

Efficiency Aspects of Durres Wastewater Treatment Plant

Blerina Beqaj^{1,*}, Joana Gjipalaj¹, Oltion Marko¹, and Enkeleda Shkurta²

ABSTRACT

The sewage system in the city of Durres has been a problem for both residents and ecosystems for years. Urban wastewater had direct effects into surface water, mainly in the Adriatic Sea, and this problem raised the need to build a wastewater treatment plant. The main purpose of this study is to give some aspects of the effectiveness of this wastewater treatment process which is one of the byproducts produced by human activity with a negative impact on all components of the environment. The study presents the description of the study area, the sewage system and the impact of this project on the environment. It is described the functioning of the urban wastewater treatment plant, the working methods followed, and the laboratory analyzes performed to maintain control of this process according to state-set standards. The discussion of the biological and chemical results obtained in the laboratory, are based on data obtained from: determination of wastewater and clean water entering the plant, the equivalent population to which this plant serves, the amount of phosphorus that has to be reduced, effectiveness of the process for total dissolved solids, as well as effectiveness of parameters on output and wetland.

Keywords: Sewage system, treatment, wastewater treatment plant, wetland.

Submitted: February 09, 2025

Published: March 26, 2025

 10.24018/ejgeo.2025.6.2.503

¹Department of Environmental Engineering, Faculty of Civil Engineering, Polytechnic University of Tirana, Albania.
²National Environmental Agency, Albania.

*Corresponding Author:
e-mail: blerina.beqaj@fin.edu.al

1. INTRODUCTION

Water is the most important issue of our children's life resources and lives. Water quality is the main issue of how we live on land. Water is one of the most valuable resources, present on the surface and underground. It is considered a key factor in the energy and thermal regime of organisms, essential for metabolic processes of conversion of substances. Every living thing needs water and the demand for its use is increasing.

Although this resource is called existential, often its evaluation and management does not have the right dimensions. Good management means the efficient administration of various human activities with an impact on surface and groundwater. The increasing need and uses of water affect its quality more day by day. The development and industrialization of a good part of the countries in the world have turned sustainable security and water quality into an ever-increasing challenge. This problem has raised the need for scientists to find an efficient and economical solution to wastewater treatment. Economically, effective wastewater treatment has important effects on saving water and preventing unnecessary water losses [1].

Due to hazardous impacts of municipal and industrial wastewater on water, soil, air wastewater treatment and the proper disposal of the sludge produced are indispensable from an environmental safety point of view [2],[3]. The main measures for the protection of the environment from these waters are the construction of appropriate plants for their treatment.

In recent years, increased research has been done on wastewater treatment using simple, low-cost, easy-to-use methods in developing countries [4],[5]. Systems and processes such as activated sludge, aerated lagoons, stabilization ponds, natural and synthetic wetlands, trickling filters, rotating biological contactors (RBCs) have been used for wastewater treatment and removal of physical, chemical and biological contaminants [6],[7].

A wastewater treatment plant is a combination of different processes (physical, chemical and biological) used to treat wastewater and remove pollutants [8]. The treatment of these waters is a technology of combining different mechanical, chemical and biological methods. Mechanical techniques consist of removing decantable or floating water substances. The chemical ones predict the process of coagulation and neutralization. After these processes the





Fig. 1. City sewerage system.

content of molten substances decreases and here biological purification plays a role. Biological purification is based on the ability of small organisms (active sludge), which, with the presence of oxygen in water, oxidize and mineralize organic matter, receiving the necessary energy and nutrients.

Until the city of Durres did not have a sewage treatment plant, sewage was discharged directly into the sea or into a river or into drainage canals which after some distance were discharged into marshy lands or the sea. The discharge of polluted waters into the coastal area has led to the destruction of the natural ecosystem and has highlighted endangered areas. Pollution has had very critical consequences because it has endangered natural resources and the progressive loss of biodiversity. The technology used in the water treatment plant is of an advanced degree, a technology which makes possible the purification of water up to 97% and enables the benefit of biogas which will cover the needs of the plant for electricity up to 30%. Only through this technology is it possible to obtain acceptable parameters of water coming out of the treatment plant and discharging into natural environments.

