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Study of the electron irradiation effect on the structure of treatment systems biomaterials

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Abstract. Experimental studies on the effects of pollution and electron irradiation on the structure of a number of treatment systems biomaterials of Sorbulak lake-storage were carried out. It was found that contamination with heavy metal and electron irradiation, respectively, affect the structure of biomaterials.

1. Introduction

Currently, there are various methods of wastewater treatment. The most commons are: mechanical, physical-chemical, chemical and biological methods. Depending on the hazard degree and nature of contamination wastewater treatment can be performed by any method or complex methods (combined method). Treatment process includes sludge treatment (or excess biomass) and disinfection of wastewater before being discharged into the pond [1 – 3]. Solution of the issues on the protection and rational use of water resources is related to the activities for the prevention of water sources pollution as a result of the dumping of industrial and domestic wastewater. In these measures, construction and improvement of sewage treatment plants are very important, as part of which the main role in terms of construction and value is assigned to biological treatment facilities. In wastewater treatment systems biological method is the final and after it is applied the waste water can be used in water recycling or discharge into surface waters. Taking into account the large volumes of domestic, industrial and rain sewage the prospect of an increasingly wide spread of biological, radiation-biological and biochemical methods becomes more clear as the most effective and cheap methods for cleaning or additional cleaning of drains. These methods provide the preservation of flora and fauna ability to use a variety of dissolved minerals and organic compounds contained in wastewater [4 – 6]. Degradation of organic compounds may take place until the complete mineralization. Biological and biochemical methods of purification of wastewater are close to the natural self-purification bioprocess of aqueous media, including using radiation. Here, the basic laws of biochemical transformation of pollutants are observed in the concentrated form [7, 8]. A dilatometric study of similar materials are presented in [9]
Today, when the deterioration of environmental conditions has particularly deep resonance because of the high population density and production, bioremediation biotechnology contributes significantly to improving the environmental situation and living conditions of the people, as a reserve for environmental well-being for years to come. The biggest negative influence on the environment comes from heavy metals [10 – 12]. In this paper, experimental studies on the effect of contamination and electron irradiation on the structure of biomaterials (reed, sedge) of Sorbulak lake treatment systems.

2. Experimental

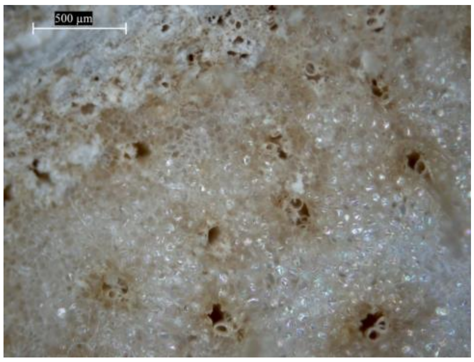
Stems of reeds and sedges uncontaminated, contaminated (with wastewater substances) and irradiated with electrons were used as a biomaterial. The expedition was organized for the collection of biological material. Uncontaminated materials were collected near clean waters, and polluted ones at the shore near the top of Sorbulak lake dam. Irradiation was carried out in air using ELU-6 linear electron accelerator. The electron energy was 2 MeV, beam current - 0.5 uA x cm^{-2}, the temperature of treated materials was 23 K, relative humidity was 55%. Irradiation of the biomaterials was controlled using the remote of high-energy electrons accelerator.

Study of the structure was carried out using an automated digital optical microscope (ACM) LeicaDM6000 M. This microscope is a precision system for research purposes with high-resolution digital cameras and software for analyzing and storing images. The device is unique and has the following features and options: 1. Automatic mode of formation and control of the light (reflection) for the experimental methods of light and dark field. 2. Automated current mode of the transmitted light. 3. Automated dimmers for regulation of change of aperture and illuminator aperture. 4. Motorized z focus gear and motorized sample platform corresponding to x, y and z displacement in the experiment. 5. X / Y panel motorized stepper motor, removable sample platform with appropriate external dimensions: 234 mm x 157 mm. 6. In this case, the range of motion is 76 mm x 50 mm, the minimum step – 0.3 μm. 7. Z panel corresponds to the removable panel: range of movement – 25 mm, minimum step: 0.015μm, maximum speed – 5 mm/s, minimum speed – 1 mm/s, maximum load – 4 kg. 8. Motorized encoded turret has a 6-lens with magnification of 5x, 10x, 20x, 50x, 100x, 150x times respectively. 9. Unique memory function allows to shift lens simultaneously and to use contrast method. Selection of different colors of the image is used (to detect small or subtle elements in contrast to the sample).

3. Results and discussion

Figure 1 a and b shows the micrographs of uncontaminated stems of reed and sedge. On the background of the uniform surface, a large number of natural micropores with the size of about 50 – 70 microns are observed in the structure of reed stem, whereas no such pores are observed in sedges. At the same time, there are various incorporatings with the sizes of from 30 to 150 microns, associated with the presence of various minerals in the soil. Structure of the contaminated materials (Figure 2) both reed and sedge changes significantly, the pores become larger. The largest changes are observed in the sedge, which is associated with the accumulation of heavy metals in it. Table 1 shows the content of heavy metals in reeds and sedges biomaterials. It is seen that reed adsorbs iron strongly, while sedge adsorbs iron, manganese and strontium. Moreover, there is an increase in the concentration of manganese in contaminated sedge compared with blank material more than 50 times.

