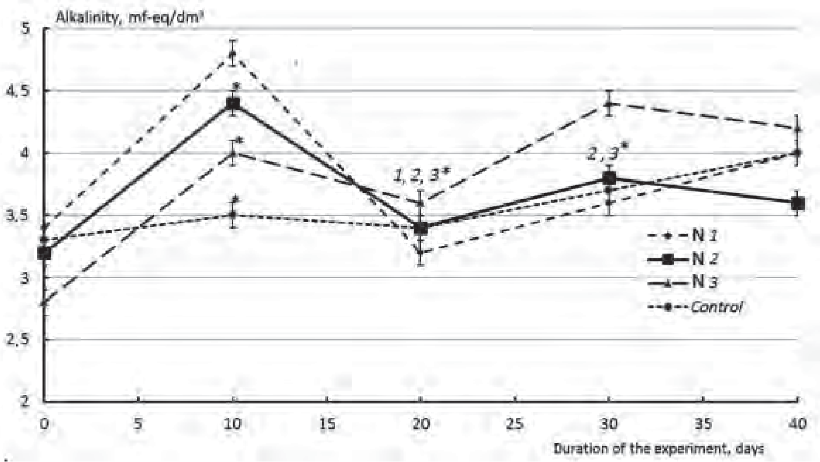


Fig. 6. **Water alkalinity while hydrophyte purification**

visible. In particular, in the first 10 days of experiment implementation the alkalinity indicator increased from 3.4 ± 0.10 mf (mean frequency)-eq/dm^3 to 4.8 ± 0.10 mf-eq/dm^3 however, within the next 20 days it reduced again to a 3.2 ± 0.10 mf-eq/dm^3 value, and then to the end of the experiment again increased to the 4.0 ± 0.10 mf-eq/dm^3 mark. Such alkalinity fluctuations were observed on other options. The highest alkalinity value was recorded in the option *N3* with mixed phytocoenoses after a month of beginning of the experiment — 4.4 ± 0.10 mf-eq/dm^3.

The alkalinity value ranged slightly less on the control; however, the instability tendency persists there during the whole research period. Therefore, we can assume that the hydrocole in biological treatment facilities presence does not significantly affect this index dynamics.

The nitrogen and phosphorus content has got special importance for biological wastewater purification. All forms of nitrogen compounds deep removal, as well as their content in wastewater is always high, task is set for wastewater purification facilities [1]. In household wastewater before its purification, oxidized forms of nitrogen (nitrites and nitrates) are absent as usually [1, 2]. The anaerobiosis processes when wastewater is transported by the water disposal system, bacteria activities that denitrify the oxidized forms of nitrogen to the molecular forms can explain wastewater impurities denitrification. The oxidized nitrogen forms appear after biological wastewater purification indicating the full process completeness. That is why we performed complex, taking into account possible nitrogen content forms transformation processes, nitrogen exchange indicators analysis.

Based on the results of our research, the nitrogen metabolism indicators had significant fluctuation tendency throughout the research period, which is quite typical for biological purification facilities (Fig. 7). Obviously, this is due to high ammonia nitrogen content (0.79–0.83 mg/l) at the beginning of the experiment and its conversion from ammoniac to nitrite and, subsequently, to nitrate forms. The ammonia content decrease was especially appreciable while *E. crassipes (Mart.) Solms* cultivation (option *N1*). The most intense ammonia nitrogen oxidation was observed in the first 10 days of experiment, during this period about a third of its total content collapsed — 38% (option *N1*), 28% — option *N2* and 21% – option *N3*. It should be noted that ammonia content remained practically unchanged during the control. So while *E. crassipes (Mart.)* cultivation the ammonia value decreased more intensively than while *P. stratiotes L.* and both cultures mixed phytocenosis cultivation.

Fig. 8 proves nitrogen ammoniac forms intense oxidation while hydrophyte purification. The sharp increase of nitrate ions concentration after a 10-day period is closely connected with nitrogen ammoniac forms concentration decrease. As we see on graphics, oxidized forms appearance for all options with hydrobionts is almost equal. In the first 10 days of nitrite ions content indicators variation was within 10%, but from 10^{th} to 20^{th} day nitrites amount increased by 6.6–8.75 times. The amount of nitrates increase for all options lasted about a month and further their contents started to decrease that demonstrates oxidized forms by hydrobionts assimilation which they took in the purification process. Over the last 10-days period (from 30^{th} to 40^{th} day) the nitrite amount decreased by 14–15%.

