INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION OF PAPERS 85-86, 2022 ZBORNIK RADOVA 85-86, 2022

DOI: 10.5937/SustFor2285065C
Original scientific paper

REMOVAL OF ORGANIC MATTER IN FLOATING TREATMENT WETLAND

Nevena ČULE[1], Aleksandar LUČIĆ[1], Marija NEŠIĆ[2], Ljiljana BRAŠANAC-BOSANAC[1], Ivana BJEDOV[2], Suzana MITROVIĆ[1], Zorica SREDOJEVIĆ[3]

Abstract: *Organic matter is considered one of the main sources of water pollution caused by the discharge of wastewater of different categories directly into rivers. The increased content of organic matter serves as a source of food for water microorganisms and significantly lowers dissolved oxygen of the recipient. Floating treatment wetlands (FTW) are an innovative green technology that removes excess organic matter from water. This paper shows the effectiveness of floating treatment wetlands in removing organic matter from the water of a polluted urban river. Cells with floating islands had BOD reduced by 84-91%, COD in the range of 57-65% and TOC by 16-20%. The highest efficiency in COD and TOC reduction was achieved in Cell I where P. australis was planted, and BOD in Cell II where C. indica was planted. The results of these studies showed that after 6 days of treatment of polluted water, a high reduction of BOD and COD was achieved, as well as a satisfactory reduction of TOC concentration.*

Key words: phytoremediation, microorganisms, plants, polluted water, urban river.

[1]Dr. Nevena Čule, Dr. Aleksandar Lučić, Dr. Ljiljana Brašanac Bosanac, Dr. Suzana Mitrović, Institute of Forestry, 3 Kneza Višeslava, 11030 Belgrade, Serbia
[2]Dr. Marija Nešić, Dr. Ivana Bjedov, Faculty of Forestry, University of Belgrade, Kneza Višeslava 1, 11030 Belgrade, Serbia
[3]Dr. Zorica Sredojević, Faculty of Agriculture, University of Belgrade, Nemanjina 6, 11080, Belgrade, Serbia

Corresponding author: Nevena Čule, e-mail: *nevena.cule@yahoo.com*

UKLANJANJE PATOGENIH MIKROORGANIZAMA U BIOLOŠKOM SISTEMU SA PLUTAJUĆIM OSTRVIMA

Izvod: *Organske materije se smatraju jednim od glavnih izvora zagađenja vode uzrokovanog izlivanjem različitih kategorija otpadnih voda direktno u reke. Povećani sadržaj organske materije poslužiće kao izvor hrane za mikroogranizme prisutne u vodi, što će dovesti do značajnog pada koncentracije kiseonika u vodi recipijenta. Biološki sistemi sa plutajućim ostrvima (FTW) su inovativna zelena tehnologija, koja omogućava uklanjanje viška organskih materija iz vode. Ovaj rad prikazuje efikasnost biološkog sistema sa plutajućim ostrvima u uklanjanju organskih materija iz vode zagađene urbane reke. U okviru bazena sa plutajućim ostrvima ostvarena je redukcija BOD od 84-91%, COD u granicama 57-65% i TOC od 16-20%. Najveća efikasnost redukcije COD i TOC je ostvarena u bazenu 1 u kome je bila posađena P. australis, a BOD u bazenu 2 u kome se nalazila C. indica. Rezultati ovih istraživanja su pokazali da je posle 6 dana tretmana zagađene vode postignuta visoka redukcija BOD i COD, kao i zadovoljavajuće smanjenje koncentracije TOC.*

Ključne reči: fitoremedijacija, mikroorganizmi, biljke, zagađena voda, urbana reka.