2. MATERIAL AND METHOD

The wastewater treatment plant is located in the village of Shen Vlash in the city of Durres. It covers an area of 64 hectares. The plant is designed to handle a total flow rate of 60,000 m³/day. Thanks to the favorable geographical position and natural resources, this city has a population of 290,000 inhabitants, which in the tourist season reaches 600,000 inhabitants. The forecast is that the population in Durrës in 2025 will reach 350,000 inhabitants.

The sewerage network in this city is a composite network where wastewater and rainwater is discharged into the same collector. The sewer system collects used and polluted water from homes, businesses and industries and sends it to the treatment plant for treatment before discharging it into the sea (Fig. 1).

The sewage system in Durres is one of the most special systems in Albania due to the fact that the movement of

water is done through pumping stations. This solution is mandatory because the slope of the pipes is insufficient for the movement of self-flowing water and their discharge into the main canal or the sea.

The plant system operates by two main mechanisms which are solid-water separation and transformation of components. The first includes gravitational separation, filtration, absorption, ion exchange, etc. While the second transformations are chemical including oxidation, reduction, flocculation, precipitation reactions, acid-base reactions, etc. These processes make it possible to remove contaminants in the wetland. The basis of wastewater treatment in this plant consists of:

- *Level of pre-treatment and primary treatment:* The methods used by this level consist of thick manual shutters, which make it possible to remove solid waste over 5 cm from polluted water; fine automatic shutters, which make it possible to remove solid waste over 0.2 cm from polluted water; sand removal units, which enable the removal of sand from polluted water.
- *Secondary level:* The method used by this level of treatment consists of addition of air, which contains about 20% oxygen, to the polluted water causing the mass of microorganisms to increase and very quickly metabolize the organic pollution.
- *Tertiary levels:* The method used by the tertiary level consists of reed field which consumes nitrogen (N) and phosphorus (P) from polluted water leading to a decrease in the values of N (total) and P (total).

The control of the technological process is done in two forms:

1. *SCADA:* This is an automated program, which controls the flow to the plant, the level of oxygen in the oxidation tubs by means of oximeters as well as the temperature and height of the sludge in anaerobic solvents; and,
2. *In laboratory:* In this form the technological process is controlled through the analysis of samples. For this it is determined how many times samples are taken

TABLE I: THE VALUES OF THE PARAMETERS WHICH ARE KEPT IN MONITORING ACCORDING TO THE STANDARD (DCM no.177 31.05.05, ANNEX No. 4 DISCHARGE LIMITS OF WATER LEAVING THE PLANT)

Parameters	Inlet (mg/l)	Outlet (mg/l)	Wetland (mg/l)
BOD	300	35	25
COD	600	130	125
TSS	400	45	35
N _{total}	40	14	10
P _{total}	5.8	1.8	1.0

TABLE II: THE VALUES OF THE PARAMETERS AT THE INLET

Month	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	N _{total} (mg/l)	P _{total} (mg/l)
January	104	192	96	22	2.5
February	99	142	78	19	2.2
March	91	149	65	21	2.7
April	112	159	88	21	2.7
May	101	186	96	23	2.7
June	99	184	86	26	3.6
July	150	267	89	32	4.0
August	146	288	132	41	4.6
September	129	233	94	32	3.5
October	86	159	88	19	2.4
November	98	182	73	27	2.8
December	119	228	88	20	2.4
Average value (mg/l)	111.1	197.4	89.41	25.25	3
Standard values (mg/l)	300	600	400	40	5.8

per day, week, month and year. Sampling should be at the entrance of the plant, at its exit and behind the reed field. The sampling quantity is done with 1 l container.