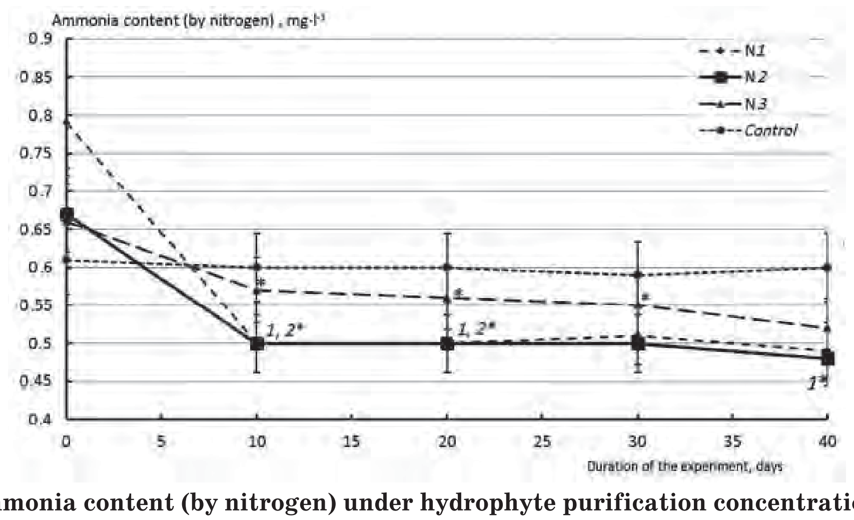


Fig. 7. **Ammonia content (by nitrogen) under hydrophyte purification concentration change**

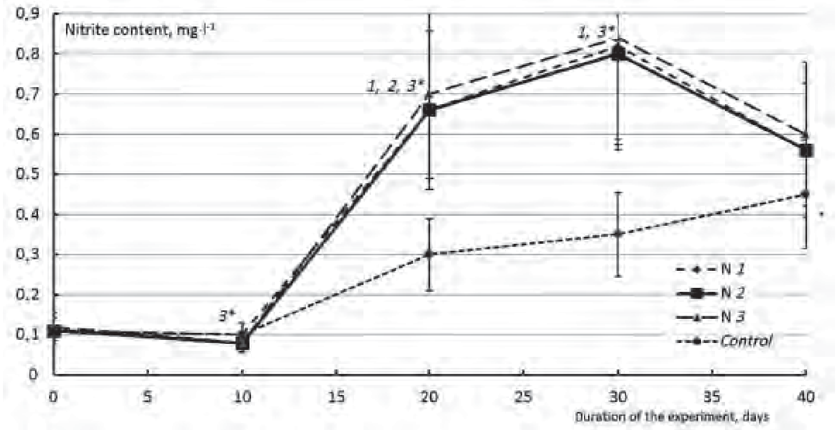


Fig. 8. **Nitrite content under hydrophyte purification concentration change**

In the control starting from the 10^{th} day nitrite concentration increased at significantly lower pace in comparison with hydrophyte purification options (only by 3 times).The nitrates amount decrease tendencies at the end the experiment were not observed. In general, under control nitrates concentration increased by 4.5 times.

We also closely associate appearance of nitrates under hydrophyte purification conditions with nitrogen ammonium and nitrate forms conversion because on the second phase of autotrophic nitrification the nitrite ions are oxidized with the help of microorganisms — *Nitrobacter, Nitrospina, Nitrococcus* into the nitrate ions [1]. As we see on Fig. 9 in first 10 days of experiment conclusion phosphates exclusion on all the options was approximately on the same level, 86% — on option *N2*, slightly lower than this indicator appeared on option *N1* and *N3* — 83 and 82% respectively.

On the control phosphates content varies insignificantly and decreased in the first 10–20 days of the experiment by 4%, phosphates content changed only by 7%, which is 75–79% less than on hydrophyte purification options.

To characterize the water under experiment conditions we also determined dichromate oxidation (Fig. 11). Because, it in comparison with permanganate oxidation, more accurately describes the organic pollutants content as potassium dichromate oxidizes about 90% or organic substances of those present in the water including hard oxidative. Under the experiment conditions chemical oxygen demand (COD) indicator (dichromate oxidation) provided by hydrophyte purification in all options tended to decrease. Moreover, dichromate oxidation decreased most intensively during the period between 10^{th} to 20^{th} day — 42%, further the process intensity decreased and before the end of the experiment COD decreased by 55% on option *N1*.