1. INTRODUCTION

Organic matter plays a crucial role in the functioning of aquatic ecosystems because it affects various biogeochemical processes, nutrient cycling, biological availability, chemical transport, and interactions in these processes. However, when municipal or industrial wastewater with a high content of organic matter is discharged directly into rivers without prior pre-treatment, the concentration of oxygen in the water of the recipient significantly decreases (Chapman, 2021). The increased content of organic matter serves as a food source for water microorganisms. Aerobic bacteria use significant amounts of oxygen to decompose organic compounds into less complex organic substances up to carbon dioxide and water (Kadlec and Wallace, 2009). If the amount of organic matter is high, the rate at which microorganisms consume dissolved oxygen exceeds the rate at which it can be recovered from the atmosphere and produced by photosynthesis. Eventually, the water becomes anaerobic (US EPA, 2001). Furthermore, the increased content of organic matter in the water favours the growth of algae and aquatic plants that consume large amounts of dissolved oxygen for their growth. Anaerobic bacteria accelerate the decomposition of organic matter caused by the death of aquatic flora and fauna and lead to further eutrophication of water. However, since the environment is now anaerobic, toxic compounds such as hydrogen sulphide are formed when microorganisms break down organic matter (US EPA, 2000). With the lack of oxygen, these compounds have devastating effects on fish populations and other aquatic organisms.

Based on everything that has been said, it can be conclude that besides preventing the introduction of a large amount of organic matter into rivers or lakes, their timely removal from the recipients is another valuable instrument for maintaining good quality and ecological status of water. Floating treatment wetlands (FTW) are an innovative green technology that uses a range of natural processes and mechanisms to remove excess organic matter from water (Yeh *et al.*, 2015; Dodkins and Mendzil, 2014; Vymazal, 2011; Prasad and de Oliveira Freitas, 2003; Davis, 1995). These nature-based solutions (NBS) are modified constructed wetlands with certain advantages over other alternative water treatment technologies (Masters, 2012; Stewart et al., 2008). Floating islands are very simple to construct. They consist of the mash platform that contains the substrate for growing terrestrial and aquatic plants (Sharma *et al.*, 2021; Chance *et al.*, 2019; Benvenuti *et al.*, 2018). Having been planted, they develop a significant mass of the root system which is in direct contact with the water. This system allows better absorption of pollutants from the water, better removal of solid matter, more spots where useful microorganisms can be bound, etc. (Van de Moortel *et al*., 2010).

The Topčiderka River is an urban river that has been long used as a collector of municipal and industrial wastewater, as well as agricultural run-off that carries a range of organic matter. According to most of its chemical, physical and microbiological parameters for water quality assessment, this highly polluted river is classified in water category V (Čule *et al.*, 2017). To investigate the possibility of using floating islands to remove different categories of pollutants from this river, a floating treatment wetland (FTW) was installed on its bank. The constructed pilot system was highly efficient in the removal of chromium and nickel (Čule *et al.*, 2021a), sodium (Čule *et al*., 2022), pathogenic microorganisms (Čule *et al*., 2021b), phosphorus and nitrogen (Čule *et al*., 2020). This paper deals with the efficiency of organic matter removal in this biological system. To achieve this, we examined possible reductions in the concentration of total organic carbon (TOC), which measures the total amount of organic matter in water, chemical oxygen demand (COD), which gives the amount of organic matter subject to chemical oxidation, and biological oxygen demand (BOD) or the amount of biodegradable organic matter.

2. MATERIAL AND METHODS

The floating treatment wetland (FTW) consisted of a collection tank (5.0 m^3) and four cells with floating islands (each 3.0 m^2 in area and 3.0 m^3 in volume). The collection tank and cells were placed on the levelled ground and connected with plastic pipes (Čule *et al.*, 2017). Each of the four cells had three floating islands (1.0 m x 1.0 m). Since the cells were 100% covered with floating islands, anaerobic conditions were expected. The mash platform of the floating islands was made of light thermoplastic materials, with handles and circular openings at the bottom. Rock wool was used as a growing substrate. Each island had 25 (Cells I-III) and 30 (Cell IV) seedlings planted. *Phragmites australis* (Cav.) Trin. ex Steud was planted in Cell I, *Canna indica* L. in Cell II, while Cell III had a mixture of *P. australis* and *C. indica* in the ratio 12:13. Each island of Cell IV contained mixed plantings of *Iris pseudacorus* L. (8 seedlings), *Iris sibirica* 'Perry's Blue' (5 seedlings), *Alisma plantago - aquatica* L. (5 seedlings), *Lythrum salicaria* L. (5 seedlings) and *Menyanthes trifoliata* L. (6 seedlings).

