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USE OF AQUATICPLANTS IN MINE WASTEWATER PURIFICATION

[1]Turdaliyeva Kh.S., [2]Huzhzhiev S.A.,[1]Safarov K.S.

[1]National University of Uzbekistan, [2] State Pedagogical Institute of Navoi,

Abstract: Hydrochemical and elemental analyses of wastewater from the Koch-Bulak mine of the Angren mining department carried out before and after the cultivation of *Carolina azolla*, *Pistis teloreo*us and *Eichhornia crassipes*. The growing conditions of the studied aquatic plants on these wastewaters selected. Features of the growth and development of the studied plants in the mine wastewater are identified. The smallest increase in biomass in the laboratory showed *Carolina azolla*, the largest - *Pistis teloreo*us. Elemental composition of the studied plants was carry out by the neutron activation analysis. Specific and organ-specific differences in the accumulation of chemical elements in the biomass of aquatic macrophytes are revealed as well. Work clarifies possibilities of aquatic plants: *Carolina azolla*, *Pistis teloreo*us and *Eichhornia crassipes* use for the purpose of mine waters' purification.

Keywords: wastewater, aquatic plants, biological treatment, hydrochemistry, neutron activation analysis.

Introduction

One of the most important modern environmental problems is the treatment of industrial and household wastewater. Protection of water basins from pollution, the development of effective biological methods of wastewater treatment - current issues of the global problem "Man and the Biosphere". Comment 1: Please change this sentence linguistically. The major point is of course important! The growth of cities, the rapid development of industry, the intensification of agriculture, the significant expansion of irrigated land, the improvement of cultural and living conditions, and a number of Comment 2: write "many". other factors even more complicate the problem of water supply. The shortage of fresh water is already becoming a global problem and requires you to look for various means and ways to solve it.

Currently, there is a number of Comment 3: write "many". solutions in the field of water protection related to the mechanical, physic-chemical and biological treatment of polluted water. Nevertheless, there are no universal solutions compatible for any natural-anthropogenic conditions, and for each natural area within specific economic activities and facilities that pollute water, so an individual approach to the choice of treatment technology is required.

One of the most effective ways of wastewater treatment is biological method, which implies the use of various algae, aquatic plants and other aquatic organisms. Methods of biological wastewater treatment are constantly improving. Comment 4: Here the authors would also point out the more technical advanced biological treatment methods such as "attached growth" – trickling filters, and the concept of activated sludge systems. Accordingly,we some lines on the combination of dual biological treatment systems could be mentioned here. In this context it is especially interesting to point out that a first stage (the trickling filter or the activated sludge) may serve as a "detoxification" system, followed by the type of different kinds of wetland treatment, as this paper is focusing on!

In this issue as a result of long-term scientific research, scientists of Republic of Uzbekistan have developed and introduced into production efficient methods for cleaning wastewater from agricultural production, industrial and municipal wastewater from organ-mineral substances, heavy metal ions, cyanides, pesticides, oil products, and from pathogens cultivation of various algae and aquatic plants [1, 2, 3].

However, research on the role of aquatic plants in the biological treatment of wastewater in the mining industry is extremely small [4, 5, 6, 7].

In this regard, the purpose of this work was a comparative study of the role of some of the introduced aquatic plants in the biological treatment of wastewater from the "Koch-Bulak" mine of the Angren mining department.

Objectives of study

Objects of the original study were wastewater of "Koch-Bulak" mine treatment facilities of the Angren mining department which situated in Axangaran region of Tashkent, Republic of Uzbekistan and aquatic plants- *Pistis teloreous* (*Pistia stratiotes* L., *Araceae* fam.), *Eichhornia crassipes* (*Eichhornia crassipes* Solms., *Pontederiaceae fam.*), *Carolina azolla*(*Azolla caroliniana* Willd. *Azollaceae fam.*)

The experiments were conducted in laboratory conditions in aquariums (water volume 10 liters). Sampling of wastewater was performed according to the research schedule.