This indicator decreased slightly faster on option with *Pistia* during the period from 10^{th} to 20^{th} day use — 45% however, the final indicator was lower in comparison with option *N1*, mixed phytocoenosis (option *N3*) the influence on COD decrease was the lowest — 41% — during the period from 10^{th} to 20^{th} day and 47% at the end of the experiment. Also on the control COD had a decrease tendency but this process occurred at extremely low pace — only 7% during the period from 10^{th} to 20^{th} day and only 10% at the end the experiment was observed.

Biochemical oxygen demand (BOD) during the period of the experiment had a similar trend with COD indicator fluctuations (Fig. 12), in particular significant variation of this indicator was not observed in the first 10 days of the experiment conduction. But, from 10^{th} to 20^{th} day on all hydrophyte purification options a sharp decrease of this indicator was observed: from 4.6 ± 0.46 mg O_2/l to 2.26 ± 0.226 mg O_2/l that is 53% from its initial value on the *Eichhornia* option (*N1*); from 4.5 ± 0.451 mg O_2/l to 2.5 ± 0.254 mg O_2/l that is 46% from its initial value on the option with *Pistia* (*N2*); from 4.4 ± 0.443 mg O_2/l to 2.3 ± 0.235 mg O_2/l that is 45% from its initial value on the option with both cultures mixed phytocoenoses (*N3*).

Starting from 20^{th} day of experiment BOD5 conduction the water was not practically changed and remained at previous level. Only on *N2* option a further slight decrease of this indicator was observed and at the end of the experiment its general decrease reached 50%, which is 3% lower than in *N1* option. On the

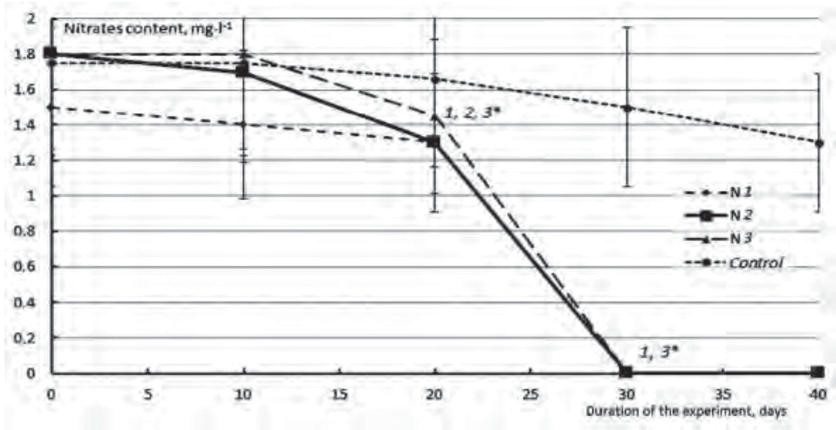


Fig. 9. **Nitrates content under hydrophyte purification concentration change**

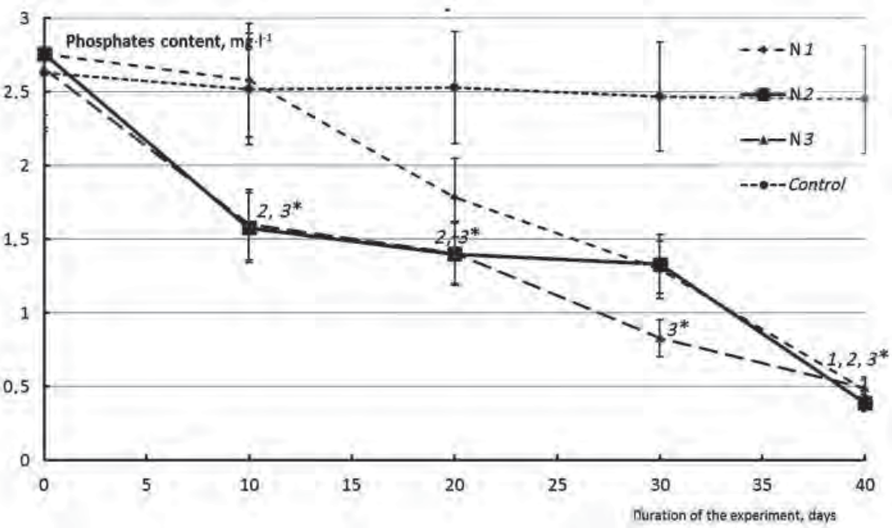


Fig. 10. **Phosphates content under hydrophyte purification concentration change**