After a month and a half of establishing the FTW, monitoring of its effectiveness in removing pollutants began. The treatment cycle began by bringing water from the river into the collection tank using a pump and distributing it, by gravity flow, simultaneously to Cells I-IV. The hydraulic retention time (HRT) in the cells was six days. After that time, the water treatment was completed, and the purified water was released into the river.

To examine the quality of polluted and treated water based on the content of organic matter, the following parameters were determined: five-day biological oxygen demand (BOD), chemical oxygen demand (COD), and total organic carbon (TOC). Polluted water needed for the analysis was sampled according to the SRPS ISO 5667-4:1997 method and treated water according to the SRPS ISO 5667-6:1997 method. Polluted water samples were taken at the beginning of the treatment cycle at the entrance to the FTW. After 6 days, the water was sampled in Cells I-IV. The water sample represented 1 litre of water collected at five spots in each cell (each corner and the centre). Water samples were brought to the laboratory in coolers and stored according to the prescribed protocol before the analysis.

Biochemical oxygen demand (BOD) was determined using the SRPS EN 1899-1:09 method. Chemical oxygen demand (COD) was determined using a method based on the manuals for the use of COD reactor ET 108 (Lovibond), RD 125 thermoreactor (Lovibond) and COD Vario photometer (Lovibond). The concentration of total organic carbon (TOC) was determined by the SRPS ISO 8245:07 method. The obtained results are expressed in mg/l.

3. RESULTS AND DISCUSSION

Organic matter found in polluted and wastewater contains about 45-50% carbon which serves as a source of energy for various microorganisms that inhabit the rhizosphere (DeBusk, 1999b). Therefore, the key mechanism for the removal of organic matter in the floating treatment wetland (FTW) was the metabolism of microorganisms, which in an aerobic environment use dissolved oxygen to oxidise and decompose organic matter (Shahid *et al.*, 2018; U.S. EPA, 2000). Plants also had an important role in removing excess organic matter. Thanks to the well-developed root system, they provided a large area for the development of a biofilm, i.e., rhizosphere that hosted aerobic microorganisms (Prajapati *et al.*, 2017). The large biomass of roots, which were hanging free in the water, enabled the filtration of solid particles of organic matter and their deposition on the surface of the root system or at the bottom of the cell (Van de Moortel *et al*., 2010). Finally, the organic matter, which was broken down by microorganisms into simple nutrients, was taken up by the plants directly from the water (Shahid *et al.*, 2018). Outside the plant rhizosphere, in the anaerobic environment of the cells, the content of organic matter in the water could also be reduced by the processes of fermentation (with the production of lactic acid or ethanol), methanogenesis (with the production of CH_4), sulphate reduction (with the production of CO_2 and H_2S), and denitrification (with the production of CO_2 and N_2) (Dodkins and Mendzil, 2014). Kadlec and Wallace (2009) state that the process of decomposition and deposition of organic carbon is very fast in biological systems with plants and BOD is reduced by 50% within six hours.