Materials anв methods

In the wastewater for hydrochemical analysis, water temperature was determined at a depth of 10-12 cm, color - visually, odor by points [8], suspended particles (dry mass only) pH, dissolved oxygen, BOD5 and oxidability, COD, ammonia, nitrite, nitrates, phosphates, carbonates, sulfates , ions of heavy metals - according to Yu.Yu. Lurie [10,11] together with the staff of the Institute "VODINGEO" The study of aquatic plants was carried out according to the methods of hydro-botanical studies proposed by V. Papchenkov.[12]

The content of macro- and microelements in the biomass of higher aquatic plants grown on the wastewater of the Angren mine department was determined in the laboratory of neutron activation analysis of the INP, Academy of Sciences of Uzbekistan. Statistical processing of the data obtained by the program SPSS (STATISTICA).

Experiments were performed in four variations:

Control –One volume of wastewater diluted with two volumes of clean water. This proportion of wastewater and clear water are mentioned bellow as "Diluted waste water)

Diluted wastewater + *Carolina azolla*;

Diluted wastewater + *Pistis teloreo*us;

Diluted wastewater + *Eichhornia crassipes*

Due to shallow-roots of studied plants, effectiveness of experimental plants calculated for definite green biomass of aquatic plant per water area of aquarium at a rate of:

300 g *Carolina azolla* per $1m^2$ aquarium water surface,

1000 g *Pistis teloreous* per $1m^2$,

1000 g *Eichhornia crassipes* per $1m^2$.

Duration of experiments is 10 days. All plants were planted simultaneously.

Prior to the beginning and at the end of the experiments, water samples were taken for hydro chemical and elemental analysis. Samples of aquatic plants and wastewater were also analysed by the neutron activation method.

Results and its discussion.

In the initial series of experiments, the effect of wastewater from the "Koch-Bulak" treatment facilities of the Angren mining department of the Almalyk Mining and Metallurgical Complex (AGMK) on the growth of water plants were studied.

As a result of the experiments, it was revealed that all 3 studied higher aquatic plants did not blossom in wastewater.

On the 3rd and 4th day, the roots almost completely died, the leaves turned pale and necrotic areas were observed on their edges (5-7 days after plant transplantation).

When diluting wastewater with tap water (1: 1) for the first three days, aquatic plants adapted to their growing conditions.

The physical properties and chemical composition of wastewater after the treatment facilities purification at the “Koch-Bulak” mine of the Angren mining department are shown in Table 1 below.

As can be seen from these data, indicators of sewage vary by seasons of the year: in the fall compared to the summer period, such indicators as BOD5, COD, the content of organic substances, insoluble sediment, etc., increase markedly.

Table 1

Physical properties and chemical composition of wastewater after purification of Angren Mining Department

Performance	Initial water 10th May	Dilute water (1:1) 15th June	Dilute water (1:1) 7th September
Smell	unpleasant specific odour	specific	specific
Color	Yellowish	Yellowish.	Yellowish
pH	6,85	6,70	6,76
Dissolved oxygen, mg O_2/l	2,15	5,50	4,95
BOD5, mg O2 / l	45,60	28,25	30,25
COD mg O2 / l	91,41	49,98	51,36
oxidizability, mg O_2/l	12,55	12,15	12,40
Sog., mg C/l	34,48	18,74	19,85
Sodium Na, mg/l	115	67	75
Potasium K, mg/l	5	3	4
Ammonia, mg/l	-	-	-
Calcium Ca, mg/l	220	200	240
Magnium Mg, mg/l	73	61	63
Suphates, mg/l	1913	1470	1550
Nitrates, mg / l	3	2	3
Nitrites, mg / l	0,6	0,4	0,4
Carbonates, mg / l	45	82	88

Chlorides, mg / l	55	35	42
H_2S	-	-	-
Oil products, mg / l	0,022	0,012	0,013
Phosphates, mg / l	0,05	0,03	0,04
Insoluble precipitate, mg / l	30	16	21
Dry residue, mg / l	2880	2240	2330

The productivity of the studied aquatic plants in the laboratory showed in Table 2.