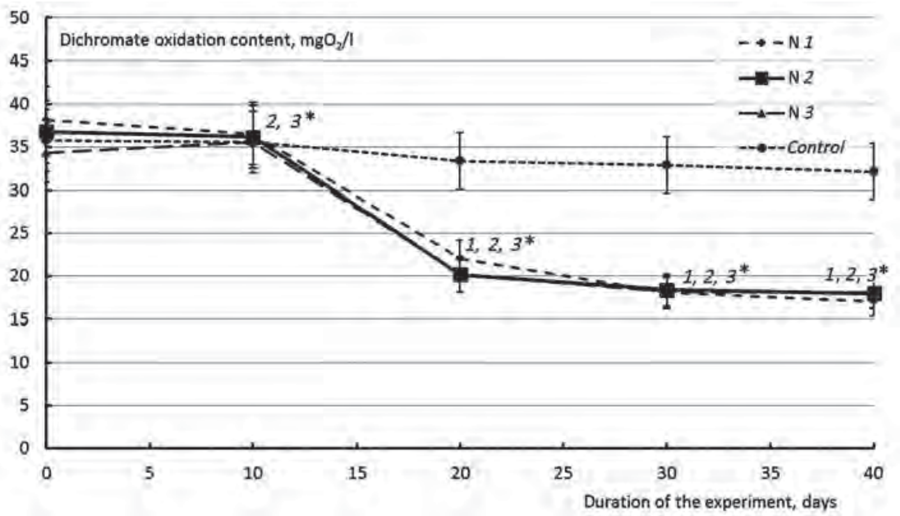


Fig. 11. **Dichromate oxidation content under hydrophyte purification concentration change**

control BOD5 decrease was not practically recorded and was only 4% from its initial value.

For both indicators (COD and BOD5) there is a positive trend concerning water quality improvement. Despite presence of hardly oxidizing organic compounds in water, experimental biological purification facilities hydrophyte loading reduced the value of these indexes by 40–53%. In this case, we can recommend including the preliminary hydrophyte purification into the waste water purification technology.

The general iron is the important indicator especially while the wastewater analysis. Under the experiment conditions in the first 10 days concentration of iron on all the hydrophyte purification options, except the control one, decreased (Fig. 13). The most intensively this process took place on option *N2* with *Pistia* — 17%, and from 10^{th} to 20^{th} day the iron removal process intensity increased and was 43%, at the end the experiment general iron concentration decreased by 53%.

Slightly lower iron removal process intensity was observed on option *N1* with *Eichhornia* use, in first 10 days concentration of iron decreased by 16%, from 10^{th} to 30^{th} day about 39% was extracted, iron content at the end of research decreased more than by a half (52%).

Some slightly lower iron removal process intensity was observed on option *N3* with mixed phytocoenoses only 10% in first 10 days, in next 20 days iron content decreased only by 22% which represents one fifth, at the end of research with mixed phytocoenoses a little more than a third of total iron content was extracted (38%).

Iron concentration varied a little on the control, only by 2% in first 10 days of research. After the end of research iron content decreased

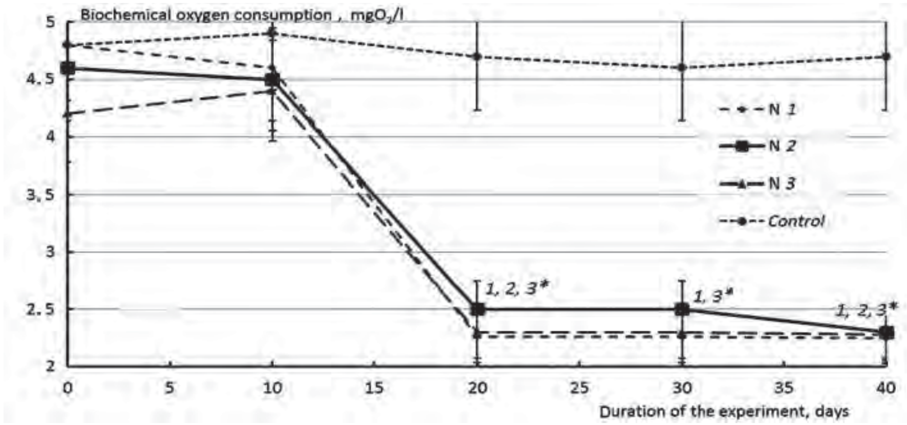


Fig. 12. **Oxygen consumption under hydrophyte purification concentration change**

