Original Research Article

USE OF AQUATICPLANTS IN MINE WASTEWATER PURIFICATION

Comments to this article are made by Dr Stig Morling and pasted yellow, written in Comic sans MS

Summary: **Comment 1: Alterntive title would be "Abstract"** Hydrochemical and elemental analyzes 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*. **Comment 2: It would be desirable to identify the location of the mine, both with the identification of what country we are presented, and preferably by a map aswell. As understood from the following text the country is Uzbekistan**(?). The growing conditions of the studied aquatic plants on these wastewaters were gently selected. The neutron activation analysis of the elemental composition of the biomass of aquatic plants was carried out. Specific and organ-specific differences in the accumulation of chemical elements in the biomass of aquatic macrophytes are revealed.

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

Comment 3: The headings to this part of the paper would either be "Background" or "Introduction"

One of the most important modern environmental problems is the treatment of industrial and household wastewater.

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 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 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.

As a result of long-term scientific research, scientists of our republic **Comment: Present the name of the republic here!** 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 higher aquatic plants [7, 10, and 11].

However, research on the role of aquatic plants in the biological treatment of wastewater in the mining industry is extremely small [1, 4, 5, 8].

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.

Objects and methods of research. **Comment 4: Divide the chapter into two parts; the first with the "Objectives" and the second one into "Material and Methods"**

Objects of the original study were wastewater of "Koch-Bulak" mine treatment facilities of the Angren mining department 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). **Comment 5. Here it would be beneficial to have a photo presented of the aquariums, to get the reader more involved.**

Sampling of wastewater was performed according to the research schedule. In the wastewater for hydrochemical analysis, water temperature was determined at a depth of 10-12 cm, color - visually, odor by points [9], pH, dissolved oxygen, BOD_5 and oxidability, COD, ammonia, nitrite, nitrates, phosphates, carbonates, sulfates, ions of heavy metals - according to Yu.Yu. Lurie [2,3] together with the staff of the Institute "VODINGEO"

Comment 6. It would be needed to insert a table here presenting the different parameters measured. As the analysis methods always are bound to a limited accuracy, it is advisable to consider: An example is given to be worked out

Parameter	Analysis method	Value	Nos of samples	Measurement accuracy	Comment
BOD_5			At least 10	+/- 20 to 30 %	Several samples to be analysed

Comment 7. In future studies also the Suspended Solids (SS) would be analysed, and in order to go deeper also future work should include both total values and filtered values!

The study of aquatic plants was carried out according to the methods of hydro-botanical studies proposed by V. Papchenkov.

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 4 variants:

control - diluted waste water without plants;

diluted waste water + Azolla;

diluted waste water + Pistia;

diluted water + Eichhornia.

Plants were planted in aquariums: at a rate **Comment 8. I submit you mean the concentration of plants?** of 300 g / m^2 Carolina azolla, Pistis teloreous – 1000 g / m^2, Eichhornia crassipes - 1000 g / m^2.

The duration of the experiments - 7-10 days. **Comment 9. The time for experiments seems to be very short!**

Prior to the beginning and at the end of the experiments, water samples were taken for hydrochemical 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 was 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 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.

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 BOD_5, COD, the content of organic substances, insoluble sediment, etc., increase markedly. **Comment 10: Make it clear here the raw wastewater composition in columns 3 and 4 (diluted water). Are the analysis taken on the diluted water or on the raw wastewater? This could call for a so called "mass balance" with respect to some of the parameters.**

Table 1

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

Performance	Initial water ___ 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
BOD_5, 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 is shown in Table 2.

Table 2

The productivity of higher aquatic plants grown on wastewater

(Dilution 1: 1, laboratory experiments, June, September 2012)

Experiments vary	Duration, twenty-four 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 azolla was higher compared to 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 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; The ions of gold, barium, cobalt, iron, and manganese are excellent in Eichhornia crassipes. The reasons for these differences still need to be clarified.

It should be noted that the content of chemical elements differs significantly in individual organs (leaves, roots) of the Carolina azolla and Eichhornia crassipes, i.e. organ specificity of accumulation of elements is shown.

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. . [7,10-14]

Conclusion

Aquatic plants are a 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. **Comment 11: In a scientific paper**

the wording “fairly effective” is questionable. The authors would indicate the needs for a comparison with for instance classical treatment methods.

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%.

Powerful root systems of Pistis teloreous and Eichhornia crassipes provide high efficiency of nutrient absorption. Selective microbiocenoses (bacteria, algae, protozoa, etc.) are formed on the surface of the Pistis teloreous and Eichhornia crassipes pistil 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.

Comment 12: For future research a technical address on the removal pathways would be beneficial: Is the reduction caused by assimilation, by oxidation or by settling of particulates?

Comment 13: A probably interesting comparison for the future would be to address various models of wetland systems, for instance in combination with upstream treatment stages. As an example an adopted technical paper is attached to these comments

Thus, the use of aquatic plants in the treatment of industrial wastewater is perspective in many ways.

Sources

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