(a)



(b)

Figure 1. Optical micrographs of stems of the uncontaminated reed (a) and sedge (b).

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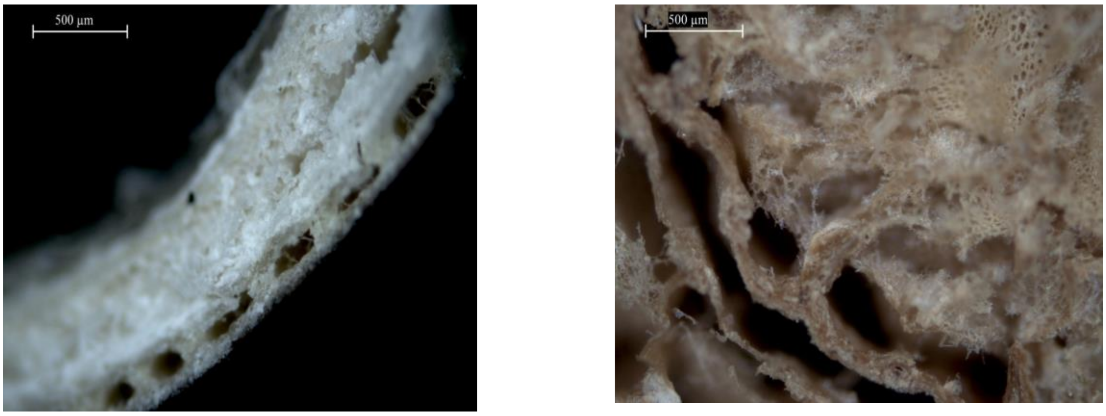
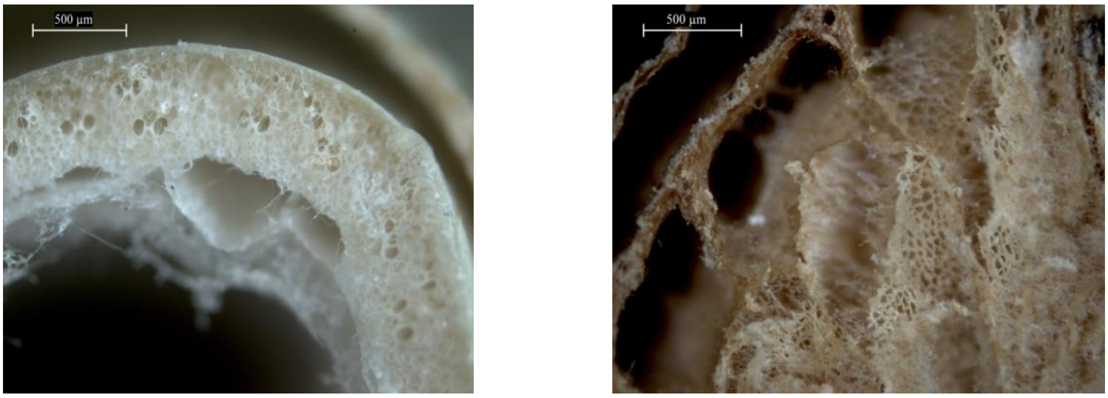


(a) (b)

Figure 2. Optical micrographs of stems of the contaminated reed (a) and sedge (b).



(a) (b)

Figure 3. Optical micrographs of stems of the contaminated and irradiated reed (a) and sedge (b).

Absorbed dose was used to determine the degree of electronic radiation exposure to biomaterials. In the case of the accelerated electrons fixed-energy, the current density, the distance from the accelerator output window and the irradiation time, the absorbed dose equals to:

$$D=\frac{dE}{d\xi} j\tau \times 10^3, \text{[Gy]},$$

Here, E is the energy of high-energy electrons in MeV, ξ is reduced thickness, kg/m^2 (ξ =xd; d is for density, kg/m^3); x is sample thickness, m; $\frac{dE}{d\xi}$ is the total loss of the electron energy; j is particle current density, μA/m^2; τ is sample irradiation time, s.

Electron irradiation with the dose of 10 kGy leads to the increase in the micropore sizes and cracking of the material (Figure 3).

Table 1. The content of heavy metals in biomaterials of reeds and sedges.

mg/kg	Pb	Cd	Zn	Cu	Fe	Ni	Co	Mn	Cr	Sr
Blank reed	5.00	2.40	67.20	12.70	360.00	24.60	0.24	367.0	19.70	48.00
Cont. reed	5.00	1.00	48.00	4.80	612.00	4.20	0.32	390.0	7.20	43.20
Blank sedge	6.40	0.80	32.00	9.60	648.0	20.40	0.40	70.0	25.20	49.60
Cont. sedge	7.00	1.00	32.00	6.40	720.0	12.60	0.48	3800.0	8.40	89.60

4. Conclusions

1. The method of optical microscopy was used for experimental study of the influence of contamination and electron irradiation with 2 MeV on the structure of biomaterials of reeds and sedges.
2. It was established that the contamination affects significantly the structure of the stems of both reed and sedge. In sedge there is a significant accumulation of heavy metals, which are grouped into larger cluster. Irradiation with high-energy electrons in some cases leads to cracking of materials and the formation of large pores in the biomaterials.

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