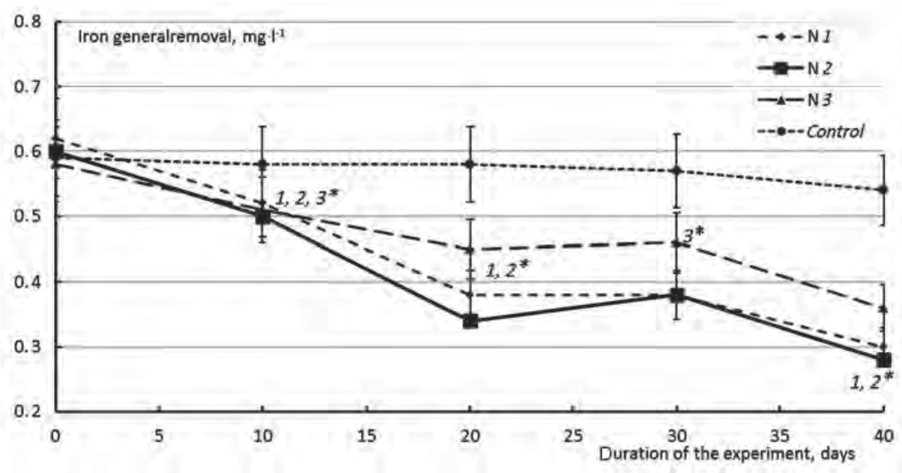


Fig. 13. **Iron general removal under hydrophyte purification concentration change**

by 8%, which is 30–46% lower than in the hydrophyte purification options.

General water mineralization decreased quite slowly during the hydrophyte purification process and in the first 20 days of conducted research mineral share content decrease was only 6–7% on the hydrophyte purification options and only 2% on the control (Fig. 14).

At the time of the experiment completion dry residue content decrease on the hydrophyte purification options was about at the same level and constituted 11–12%. This indicator changed only by 3% on the control that is 7–8% less than on the hydrophyte purification options.

To substantiate the dry residue in drinking tap water normative primarily we need to consider its influence on organoleptic properties.

Chlorides and sulfates content remains virtually unchanged in urban wastewater treatment plants and their concentrations in wastewater do not have significant values neither for physicochemical, nor for biological water purification processes. The microorganism existence threshold was discovered during the research: 150–300 mg/l for urban sewage.

Chlorides content variation was insignificant under the experiment conditions. Water hydrophyte purification use did not significantly affect the chlorides content indicator (Fig. 15).

During the entire research period their content decreased only by 11% on option *N1* with hydrophyte purification load by *E. crassipes (Mart.) Solms* species, slightly lower on the option with mixed phytocoenoses — 10%, on the option with *P. stratiotes L.* chlorides content decrease was within 9%.

