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RECOGNITION AND DETERMINATION OF HYDRODYNAMIC DEFICIENCIES IN THE BIOREACTORS OF A REAL WASTEWATER TREATMENT PLANT BY A COMPREHENSIVE APPROACH: LIVE ANALYSIS USING COMPUTATIONAL FLUID DYNAMICS

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Abstract

The paper presents the results of research conducted on the technological analysis of bioreactors operated at the Iasi wastewater treatment plant (WWTP) and based on them, some proposals for the intervention works needed to improve the technological process, proposals that were subsequently developed. The Iasi WWTP process is using, in the advanced biological stage, an artificial biological treatment with an activated sludge aerobic process, with continuous recirculation. The treatment process scheme is of A2/O type, including a nitrification-denitrification process, so named because it includes 3 distinct areas (anaerobic, anoxic for denitrification and oxic for nitrification). The biological treatment processes are complex, and in the development of the processes intervene physical, hydraulic, chemical and biochemical phenomena. The role of active sludge bioreactors is to remove the non-sedimentable organic compounds, to stabilize sludge organic matter, and to decrease the load of nitrogen and phosphorus-based nutrients from wastewater. Therefore, to gain a higher efficiency and to reach lower operating costs, there is a need for a more uniform flow and distribution of the poly-phase environment, with uniform aeration and a constant transit time for aeration tanks. The parameters being studied within the research program were: flow regime in bioreactors, transient flow distribution in bioreactors, retention time in bioreactors, air distribution in the aerobic area, the state of active sludge bioreactors, reliability of measuring and control devices and all related facilities.

Key words: activated sludge, aeration tanks, ANSYS, wastewater treatment plant

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1. Introduction and objectives of the study

1.1. Introduction

The wastewater treatment plant (WWTP) can ensure advanced treatment on three treatment lines of an average daily flow of 2200 L/s and of a maximum flow of 4033 L/s in the precipitation with discharge in the emissary through the GV3 discharge channel. Also, during heavy rainfall, the WWTP can ensure the primary treatment of a flow rate of up to 4200 L/s, through the rainwater treatment zone, with discharge through the GV2 discharge channel. If the flow recorded at the entrance to the WWTP exceeds the maximum flow designed for rainy weather, respectively 8233 L/s, a maximum flow of 5000 L/s mixture of wastewater and rainwater can be discharged directly into the effluent through the GV1 discharge channel (AVMI, 2017).

The main area studied are the bioreactors of the WWTP, which have special importance in wastewater treatment processes, in which nitrification and

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denitrification processes are performed. Good nitrification/denitrification in bioreactors is achieved by modifying the dissolved oxygen (DO) set point in the last aerobic reactor and internal recirculation (Serralta et al., 2002).

The variability of the elimination rates of pollutants can furthermore be related to operational parameters (SRT) and predicted degradation pathways (Galle et al., 2019). The technological deficiencies presented in the article can decrease the elimination rates of the pollutants in the bioreactors.

The treatment of wastewaters of Iasi City (and boundary localities) is achieved in the Iasi WWTP (Fig. 1). Nowadays, one of the major challenges in the wastewater sector is the successful design and reliable operation of treatment processes. This situation can guarantee high treatment efficiency to comply with effluent quality criteria, while keeping the investment and operating cost as low as possible (Karpinska and Bridgeman, 2016). Currently, the activated sludge process is the most widely used process in WWTP's to reduce the biochemical oxygen demand (BOD), nutrients and to some extent other micro-pollutants such as pharmaceuticals, personal care products and other household chemicals (Du et al., 2018).

The Iasi WWTP is located in the Holboca commune, in the area of the Dancu district, on the left bank of the Bahlui River, which is also its effluent. The WWTP features a designed capacity of approximately 8000 L/s at 933.000 P.E. (AVMI, 2017) and is composed of: the intake chamber, equipped with a pre-cleaning screen, two pre-cleaning screens and an excess rainwater pumping station (2+1R), two wastewater pumping stations (3+1R) that pump wastewater towards the two process lines, eight" step by step" type fine screens, with automatic cleaning (four screens for each process line), greases and grit separators (one for each process line), eight primary radial clarifiers (four for each process line), three active sludge aeration tanks, nine secondary radial clarifiers, serving the two process lines, distribution and connection channels, two $FeCl_3$ storage tanks, the $FeCl_3$ systems: dosing pumping station and nine $FeCl_3$ dosing systems, four sludge pumping stations, two gravity thickeners, two belt press filter type thickeners, four sludge digesters, two digested sludge storage tanks, two sludge dewatering installations (belt press filter type), two centrifugal dehydration facilities, biogas metering chamber, biogas tank, surplus biogas burner, biogas cogeneration plant and a dehydrated sludge storage platform.

1.2. Objectives of the study

The study aims to improve the efficiency of the three active sludge bioreactors that belong to the biological treatment stage in the Iasi City WWTP, by their analysis and modeling to upgrade them and increase their efficiency. This measure is necessary because problems such as bad distribution of flow in bioreactors, dead zones or broken diffusers, greatly reduce their efficiency, affecting the technological processes in the bioreactor.