Table 1, shows the values of the parameters that must have water at the inlet of the plant to work normally for its purification but also to give as soon as possible a quantity of sludge to turn it into biogas. Once the water has entered the plant and has been treated until the plant exits, it should have the indicators shown in Table I.

Sampling is done mechanically by plant workers. The equipment used for sample analysis are:

- The thermoreactor to which the pipettes for the analysis of BOD, COD, N (total) and P (total) are left.
- The filtration system and the drying machine by which the TSS is measured.
- Photometer (PhotoLab S6) by which COD is measured, and N (total).
- Photometer (PhotoLab 7600UV-VIS) where nitrites, nitrates, phosphates, ammonia are measured.
- BOD measuring vessels and the BOD incubator where these vessels are left.

The start date of these analyzes is January 2022 and the last date is December 2022, so the analyzes received include a one year time period.

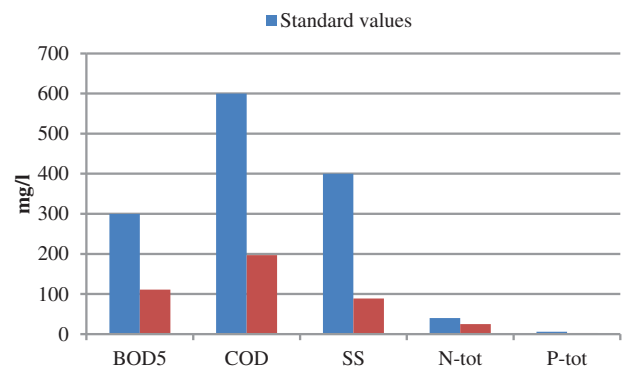


Fig. 2. Comparison of the parameters at the inlet.

3. RESULTS AND DISCUSSIONS

Based on the analyses made for one year (January 2022–December 2022), we estimate the average monthly values at the inlet of the plant for each parameter (Table II).

Based on the above results, the parameters that enter the plant are from 1.6 to 4.4 times smaller than the parameters required by this plant, at the entrance. This is explained by considering three factors:

1. Sampling does not involve 24 hours a day, despite the fact that composite samples were taken, they were not taken day by day but on certain days. If samples were taken every half hour throughout the day the result would be even more accurate.
2. Time when the sample was taken. During sunny weather the parameter values were higher while during rainy weather they were lower.

Fig. 2 shows the comparison of the parameters at the inlet of the plant.

TABLE III: THE VALUES OF THE PARAMETERS AT THE OUTLET

Month	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	N _{total} (mg/l)	P _{total} (mg/l)
January	11	29	7.0	9.9	0.8
February	19	26	7.2	8.1	0.8
March	12	27	12.5	6.3	0.7
April	22	34	11.3	10.4	0.8
May	12	31	9.2	10.7	1.0
June	12	38	10.5	11.0	1.3
July	16	48	12.0	13.2	1.7
August	17	66	22.6	1.0	2.1
September	20	57	20.5	14.7	1.4
October	12	28	8.9	7.8	0.9
November	11	28	8.3	9.0	0.8
December	11	38	9.7	6.2	0.6
Average value (mg/l)	14.5	37.5	11.6	9.55	1
Standard values (mg/l)	35	130	45	14	1.8

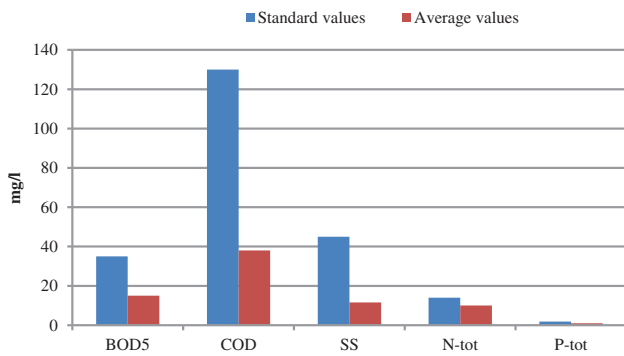


Fig. 3. Comparison of the parameters at the outlet.