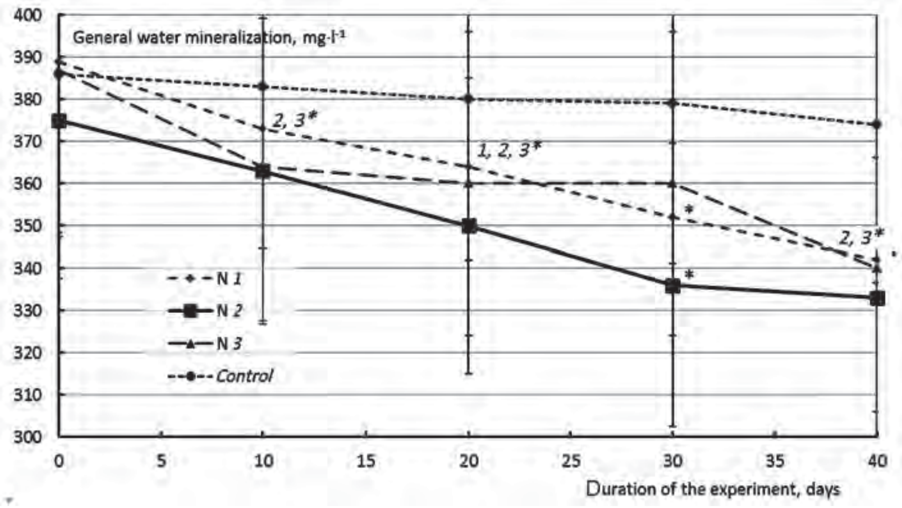


Fig. 14. **General water mineralization when hydrophyte purification**

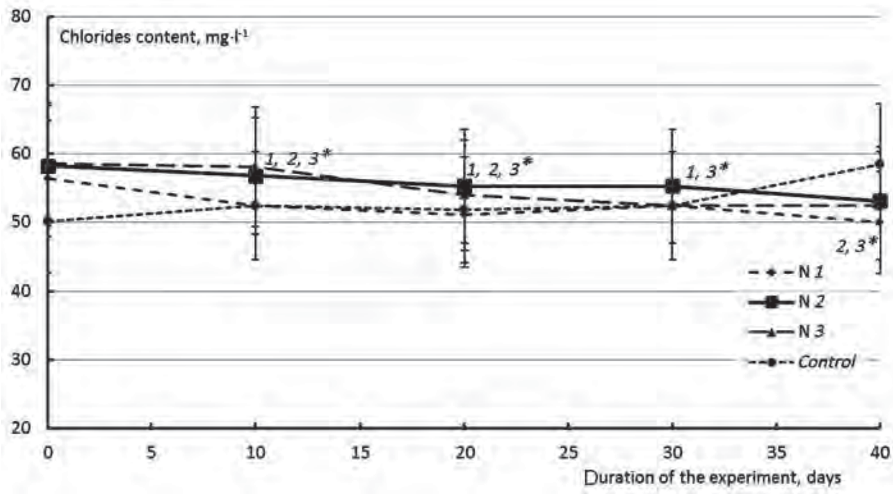


Fig. 15. **Chlorides content under hydrophyte purification concentration change**

Sulphates concentration may vary only under anaerobic conditions while wastewater treatment in two tiered sediment bowls and sludge in methane tanksfermentation. This sustainability can be a kind of the executed analysis accuracy level controller. Sulfates in water concentration also had a slight decrease tendency during the conducted research period (Fig. 16).

On option *N1* with *E. crassipes (Mart.) Solms* use in first 10 days of experiment sulfates concentration decreased by 18% and then their content was stabilized and before the end of the experiment remained at the same level. On option *N2* with *P. stratiotes L.* use sulfates concentration varied slightly less, 17% in total. Nevertheless, their removal process was slower, only 10% in first 10 days. Mixed phytocoenoses on option *N3* use caused sulfates concentration only by 5% decreased during first 20 days of conducted experiment and at the time of experiment completion sulfates concentration decreased by 10% from its general initial content.

Sulfates decrease by 5% on the control occurred on the 20th day of conducted experiment, but at the time of experiment completion their concentration returned to the initial level.

Therefore, as for sulfates content decrease, hydrophyte purification also had a positive trend compared with control.

Phosphates nitrites, ammonia nitrogen high concentrations are the most acute problem at wastewater treatment caused by modern synthetic anionic detergent anionic surface active substances (ASAS) composition use that are presented in the Ukrainian detergents market.

In the studied waters ASAS was detected in the concentration of 0.1 mg/dm^3. Water in the bioreactors load showed positive trend to this indicator improvement.

The best biopurification process took place in the option of *E. crassipes (Mart.) Solms* species were ASAS content decreased by 40% during the first 10 days of experiment. ASAS content decreased twice in option *N1*; it occurred on the 30th day of conducted research and before the experiment completion their concentration decreased by 60%. On options *N1* and *N2* in the first 10 days ASAS were removed only by 20–22%, at the moment of the experiment completion ASAS concentration decreased by 40–44% in general. This indicator decrease on the control without hydrocoles practically does not occur during a month period, however, at the moment of the experiment completion, 10% of them had oxidized as a result of natural physical and chemical processes (Fig.17).

Aquatic plants biomass could be used not only as wastewater meliorant but also in different economic sectors — as a feed additive food for livestock and poultry. We have analyzed the biochemical composition of aquatic plant mass that was used in wastewater purification processes. Furthermore, biomass biochemical composition varies greatly in different parts of plants, therefore, the composition water surface and underwater plants parts were monitored simultaneously.

E. phytomass is characterized by a fairly high nitrogen content. This is one of the key elements — organogenes, its plant tissues content is usually about 1.5% of dry substance, however in *Eichornia* green mass