Table 1 shows the results related to the concentration of organic matter in polluted and treated water, as well as the efficiency of FTW in their removal. According to the results of the analysis of the efficiency of the removal of the organic matter, after six days of treating polluted water in cells with plants, a high reduction in biological oxygen demand (BOD) and chemical oxygen demand (COD) was achieved, as well as a satisfactory reduction in the concentration of total organic carbon (TOC). Extremely lower BOD values (0.50 - 0.90 mg/L) were recorded in the cells compared to the BOD value in the inlet (5.70 mg/L). The highest BOD removal efficiency of 91% was recorded in Cell II where *C. indica* was planted. The BOD reduction efficiency was 88% in Cell IV with mixed plantings of decorative macrophytes, 86% in Cell I with *P. australis*, and 84% in Cell III with mixed plantings of *P. australis* and *C. indica*. The initial influent COD value (10.00 mg/L) was reduced to 3.50 mg/L - 4.30 mg/L in the cells, and the highest removal efficiency of 65% was recorded in Cell I with *P. australis*. It was followed by Cell III with 61% efficiency, Cell IV with 58% and Cell II with 57%. The initial concentration of total organic carbon (TOC) in the cells was reduced to 3.97 mg/L - 4.19 mg/L. The maximum efficiency of total organic carbon (TOC) removal was achieved in Cell I with *P. australis* and amounted to 20%. The efficiency was 19% in Cell II with *C. indica*, 18% in Cell III with *C. indica* and *P. australis*, and 16% in Cell IV with decorative macrophytes.

Table 1. *Biological oxygen demand, chemical oxygen demand and concentration of total organic carbon in polluted and treated water and efficiency of FTW*

		BOD	COD	TOC
Influent to FTW (mg/L)	Tank	5.70	10.00	4.97
Effluent of a single cell (mg/L)				
	Cell I	0.80	3.50	3.97
	Cell II	0.50	4.30	4.05
	Cell III	0.90	3.90	4.06
	Cell IV	0.70	4.20	4.19
Reduction in a single cell (mg/L)				
	Cell I	4.90	6.50	1.00
	Cell II	5.20	5.70	0.92
	Cell III	4.80	6.10	0.91
	Cell IV	5.00	5.80	0.78
Single-cell efficiency (%)				
	Cell I	86	65	20
	Cell II	91	57	19
	Cell III	84	61	18
	Cell IV	88	58	16

Each value represents the value of a composite sample taken from 5 spots in each cell. BOD - biological oxygen demand (mg/L), COD - chemical oxygen demand (mg/L), TOC - concentration of total organic carbon (mg/L). Cell I - *Phragmites australis* (Cav.) Trin. ex Steud., Cell II - *Canna indica* L., Cell III - *P. australis* and *C. indica*, Cell IV - *Iris pseudacorus* L., *Iris sibirica* 'Perry's Blue', *Alisma plantago - aquatica* L., *Lythrum salicaria* L. and *Menyanthes trifoliata* L.

Biological systems for the treatment of waste and polluted water generally have high efficiency in removing organic matter (DeBusk, 1999a). Chen *et al.* (2016) emphasize that the efficiency of BOD and COD reduction in FTW has a very wide range of limits, i.e., 36-90% for BOD and 17-84% for COD. In the experimental FTW established by Prajapati *et al.* (2017) the efficiency of BOD reduction was 87-94%, COD 50-57% and TOC 48-53%. According to the authors, these results point to a significant reduction of organic matter in FTW. Comparing the efficiency achieved in our research with these results, we can see that BOD reduction was almost the same amounting to 84-91%, while COD reduction was slightly higher and ranged from 57-65%. The reduction of TOC concentration was slightly lower with an achieved efficiency of 16-20%. The comparison of the effectiveness of FTW in our research with the results presented by other authors (White and Cousins, 2013; Van de Moortel *et al*., 2010; Yang *et al*., 2008b; Stewart *et al*., 2008) for a similar type of FTW shows that the wastewater treatment system was more efficient in removing different forms of organic matter.