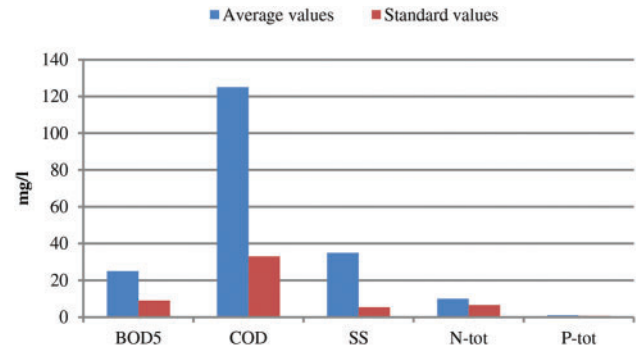


Fig. 4. Comparison of the parameters at the wetland.

Based on the performed analyzes, we estimate (Table III) the values at the outlet of the plant for each parameter.

Based on the above results, the parameters entered in the plant are from 1.4 to 3.8 times smaller than the parameters required by this plant, in the input.

The reason for these results has to do with the three factors we mentioned a bit above together and with a new factor which is the effectiveness of the plant. The effectiveness of the plant includes the work of this plant in water purification at two levels, at the primary and secondary level. At the primary level we have the physical treatment and the addition of ferric chloride, while at the secondary level we have the biological treatment.

Fig. 3 shows the comparison of the parameters at the output of the plant.

Based on the 30 analyzes performed, we estimate the values in the wetland area for each parameter (Table IV).

Based on the analysis of the parameters that the water has in wetland, the parameters range from 1.4 to 6.4 times smaller than they should have been. The reason for these results has to do with the four factors we mentioned a bit above along with a new factor which has to do with the wetland field. The work of these reeds in water purification, especially N (total) and P (total), is introduced in the wetland field. Reeds consume N and P, clearing it of water and also have a little effect on the removal of BOD, COD and TSS.

Fig. 4 shows the comparison of the parameters at the output of the plant.

Efficiency of a wastewater treatment plant means the work that the plant does in treating wastewater. The effectiveness measurement is done after each analysis and for all five parameters considered. We measure the efficiency at the exit and in the reed area. To measure the efficiency, the following formulas are used:

At the outlet:

$$\text{Effectiveness}_{\text{of parameter}} = \frac{\text{Parameter value}_{\text{inlet}} - \text{Parameter value}_{\text{outlet}}}{\text{Parameter value}_{\text{inlet}}}$$

At the wetland:

$$\text{Effectiveness}_{\text{of parameter}} = \frac{\text{Parameter value}_{\text{inlet}} - \text{Parameter value}_{\text{reed bed}}}{\text{Parameter value}_{\text{inlet}}}$$

The effectiveness for each parameter at the outlet:

$$\begin{aligned} \text{Effectiveness}_{\text{BOD}} &= \frac{\text{BOD value}_{\text{inlet}} - \text{BOD value}_{\text{outlet}}}{\text{BOD value}_{\text{inlet}}} \\ &= \frac{111 - 15}{111} \times 100 = 86.5\% \end{aligned}$$

The effectiveness of BOD at the output should be 95.7%. Comparing it with the value that emerges based on the analysis 86.5%, we say that this plant has a lack of efficiency of: 95.7%–86.5% = 9.2%.

$$\text{Effectiveness}_{\text{COD}} = \frac{\text{COD value}_{\text{inlet}} - \text{COD value}_{\text{outlet}}}{\text{COD value}_{\text{inlet}}}$$