Table 2 The productivity of higher aquatic plants grown on wastewater

(Dilution 1: 1, laboratory experiments, June, September 2015)

Experiments vary	Duration, 24 hours	Raw biomass, g/m^2		
		At the beginning of experiment	At the end of experiment	Daily gain, g
Carolina azolla	10	160	495±2,0	33,5±0,9
Pistis teloreous	10	300	861±3,5	56,1±0,2
Eichhornia crassipes	10	300	793±3,2	49,3±0,2

As can be seen from the presented data, the average daily growth of the studied aquatic plants on diluted wastewater is 33.5 g / m^2 for *Carolina azolla*, 56.1 g / m^2 for *Pistis teloreous*, and 49.3 g / m^2 for *Eichhornia crassipes*.

In order to clarify the role of floating aquatic plants in the biological purification of mine wastewaters, we cultivated them in diluted (2 times) wastewater. The results are shown in tables 3 - 4.

As can be seen from these data, after the cultivation of *Carolina azolla*, the *Pistis teloreous* and the *Eichhornia crassipes*, the unpleasant and peculiar smell of water disappears, they become slightly yellowish, the pH increases from 6.7 to 7.2 At the same time, BOD5 and COD are reduced by 2 times, and other hydrochemical indicators of wastewater are significantly reduced. According to preliminary data, in laboratory experiments in the aquarium the "cleansing effect” of *Carolina azoll*a is higher than *Pistis teloreous* and *Eichhornia crassipes*. Upon a detailed examination of the results of the experiment, it turned out that the volume of water transpirated by the *Eichhornia* per unit of time is 3 times as much as *Pistis* are almost 2 times more than the *Carolina azolla*. Whereby all given information, it can be summered that, according to the degree of the “cleansing effect”, the studied aquatic plants arrange in sequence as:

Eichhornia crassipes > *Pistis teloreous* > *Carolina azolla*.

Table 3

Physical properties and chemical composition of wastewater Angren Mining departmnet after growing aquatic plants

Показатели	*Carolina azolla*	*Pistis teloreous*	*Eichhornia crassipes*
Smell	inodorous	inodorous	inodorous
Color	Light yellowish	yellowish	yellowish
pH	7,20	6,80	7,14
Dissolved oxygen, mg O_2/l	4,95	4,80	4,40
BOD5, mg O2 / l	13,80	15,63	21,63
COD mg O2 / l	30,52	32,05	42,65
oxidizability, mg O_2/l	3,85	6,95	9,11
Sog., mg C/l	11,44	12,02	16,70
Sodium Na, mg/l	6,0	5,4	6,1
Potasium K, mg/l	3,0	2,9	2,9
Ammonia, mg/l	No	No	No
Calcium Ca, mg/l	120	47,5	51,4
Magnium Mg, mg/l	5,5	5,2	5,5
Suphates, mg/l	1207	1374	1490
Nitrates, mg / l	2	2,0	2,1
Nitrites, mg / l	0,2	0,2	0,2
Carbonates, mg / l	134	58	130

Chlorides, mg / l	41	44	37
H_2S	No	No	No
Oil products, mg / l	0,010	0,016	0,013
Phosphates, mg / l	0,04	0,67	0,33
Insoluble precipitate, mg / l	14	12	18
Dry residue, mg / l	1920	2110	2215

Table 4

The content of chemical elements in wastewater Angren Mining Department before and after the cultivation of aquatic plants (μg / l).

Element	Before the experiment 1:1	After cultivation		
		Carolina azolla	*Pistis teloreous*	*Eichhornia crassipes*
As	6,81	0,56	0,58	0,71
Au	0,16	0,041	0,024	0,018
Ba	3610	1950	2800	1860
Br	98,8	6,31	7,82	7,60
Ca	155610	79980	76120	78060
Ce	0,67	0,087	0,032	0,105
Cl	162310	7438	13260	9685
Co	3,66	1,67	1,83	1,59
Cr	93,4	19,3	24,4	21,8
Rb	1,71	0,164	0,159	0,165
Cu	4,30	0,8	0,9	0,8
U	0,36	0,26	0,16	0,30
Fe	2530	1490	1460	1160
Se	1,12	0,048	<0,01	0,016
Na	53910	3810	3081	3260
K	4237	3104	3634	3567