The efficiency of a FTW in the removal of different forms of organic matter can also be tested by comparing the content of BOD, COD and TOC as parameters for assessing the ecological status of water (Official Gazette of RS, 2011) in the FTW influent and effluent water. Based on the content of BOD (5.70 mg/L), the influent water belonged to class III and based on the concentrations of COD (10.00 mg/L) and TOC (4.97 mg/L) to class II (Official Gazette of RS, 2012). After the water had passed through the FTW, the concentrations of organic matter decreased and based on the content of BOD (0.50 - 0.90 mg/L) and COD (3.50-4.30 mg/L) the effluent water was class I (water with excellent ecological status), while regarding the TOC content (3.97-4.19 mg /L), it was class II (water with good ecological status) (Official Gazette of RS, 2012).

5. CONCLUSION

Organic matter is considered as one of the main sources of water pollution caused by the discharge of various categories of wastewater directly into rivers. An excess of organic matter in the water poses a threat to the aquatic world because microorganisms use dissolved oxygen in the water to decompose the pollutants. Floating treatment wetlands (FTW) are a relatively new and innovative technology. They are very similar to constructed wetlands which enable efficient treatment of wastewater and polluted waters of rivers, lakes and other water bodies. The key advantages of this nature-based solution (NBS) are the large free surface of the root system in the water and the adjustability of floating islands to different water levels and depths. Besides the main function of removing pollutants, FTW also have other functions, which can be significant at some treatment sites. They can become a habitat for a range of animal species (birds, insects, reptiles, fish, etc.), increase the aesthetic value of an often-degraded landscape, easily fit into the surrounding landscape, encourage the scientific community to conduct research there and achieve the education in line with sustainable development by promoting the importance of environmental protection and water conservation. The results of this study showed that the FTW installed on the banks of the Topčiderka River proved to be effective in removing excess organic matter from polluted water. The highest reduction efficiency of COD (65%) and TOC (20%) was achieved in cell I where *P. australis* was planted, and BOD (91%) in cell II with *C. indica*. Given that microorganisms play an important role in decomposing organic pollutants, future research should identify species of microorganisms adequate for specific types of pollutants and examine their capacity to break down organic matter, activities that encourage plant growth, their performances, and synergistic interactions with plants, which can help improve the efficiency of FTW.

Acknowledgements: *This research was supported by the City of Belgrade - Belgrade City Administration - Secretariat for Environmental protection, Serbia [contract number V-01 401.1-83].*

REFERENCES

Benvenuti, T., Hamerski, F., Giacobbo, A., Bernardes, A.M., Zoppas-Ferreira, J., Rodrigues, M.A. (2018): Constructed floating wetland for the treatment of domestic sewage: a real-scale study. Journal of Environmental Chemical Engineering. 6(5), 5706-5711.

Chance, L.M.G., Van Brunt, S.C., Majsztrik, J.C., White, S.A. (2019): Short-and long-term dynamics of nutrient removal in floating treatment wetlands. Water Research. 159, 153-163.

Chapman, D. (2021). Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring. CRC Press, Taylor & Francis, London.

Chen, Zhongbing, Diego Paredes Cuervo, Jochen A. Müller, Arndt Wiessner, Heinz Köser, Jan Vymazal, Matthias Kästner, and Peter Kuschk (2016): Hydroponic root mats for wastewater treatment—a review. Environmental Science and Pollution Research, 23(16), 15911-15928.

Čule, N., Lučić, A., Nešić, M., Veselinović, M., Mitrović, S., Brašanac-Bosanac, Lj. (2022): The efficiency of sodium removal by decorative plant species and algae in the floating treatment wetland. Fresenius Environmental Bulletin 31(05/2022), 5243-5254.

Čule, N., Lučić, A., Nešić, M., Veselinović, M., Mitrović, S., Sredojevic, Brašanac-Bosanac, Lj. (2021a): Accumulation of chromium and nickel by *Canna indica* and decorative macrophytes grown in floating treatment wetland. Fresenius Environmental Bulletin, Vol. 30(06B), 7881-7890.