TABLE IV: THE VALUES OF THE PARAMETERS AT THE OUTLET

Month	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	N _{total} (mg/l)	P _{total} (mg/l)
January	8	25	2.2	7.7	0.8
February	11	23	2.2	5.1	0.7
March	10	21	2.7	2.5	0.7
April	15	29	2.8	7.2	0.7
May	7	31	3.3	7.9	0.7
June	9	37	5.9	7.4	0.7
July	11	44	7.7	8.3	0.8
August	11	56	12.1	10.1	0.9
September	10	44	8.1	8.3	0.7
October	7	30	7.3	4.9	0.5
November	7	26	5.3	6.0	0.6
December	6	36	5.9	4.9	0.5
Average value (mg/l)	9.3	33.4	5.4	6.6	0.691
Standard values (mg/l)	25	125	35	10	1.0

$$= \frac{197 - 38}{111197} \times 100 = 80.7\%$$

The effectiveness of COD at the output should be 88.3%. Comparing it with the value that emerges based on the analysis 80.7%, we say that this plant has a lack of efficiency of: $88.3\% - 80.7\% = 7.6\%$.

$$\begin{aligned} \text{Effectiveness}_{TSS} &= \frac{TSS \text{ value}_{inlet} - TSS \text{ value}_{outlet}}{TSS \text{ value}_{inlet}} \\ &= \frac{89 - 11.6}{89} \times 100 = 86.9\% \end{aligned}$$

The effectiveness of TSS at the output should be 92.5%. Comparing it with the value that emerges based on the analysis 86.9%, we say that this plant has a lack of efficiency of: $92.5\% - 86.9\% = 5.6\%$.

$$\begin{aligned} \text{Effectiveness}_N &= \frac{N \text{ value}_{inlet} - N \text{ value}_{outlet}}{N \text{ value}_{inlet}} \\ &= \frac{25 - 10}{25} \times 100 = 60\% \end{aligned}$$

The effectiveness of N at the output should be 65%. Comparing it with the value that emerges based on the analysis 60%, we say that this plant has a lack of efficiency of: $65\% - 60\% = 5\%$.

$$\begin{aligned} \text{Effectiveness}_P &= \frac{P \text{ value}_{inlet} - P \text{ value}_{outlet}}{P \text{ value}_{inlet}} \\ &= \frac{3 - 1}{3} \times 100 = 66\% \end{aligned}$$

The effectiveness of P at the output should be 68%. Comparing it with the value that emerges based on the analysis 66%, we say that this plant has a lack of efficiency of: $68\% - 66\% = 2\%$.

Fig. 5 shows the comparison of wastewater treatment plant effectiveness at the output.

The effectiveness for each parameter at the wetland:

$$\begin{aligned} \text{Effectiveness}_{BOD} &= \frac{BOD \text{ value}_{inlet} - BOD \text{ value}_{wetland}}{BOD \text{ value}_{inlet}} \\ &= \frac{111 - 9}{111} \times 100 = 91.8\% \end{aligned}$$

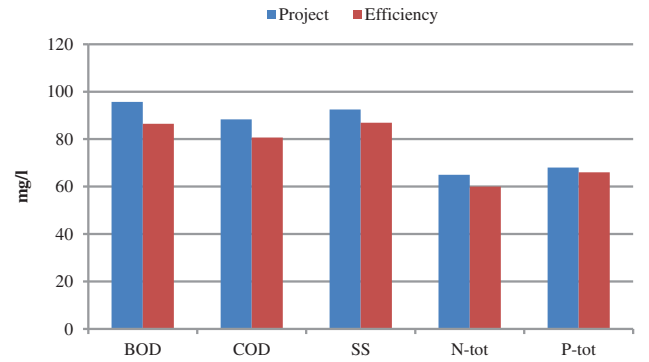


Fig. 5. Comparison of wastewater treatment plant effectiveness at the output.