La	23,6	14,4	16,3	16,5
Zn	0,001	0,0005	0,0001	0,0003
Mg	42550	3160	3235	4150
Mn	148	2,79	6,45	1,05
Mo	25,2	3,53	2,41	5,06

As can be seen from these data, the absorption of nutrients from wastewater by the studied plants varies greatly. Thus, the ions of magnesium, potassium, chlorine are more absorbed by the *Carolina azolla*, and the ions of calcium, cerium, rubidium, uranium, selenium and molybdenum - more in *Pistis teloreous*; Ions of gold, barium, cobalt, iron, and manganese are excellent in *Eichhornia crassipes*. The reasons for these differences need an explanation and in-depth study. It is necessary to highlight that the content of chemical elements differs significantly in individual organs (leaves, roots) of the *Carolina azolla* and *Eichhornia crassipes*. Plants show specific organ accumulation of elements.

Comment 5: The comments on nutrient uptake would accordingly focus on both Phosphates and nitrogen compounds, being the crucial elements of nutrients!

Thus, studies of the absorption of ions of chemical elements by aquatic plants show that there are differences in the nature of the accumulation and migration of these substances to different parts of the plant. The decrease in the concentration of pollutants in wastewater when growing higher aquatic plants varies widely and depends on many factors: plant density and species composition, their physiological activity, construction area, season of the year, nature of wastewater, water and air temperature, etc.[1-3,13,14]

Conclusion

Aquatic plants are fairly effective natural system for regulating water quality and can be used as a major component in engineering devices (bioplato, bioengineering structures and biological ponds) for the treatment and purification of wastewater with a fairly wide range of pollutants.

The decrease in pollutant concentrations when aquatic plants used (total nitrogen and phosphorus, some heavy metals, petroleum and petroleum products, pesticides, etc.) varies widely and depends on many factors: season of the year, plant density and species composition, area facilities and wastewater load on it, etc. Depending on the listed conditions, the degree of wastewater treatment from nitrogen compounds varies from 25 to 97%, from heavy metals - 14-90%, from oil and oil products - up to 100%.

Should note that most of the literature does not provide information on the species composition of plants and the area they cover the water area of buildings, on the initial concentrations of pollutants, on the modes of operation and the influence of external influences (water and air temperature, dilution, the presence of extreme loads, etc.). This makes it difficult to compare the efficiency of using different types of plants depending on the listed factors determining the development of technology for operating structures of this type in relation to different climatic zones.

Until now, there are also no scientifically based data on the dynamics of wastewater treatment using *Eichhornia crassipes, Carolina azolla, and Pistis teloreous*.

In this regard, during the reporting period, we studied the growth, development and productivity of higher aquatic plants (*Eichhornia crassipes, Carolina azolla, and Pistis teloreous*) on wastewater after the Koch-Bulak mine treatment plant of the Angren mine department of the Almalyk mining and smelting combine.

As the consequence of the conducted research, conditions were selected for growing the studied higher aquatic plants in wastewater; hydro chemical and elemental analysis of wastewater were conducted before and after the cultivation of aquatic plants. Comparative analysis of the elemental composition of the biomass of *Eichhornia crassipes, Carolina azolla, and Pistis teloreous* grown on wastewater carried out too.

Comparison of literature data and the results allowed us to note the following:

- Aquatic plants regulate water quality not only due to filtration properties but also by help of ability to absorb nutrients. The ability of aquatic plants to accumulate, utilize, transform many substances makes them indispensable in the general process of self-purification of water bodies;

- The vital activity of plants during wastewater treatment varies depending on many factors, such as the concentration of substances in the waste water, water and air temperature, oxygen supply, light, daylight longitude;

- Similar to all water plants floating on the surface *Eichhornia crassipes, Carolina azolla, and Pistis teloreous*, they use carbon dioxide for photosynthesis of air, and using the root system and leaves that come in contact with water, carbonate carbonates, mineral salts, low molecular weight carbohydrates, amino acids and other substances. Powerful root systems of pistols and *Eichhornia* provide high efficiency of surface adsorption absorption of nutrients;

- selective microbiocenoses (bacteria, algae, protozoa, invertebrates) are formed on the surface of the strongly developed roots of the *Eichhornia crassipes Eichhornia crassipes* which promote more active biodegradation and absorption of organic and mineral substances. Such symbiotic relationships are possible due to root secretions of macrophytes.