Čule, N, Lučić, A, Miletić, Z, Veselinović, M, Mitrović, S. (2020): Removal of phosphorus and nitrogen in modified floating treatment wetland. Proceedings of 28th International Conference Ecological Truth and Environmental Research - EcoTER'20 University of Belgrade, Technical Faculty in Bor (Serbia), 6 - 19 Jun 2020, Kladovo, Serbia, 94 - 99.

Čule, N., Lučić, A., Dražić, D., Popović, V., Veselinović, M., Brašanac-Bosanac, Lj., Mitrović, S. (2017): Construction of floating treatment wetlands for remediation of polluted waters. Sustainable Forestry: Collection of papers 75-76, 1-12.

Čule, N., Lučić, A., Nešić, M., Brašanac-Bosanac, Lj., Mitrović, S., Veselinović, M., Ćirković-Mitrović, T. (2021b): The removal of pathogenic microorganisms in a biological system with floating islands. Sustainable Forestry: Collection of papers 83-84, 13-25.

Davis, L. (1995): A handbook of constructed wetlands: A guide to creating wetlands for: agricultural wastewater, domestic wastewater, coal mine drainage, stormwater. In the Mid-

Atlantic Region. Volume 1: General considerations. USDA-Natural Resources Conservation Service.

DeBusk, W.F. (1999a): Wastewater treatment wetlands: Contaminant Removal Processes. Institute of Food and Agricultural Science, University of Florida, 5.

DeBusk, W.F. (1999b): Wastewater treatment wetlands: Applications and Treatment Efficiency. Institute of Food and Agricultural Science, University of Florida.

Dodkins, I. and Mendzil, A.F. (2014) Enterprise Assist: Floating Treatment Wetlands: Treatment efficiency and potential benefits of activated carbon. Sustainable Expansion of the Applied Coastal and Marine Sectors (SEACAMS), Swansea University, Swansea, Wales.

Kadlec, R.H., Wallace, S.D. (2009): Treatment Wetlands (2nd Edition). CRC Press, Taylor & Francis, Boca Raton, Florida.

Masters, B. (2012) The ability of vegetated floating Islands to improve water quality in natural and constructed wetlands: a review. Water Pract. Technol. 7 (1),1-9.

Prajapati, M., van Bruggen, J. J., Dalu, T., & Malla, R. (2017): Assessing the effectiveness of pollutant removal by macrophytes in a floating wetland for wastewater treatment. Applied Water Science, 7(8), 4801-4809.

Prasad, M.N.V., de Oliveira Freitas, H.M. (2003): Metal hyperaccumulation in plants: biodiversity prospecting for phytoremediation technology. Electronic Jurnal of Biotechnology. 6(3), 285-321.

Shahid, M. J., Arslan, M., Ali, S., Siddique, M., & Afzal, M. (2018): Floating wetlands: a sustainable tool for wastewater treatment. Clean–Soil, Air, Water, 46(10), 1800120.

Sharma, R., Vymazal, J., Malaviya, P. (2021): Application of floating treatment wetlands for stormwater runoff: A critical review of the recent developments with emphasis on heavy metals and nutrient removal. Science of The Total Environment. 777, 146044.

Službeni glasnik RS (2011): Pravilnik o parametrima ekološkog i hemijskog statusa površinskih voda i parametrima hemijskog i kvantitativnog statusa podzemnih voda. Službeni glasnik RS 74/2011.

Službeni glasnik RS (2012): Uredba o graničnim vrednostima zagađujućih materija u površinskim i podzemnim vodama i sedimentu i rokovima za njihovo dostizanje Službeni glasnik RS 50/2012.

Stewart, F.M., Muholland T., Cunningham A.B., Kania B.G., Osterlund M.T. (2008) Floating islands as an alternative to constructed wetlands for treatment of excess nutrients from agricultural and municipal wastes–results of laboratory-scale tests. Land contam. reclam. 16, 25-33.