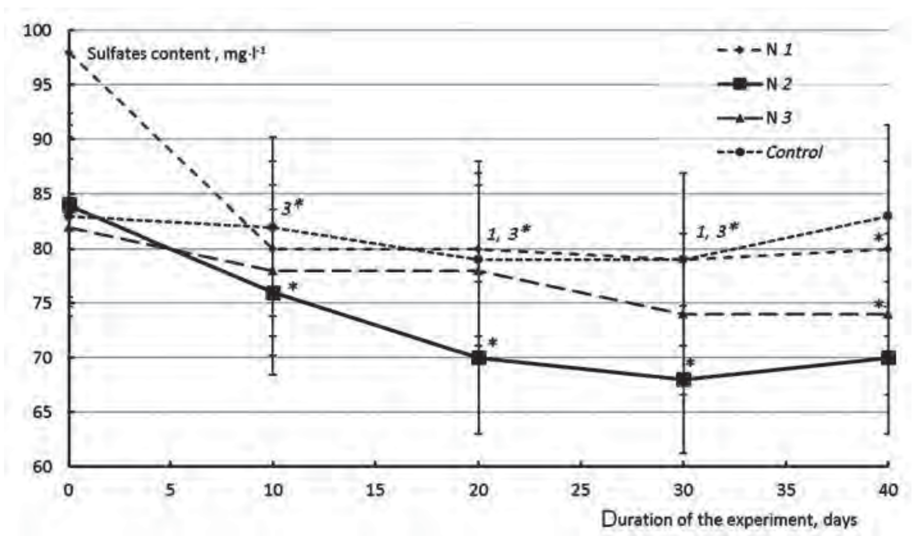


Fig. 16. **Sulfates content under hydrophyte purification concentration change**

its content was higher — 2,69 ± 0,019% and 2,48 ± 0,112% — in the roots (Table). Phosphorus in green mass and roots content also had minor differences — 0.74 ± 0.002% and 0.87 ± 0.011% accordingly.

Potassium in studied plants content did not deviate from conventional indicators. In general, the majority of plants are characterized by a high potassium content (0.9–1.2% of plant tissue dry mass) and it also did not exceed 2% in water hyacinth phytomass content during the studied period. While this minimum general potassium content indicators are typical for underwater part — 0.46 ± 0.044% and maximal — for green mass — 1.93 ± 0.004%.

Fairly high content of ash elements is inherent for *Eichornia* phytomass, their higher land part content is 17.68 ± 0.832% of dry substance, which is 2.3% more than in the roots.

Calcium content in *Eichornia* organs in different options is less variable in both cases. In leaves and roots its content was at the level of 1.86–1.87% of dry substance. However, it should be noted that in comparison with other plant species, where calcium content usually was at the 0.02% level, *Eichornia* has got almost 9 times more of it. Regarding the cellular tissue plant phytomass distribution their high concentrations in both leaves should be noted — 18.19 ± 1.020%, as well as in the roots — 21.82 ± 1.440%.

As the conducted research has shown *Eichornia* like the most of the higher aquatic plants is able to accumulate significant quantities of a heavy metals (lead, mercury, copper, cadmium, cobalt, nickel, tin,

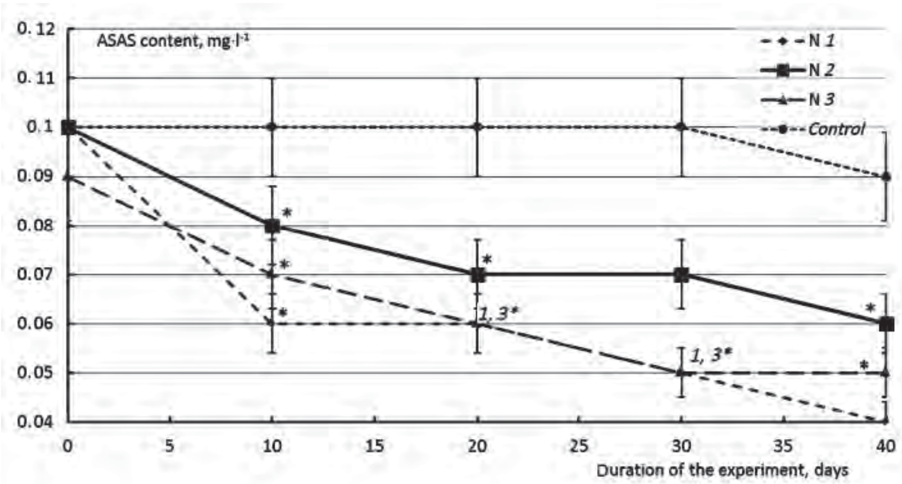


Fig. 17. **Anionic surface active substances (content under hydrophyte purification concentration change**

Eichornia crassipes **plants which are used in water treatment processes biochemical composition**