The effectiveness of BOD in the reed area at the wetland should be 96%. Comparing it with the value that emerges based on the analysis 91.8%, we say that this plant has a lack of efficiency of: $96\% - 91.8\% = 4.2\%$.

$$\begin{aligned} \text{Effectiveness}_{COD} &= \frac{COD \text{ value}_{inlet} - COD \text{ value}_{wetland}}{COD \text{ value}_{inlet}} \\ &= \frac{197 - 33}{197} \times 100 = 83.2\% \end{aligned}$$

The effectiveness of COD at the wetland should be 95%. Comparing it with the value that emerges based on the analysis 83.2%, we say that this plant has a lack of efficiency of: $95\% - 83.2\% = 11.8\%$.

$$\begin{aligned} \text{Effectiveness}_{TSS} &= \frac{TSS \text{ value}_{inlet} - TSS \text{ value}_{wetland}}{TSS \text{ value}_{inlet}} \\ &= \frac{89 - 5.4}{89} \times 100 = 93.9\% \end{aligned}$$

The effectiveness of TSS at the wetland should be 96%. Comparing it with the value that emerges based on the analysis 93.9%, we say that this plant has a lack of efficiency of: $96\% - 93.9\% = 2.1\%$.

$$\begin{aligned} \text{Effectiveness}_N &= \frac{N \text{ value}_{inlet} - N \text{ value}_{wetland}}{N \text{ value}_{inlet}} \\ &= \frac{25 - 6.6}{25} \times 100 = 73.6\% \end{aligned}$$

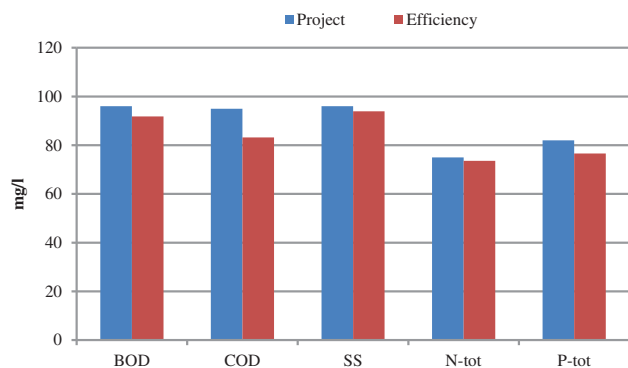


Fig. 6. Comparison of wastewater treatment plant effectiveness at wetland.

The effectiveness of N at the wetland should be 75%. Comparing it with the value that emerges based on the analysis 93.9%, we say that this plant has a lack of efficiency of: $75\% - 73.6\% = 1.4\%$.

$$\begin{aligned} \text{Effectiveness}_P &= \frac{P \text{ value}_{\text{inlet}} - P \text{ value}_{\text{wetland}}}{P \text{ value}_{\text{inlet}}} \\ &= \frac{3 - 0.7}{3} \times 100 = 76.6\% \end{aligned}$$

The effectiveness of P at the wetland should be 82%. Comparing it with the value that emerges based on the analysis 76.6%, we say that this plant has a lack of efficiency of: $82\% - 76.6\% = 5.4\%$.

Fig. 6 shows the comparison of wastewater treatment plant effectiveness at the wetland.

Based on the above results we can say that the effectiveness of the plant is not in those parameters provided by the project. The effectiveness at the outlet of the wastewater treatment plant was expected to vary from 65%–95.7% but it varies from 60%–86.9%. The effectiveness at wetland was expected to range from 75%–96% but it varies from 73.6%–93.9%. The reasons why this process gives us these values of effectiveness are summarized below.

The efficiency of the plant for 2022 has been in satisfactory values because the difference with the effectiveness that the project predicts is very small. For this we can say that this plant works very well and with maximum effectiveness.

Dilution of wastewater with white water in December, to the extent of 1/2, results in wastewater losing the expected values of parameters as a result of not separating wastewater from white water. Various breakdowns that occur in the plant mechanically, electrically, hydraulically and technologically affect the effectiveness of the plant. Sampling affects the effectiveness of the plant. Despite the fact that composite samples have been taken, it has not yet been possible to have a 24-hour control of the water coming to the plant. The possibility of any error during the analysis in the laboratory is not excluded.