U.S. EPA (2000): Manual – Constructed Wetlands Treatment of Municipal Wastewater. U.S. Environmental Protection Agency. Report no. EPA/625/R-99/010. Office of Research and Development, Cincinnati, OH.

U.S. EPA (2001): Parameters of Water Quality - Interpretation and Standards. U.S. Environmental Protection Agency, Ireland.

Van de Moortel, A.M.K., Meers E., De Pauw N., Tack F.M.G. (2010) Effects of Vegetation, Season and Temperature on the Removal of Pollutants in Experimental Floating Treatment Wetlands. Water Air Soil Pollut 212, 281-297.

Vymazal, J. (2011): Constructed Wetlands for Wastewater Treatment: Five Decades of Experience. Environmental Science & Technology. 45(1), 61-69.

White, S.A., Cousins, M.M. (2013): Floating treatment wetland aided remediation of nitrogen and phosphorus from simulated stormwater runoff. Ecological Engineering, 61, 207-215.

Yang, Z., Zheng, S., Chen, J., Sun, M. (2008b): Purification of nitrate-rich agricultural runoff by a hydroponic system. Bioresource technology 99: 8049–8053.

Yeh, N., Yeh, P., Chang, Y.-H. (2015): Artificial floating islands for environmental improvement. Renewable and Sustainable Energy Reviews. 47, 616-622.

REMOVAL OF ORGANIC MATTER IN FLOATING TREATMENT WETLAND

Nevena ČULE, Aleksandar LUČIĆ, Marija NEŠIĆ, Ljiljana BRAŠANAC-BOSANAC, Ivana BJEDOV, Suzana MITROVIĆ, Zorica SREDOJEVIĆ

Summary

Organic matter is considered as one of the main sources of water pollution caused by the discharge of wastewater of different categories directly into rivers. The increased content of organic matter serves as a source of food for microorganisms in the water. Aerobic bacteria decompose organic compounds into less complex organic substances up to carbon dioxide and water, and in doing so use significant amounts of dissolved oxygen. If the amount of organic matter is high, the rate at which microorganisms consume dissolved oxygen exceeds the rate at which it can be recovered from the atmosphere and produced by photosynthesis. Eventually, the water becomes anaerobic which poses a threat to the aquatic world. Besides preventing the introduction of large amounts of organic matter into rivers or lakes, their timely removal from recipients is another valuable instrument for maintaining the good quality and ecological status of water. Floating treatment wetlands (FTW) are innovative green technology that uses different natural processes and mechanisms to remove excess organic matter from water. The Topčiderka River is an urban river, which has long been used as a collector of municipal and industrial wastewater and agricultural run-off that carries a range of organic substances. To examine the possibility of using floating islands to remove different categories of pollutants from this river, a FTW was installed on its bank. It consisted of a collection tank and four cells with floating islands. There were 3 floating islands in each cell. *Phragmites australis* (Cav.) Trin. ex Steud, *Canna indica* L., *Iris pseudacorus* L., *Iris sibirica* 'Perry's Blue', *Alisma plantago - aquatica* L., *Lythrum salicaria* L. and *Menyanthes trifoliata* L were used to form the islands' vegetation. This paper shows the efficiency of organic matter removal in the mentioned FTW. According to the results, BOD was reduced by 84-91%, COD by 57-65% and TOC by 16-20%. The highest efficiency in COD and TOC reduction was achieved in cell I where *P. australis* was planted, and BOD in cell II with *C. Indica* plants. Owing to microorganisms and plants, i.e., processes of decomposition, filtration, sedimentation,

fermentation, methanogenesis, sulphate reduction and denitrification, after six days of treating polluted water in FTW, a high reduction of BOD and COD was achieved, as well as a satisfactory reduction of TOC concentration. The efficiency of FTW in removing different forms of organic matter is reflected in the fact that the polluted water belonged to class III (based on BOD) and class II (based on COD and TOC), while after the treatment, it had the characteristics of class I water (water with excellent ecological status) based on BOD and COD, and class II (water with good ecological status) based on TOC concentration.