Indicator	Green mass	Roots
N, %	2.69 ± 0.019	2.48 ± 0.112
P, %	0.74 ± 0.002	0.87 ± 0.011
K, %	1.93 ± 0.004	0.46 ± 0.044
Ash, %	17.68 ± 0.832	15.41 ± 0.871
Ca, %	1.86 ± 0.023	1.87 ± 0.089
Cellulose, %	18.19 ± 1.020	21.82 ± 1.440
Fat, %	–	–
Cu, mg/ dry substance kg	12.26 ± 0.854	44.98 ± 1.651
Zn, mg/ dry substance kg	29.45 ± 0.144	28.34 ± 1.520
Mn, mg/ dry substance kg	354.93 ± 3.337	945.43 ± 7.568
Co, mg/ dry substance kg	1.67 ± 0.041	3.67 ± 1.102
Fe, mg/ dry substance kg	146.63 ± 4.536	1215.60 ± 10.356
Pb, mg/ dry substance kg	8.28 ± 0.114	16.67 ± 1.110
Cd, mg/ dry substance kg	0.83 ± 0.011	1.47 ± 0.024

manganese, iron, zinc, chromium) and also radionuclides and therefore to remove these metals from water. It should be noted that plants were in the substratum in which the most heavy metals contents were by 25, 16, 76 and 110 times higher than these metals maximum allowable concentration in water set. *Eichornia* plants accumulated these elements in small amounts. It was established that *Eichornia* plants root system, directly contacting with sewage, accumulates 2–10 times more heavy metals than ground phytomass. This indicates the intensive water purification process progress precisely because of powerfully developed root system of this plant species.

In particular, copper content in root system exceeded this element in green mass contents by 3.7 times, manganese — by 2.7, cobalt — 2.2, iron — 8.2, lead — 2, cadmium — 1.8 times. Only zinc in the green mass concentration almost meets the root system concentration (29.45 ± 0.144 mg/kg of dry substance. vs. 28.34 ± 1.520 mg/kg of dry substance).

So, hydrophyte load use by all the studied options showed the positive tendency regarding all studied water quality indicators improvement and pollutants purification effect on some indicators was then 80%. The developed hydrophyte load compositions showed high resistance to high water pollutants concentrations. Studied hydrocoles species: *Eichhornia* and *Pistia* are recommended for phytoremediation purposes. The biochemical phytomass of studied hydrophytenyh loads composition showed their high nutritional value in comparison with traditional feed crops (clover) which indicates the possibility of their further processing for high quality nutriment.

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ГІДРОФІТНЕ ОЧИЩЕННЯ ВОДИ В УМОВАХ КОМУНАЛЬНОГО ПІДПРИЄМСТВА «ЖИТОМИРВОДОКАНАЛ»

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Метою дослідження було тестування очищення води гідрофітним методом, визначення ефекту очищення води, допустимих навантажень найбільш токсичних забруднювачів на вищі водні рослини за умов моделювання на лабораторних моделях і способів використання обробленої фітомаси.

Наведено результати очищення методом визначення біологічного різноманіття, аналізуються різні види вищих водних рослин у рамках лабораторної моделі якості води, ефект очищення води і перспективні способи використання фітомаси відходів. Застосування гідрофітного навантаження відповідно до всіх розглянутих варіантів показало позитивну динаміку щодо поліпшення всіх вивчених показників якості води та очищення від забруднювальних речовин. Згідно з деякими показниками ступінь очищення становив понад 80%. Біомасу водних рослин можна використовувати не тільки для одержання меліоранту зі стічних вод, але і як кормову добавку для сільськогосподарських тварин.

Ключові слова: фітомеліорація, гідрофіти, ефект очищення, хімічне забруднення, господарсько-побутові стічні води.

ГИДРОФИТНАЯ ОЧИСТКА ВОДЫ В УСЛОВИЯХ КОММУНАЛЬНОГО ПРЕДПРИЯТИЯ «ЖИТОМИРВОДОКАНАЛ»

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Целью исследования было тестирование очистки воды гидрофитным методом, определение эффекта очистки воды, допустимых нагрузок наиболее токсичных загрязнителей на высшие водные растения в условиях моделирования лабораторных систем и способов использования обработанной фитомассы.

Представлены результаты очистки методом определения биологического разнообразия, анализируются различные виды высших водных растений в рамках лабораторной модели качества воды, эффект очистки воды и перспективные способы использования фитомассы отходов. Применение гидрофитной нагрузки в соответствии со всеми рассмотренными вариантами показало положительную динамику относительно улучшения всех изученных показателей качества воды и очистки от загрязняющих веществ. Согласно некоторым показателям степень очистки составляла более 80%. Биомасса водных растений может быть использована не только для получения мелиоранта из сточных вод, но и в качестве кормовой добавки для сельскохозяйственных животных.

Ключевые слова: фитомелиорация, гидрофиты, эффект очистки, химическое загрязнение, хозяйственно-бытовые сточные воды.