Powerful root systems of *Pistis teloreous* and *Eichhornia crassipes* provide high efficiency of nutrient absorption. Selective microbiocenoses (bacteria, algae, protozoa, etc.) formed on the surface of the *Pistis teloreous* and *Eichhornia crassipes* roots that contribute to more active biodegradation and absorption of organic and mineral substances. Such symbiotic relationships are possible due to root secretions of aquatic macrophytes.

Thus, the use of aquatic plants in the treatment of industrial wastewater is perspective in many ways. Comment 6: Yes, and this in turn points out to additional research studies. As mentioned above, the point of using a two-stage biological model would be relevant to discuss in this context!

References

1. A.A.Azizov "Water use in Uzbekistan, traditions and modernity" Tashkent 2015 UNESCO
2. Kyptsevich EP, Potekhin SA, Soldatov Yu.N., Olontsev V.M., Drotchenko V.I. Use of Eichhornia for cleaning industrial wastes // Ecology and industry of Russia. - 2001. - № 2. - p. 21-23.
3. Lurie Yu.Yu. Unified methods for the analysis of water. - M :, Chemistry, 1973. - 376 p.
4. Lurie Yu.Yu. Analytical chemistry of industrial wastewater. -M .: Chemistry, 1984. - 447 p.
5. Mustafin AG, Ishmakov R.V., Kovtunenko S.V., Dausheva G.Zh., Suyundukov Ya.T. Ecological problems of mining regions of the Republic of Bashkortostan and ways to solve them // Problems and prospects of competitive reproduction in the Bashkir Trans-Urals: Materials of the Republican scientific-practical conference. In 3 parts. Part III. -Ufa: RIC BashGU, 2008. –C.127-131.
6. Mustafin AG, Kovtunenko S.V., Sabitova Z.Sh. Technological scheme of wastewater treatment at the Buribaevsky mining and processing plant // Science, education, production in solving environmental problems (Ecology-2007): Collection of scientific articles of the IV-th International Scientific and Technical Conference. -Ufa: USATU, 2007. - p. 337-340.
7. Papchenkov V.G. Production of macrophytes of waters and methods for studying it // Hydrobotany: Methodology, Methods: School materials on hydrobotany. - Rybinsk: OJSC Rybinsk House of the Press, 2003. - p. 137-145.
8. Safarov K.S., Rakhimov Z.A., Muminova R.N., Khuzhzhiev S.O. Physiological and biochemical features of some aquatic macrophytes and

their role in the purification of polluted water // Hydrobotany 2010: Proceedings of the I (VII) international conference on aquatic macrophytes. - Yaroslavl, 2010. –C. 262-264.

9. Seleznev A.M. Influence of the mining industry on the state of the Khudolaz and Tanalyk rivers // Scientific reports of the conference “Science Week - 2003” of the Sibay Institute of the Bashkir State University: Part 1. - Sibay, 2004. - P. 10-18.
10. Stroganov N.S., Buzinova N.S. A practical guide to hydrochemistry. -M :, ed. Moscow State University, 1980. -196 p.
11. Turdaliyeva Kh.S., Safarov KS Intensification of biological wastewater treatment processes. Vestnik KKO AS RUz, 2013. No. 1. p. 42-44.
12. Shoyakubov R.Sh., Safarov K.S. Higher aquatic plants: achievements, perspectives of study and use in Uzbekistan. // Actual problems of algology, mycology and hydrobotany: materials of the international scientific conference. - Tashkent, 2009. –C.30-
13. Civilini M., Ceccon L., Debertoldi M. Biological wastewater treatment for metallyrgical undustries // Ann. Microbiol. – 2006. – N 1. – P.7-12.
14. Driver Ch. Pflanzen reinigen Deponiesickerwasser // Umwelt. - 1989. - 19, №6. - P. 322-327.
15. Feiler U., Krebs F., Heininges P. Aquatic plant bioassays used in the assessment of water quality in German rivers // Hydrobioilogia. – 2006. N1. – P.67-71.