UKLANJANJE ORGANSKIH MATERIJA U BIOLOŠKOM SISTEMU SA PLUTAJUĆIM OSTRVIMA

Nevena ČULE, Aleksandar LUČIĆ, Marija NEŠIĆ, Ljiljana BRAŠANAC-BOSANAC, Ivana BJEDOV, Suzana MITROVIĆ, Zorica SREDOJEVIĆ

Rezime

Organske materije se smatraju jednim od glavnih izvora zagađenja vode uzrokovanog izlivanjem različitih kategorija otpadnih voda direktno u reke. Povećani sadržaj organske materije poslužiće kao izvor hrane za mikroogranizme prisutne u vodi. Aerobne bakterije će organska jedinjenja razlagati na manje složene organske supstance, sve do ugljen dioksida i vode, a pri tome će koristiti značajne količine kiseonika. Ukoliko je količina organskih materija visoka, brzina trošenja rastvorenog kiseonika od strane mikroorganizama će nadmašiti brzinu kojom rastvoreni kiseonik može da se nadoknadi iz atmosfere i fotosintezom i na kraju će voda postati anaerobna, što predstavlja opasnost za akvatični svet. Pored prevencije unosa velike količine organske materije u reke ili jezera, njihovo blagovremeno uklanjanje iz recipijenata, predstavlja važan instrument za održavanje dobrog kvaliteta i ekološkog statusa voda. Biološki sistemi sa plutajućim ostrvima (FTW) su inovativna zelena tehnologija, koja na osnovu različitih prirodnih procesa i mehanizama omogućava uklanjanje viška organskih materija iz vode. Topčiderka je urbana reka, koja se dugi niz godina koristi kao kolektor komunalnih, industrijskih i poljoprivrednih otpadnih voda, koje sa sobom nose različite organske materije. Kako bi se ispitala mogućnost korišćenja plutajućih ostrva za uklanjanje različitih kategorija polutanata iz ove reke, na njenoj obali je postavljen biološki sistem, koji se sastojao od sabirnog tanka i četiri bazena sa plutajućim ostrvima. U svakom bazenu su se nalazila po 3 plutajuća ostrva. Za formiranje vegetacije ostrva korišćene su vrste *Phragmites australis* (Cav.) Trin. ex Steud, *Canna indica* L., *Iris pseudacorus* L., *Iris sibirica* 'Perry's Blue', *Alisma plantago - aquatica* L., *Lythrum salicaria* L. i *Menyanthes trifoliata* L. Ovaj rad prikazuje efikasnost uklanjanja organskih materija u pomenutom FTW. Rezultati istraživanja pokazuju da je ostvarena redukcija BOD od 84-91%, COD u granicama 57-65% i TOC od 16-20%. Najveća efikasnost redukcije COD i TOC je ostvarena u bazenu 1 u kome je bila posađena *P. australis*, a BOD u bazenu 2 u kome se nalazila *C. indica*. Zahvaljujući mikroorganizmima i biljkama odnosno procesima razlaganja, filtracije, taloženja, fermentacije, metanogeneze, redukcije sulfata i denitrifikacije, posle 6 dana tretmana zagađene vode u FTW je postignuta visoka redukcija BOD i COD, kao i zadovoljavajuće smanjenje koncentracije TOC. Na dobru efikasnost FTW u uklanjanju različitih formi organskih materija može da se ukaže i činjenica da je zagađena voda pripadala III klasi (na osnovu BOD) i II klasi (na osnovu COD i TOC), a da je po završenom tretmanu imala karakteristike vode klase I (voda sa odličnim ekološkim statusom) na osnovu BOD i COD odnosno klase II (voda sa dobrim ekološkim statusom) na osnovu koncentracije TOC.