4. CONCLUSION

Based on the geographical position and population of the city we can say that the urban water treatment plant plays a very important role as it has a positive impact

on the environment and tourism development of this coastal city.

Temperature and precipitation that fall in this area directly affect the quantity and quality of water coming to the plant, as a result of mixing white water with sewage, as well as in the biological processes of the plant. The sewerage system directly affects the inflows and efficiency values of the plant.

Based on the inflows coming to the plant, which are increasing, we can say that the plant is stabilizing and operating normally:

- The methods used for water treatment are quite effective in treating urban wastewater.
- Technology used for: a) water treatment; b) sludge; c) process control, both on-line and laboratory, is one of the best and most modern.
- Based on the analysis we draw these conclusions:
- In rainy periods water has a mixture of 20% wastewater and 80% white water.
- Power outages play a negative role in plant effectiveness.
- Wetland performs less effectively in winter than in summer.
- Plant efficiency goes up to 86.9% at the outlet while in wetland up to 93.9%

It is recommended that the sewerage system in should separate sewage from white water. With the introduction of the plant and the sewerage system at full capacity, it is recommended to invest in the plant for the construction of two more sediments and two sludge thickeners. To the chemical method at the tertiary level, various chemicals can be added to increase the effectiveness, especially in the winter and autumn seasons, or the addition of ferric chloride should be done, based on measurements. Given the fluctuations of the analysis during hours, days or even seasons it is recommended to install automatic sampling at the inlet, outlet and wetland. As a result of power outages, there should be a special electricity network which will be assisted later by the introduction of biogas.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

REFERENCES

- [1] Zhang QH, Yang WN, Ngo HH, Guo WS, Jin PK, Dzakupasu M, et al. Current status of urban wastewater treatment plants in China. *Environ Int.* 2016;92–93:11–22. doi: 10.1016/j.envint.2016.
- [2] Qu X, Zhao Y, Yu R, Li Y, Falzone C, Smith G, et al. Health effects associated with wastewater treatment, reuse, and disposal. *Water Environ Res.* 2016;8(10):1823–55. doi: 10.2175/106143016X14696400495776.
- [3] Choudri BS, Charabi Y, Ahmed M. Health effects associated with wastewater treatment, reuse and disposal. *Water Environ Res.* 2018;90(10):1759–76. doi: 10.2175/106143018X15289915807425.
- [4] Kelessidis A, Stasinakis AS. Comparative study of the methods used for treatment and final disposal of sewage sludge in European countries. *Waste Manag.* 2012;32(6):1186–95. doi: 10.1016/j.wasman.2012.01.012.
- [5] Masciandaro G, Iannelli R, Chiarugi M, Peruzzi E. Reed bed systems for sludge treatment: case studies in Italy. *Water Sci Technol.* 2015;72(7):1043–50. doi: 10.2166/wst.2015.309.

- [6] Chen HJ, Lin YZ, Fanjiang JM, Fan C. Microbial community and treatment ability investigation in AOA process for the optoelectronic wastewater treatment using PCR-DGGE biotechnology. *Biodegradation*. 2013;24(2):227–43. doi: 10.1007/s10532-012-9579-0.
- [7] Zhang B, Yu Q, Yan G, Zhu H, Xu XY, Zhu L. Seasonal bacterial community succession in four typical wastewater treatment plants: correlations between core microbes and process performance. *Sci Rep*. 2018;8(1):4566. doi: 10.1038/s41598-018-22683-1.
- [8] Hreiz R, Benyahia B, Lati MA. Multi objective optimal control of small-size wastewater treatment plants. *Chem Eng Res Des*. 2015;102:345–53. doi: 10.1016/j.cherd.2015.06.039.