The proper treatment and sanitation of wastewater is crucial for protecting public health and environment (Azimi and Shabanlou, 2019). Water and wastewater systems are relevant energy consumers, demanding not only a large amount of energy onsite, such as electricity used for pumping and aeration. They also need energy offsite for producing and transporting building materials and chemicals for treatment (Longo et al., 2016). Apart from adequate treatment to protect public health and the environment, it is necessary that this treatment to be conducted in optimal conditions (Colacicco and Zacchei, 2020), to obtain the expected results, like high energy efficiency of the treatment plant, a high efficiency of technological processes, parameter flexibility (Karzeminski et al., 2012) etc.

Fig. 1. View and site of the Iasi wastewater treatment plant

By using dedicated software for modeling and studying bioreactors, the technological process problems in a bioreactor can be simulated much more easily.

2. Materials and method

The methodology consists of the description of the bioreactors, their current state, the hydraulic modeling of the tanks, with a brief description of the software used and the chosen solution. The A2/O treatment scheme (Fig. 5) has been implemented to increase the capacity of the WWTP to decrease nutrients from wastewater.

The total working volume of the bioreactor being studied is 39821 m3, and the ratio between the volumes of the anaerobic, anoxic and oxic zone is 7.9% anaerobic, 22% anoxic and 70.1% oxic. The monitoring period of bioreactors was about 12 months (January 2018 to December 2018), during which, wastewater temperature varied most time at 10–30 °C.

2.1. Description

The three bioreactors are divided into anaerobic, anoxic and oxic zones. Due to this type of partition, the bioreactors comply with the A^2/O type of active sludge treatment, removing nutrients in the wastewater via nitrification-denitrification processes, combined with chemical precipitation (Prăjanu et al., 2018). The three bioreactors have the following geometric features (Database APAVITAL, 2017):

Bioreactor no. 1 (Table 1): includes the compartments P and Q, having a rectangular shape in longitudinal and transverse sections and is built of reinforced concrete.

Bioreactor no. 2 (Table 2): has the same shape in cross-section and longitudinal section as the bioreactor no. 1. It is also constructed of reinforced concrete, having the length of 72.9 m, width of 48.95 m and 4.79 m high.

Bioreactor no. 3 (Table 3): has an L-shaped longitudinal and transverse section, is also constructed of reinforced concrete.

2.2. Current situation

The activated sludge bioreactors of the Iași WWTP (Fig. 2) have been developed during the rehabilitation and modernization of the WWTP. The bioreactor no. 1 (P and Q) and bioreactor no. 2 were the first developed in the Iasi City WWTP, built during the 80's (Database APAVITAL, 2017). Of the two compartments, only the P compartment has been rehabilitated during 1996 and 2000, while bioreactor no. 2 underwent rehabilitation works in 2005. Bioreactor no. 3 was built in the last stage of the WWTP modernization process, during 2012–2016, when the two existing bioreactors have also been rehabilitated. This modernization was necessary in the context of the new European directives regarding nutrient limits in effluents released to emissaries by WWTP's, and in the perspective of a population increasing.

Table 1. Geometric characteristics of Bioreactor no. 1

Bioreactor no. 1				
Compartment		***U.M.***	***Dimensions***	
			P	***Q***
ANAEROBIC	L	m	5.62	5.42
	H		4.55	4.55
	W		96.25	48,55
ANOXIC	L		15	15
	H		4.55	4.55
	W		96.25	48.55
OXIC	L		51.88	52.08
	H		4.55	4.55
	W		96.25	48.55

Table 2. Geometric characteristics of Bioreactor no. 2

Bioreactor no. 2			
Compartment		***U.M.***	***Dimensions***
ANAEROBIC	L	m	11.5
	H		4.79
	W		11.45
ANOXIC	L		22.1/10.3
	H		4.79
	W		24.47/13.2
OXIC	L		49.6
	H		4.79
	W		48.95

Table 3. Geometric characteristics of Bioreactor no. 3

Bioreactor no. 3			
Compartment		***U.M.***	***Dimensions***
ANAEROBIC	L	m	10.95
	H		4.12
	W		42
ANOXIC	L		55
	H		4.12
	W		50.5
OXIC	L		180
	H		4.12
	W		50

After modernization, all three bioreactors were subdivided into anaerobic zone, anoxic zone and oxic zone. Considering the population increase, combined with a significant decreasing of Iasi industry, we have reached the current situation, which means that only 55% of the bioreactor capacity is used (more precisely the compartment Q in bioreactor no. 1 and bioreactor no. 3) due to the decreasing of flows and loads in incoming wastewater. The current situation of the three bioreactors can be described as follows:

Bioreactor no. 1 (Fig. 3) was commissioned after modernization works and final tests, but due to the lack of flow, compartment P (Fig. 3b) was filled with water up to the level of the oxic zone outlet, without discharge, being kept in balance, to avoid the structure flotation phenomenon, while this compartment is held in standby.

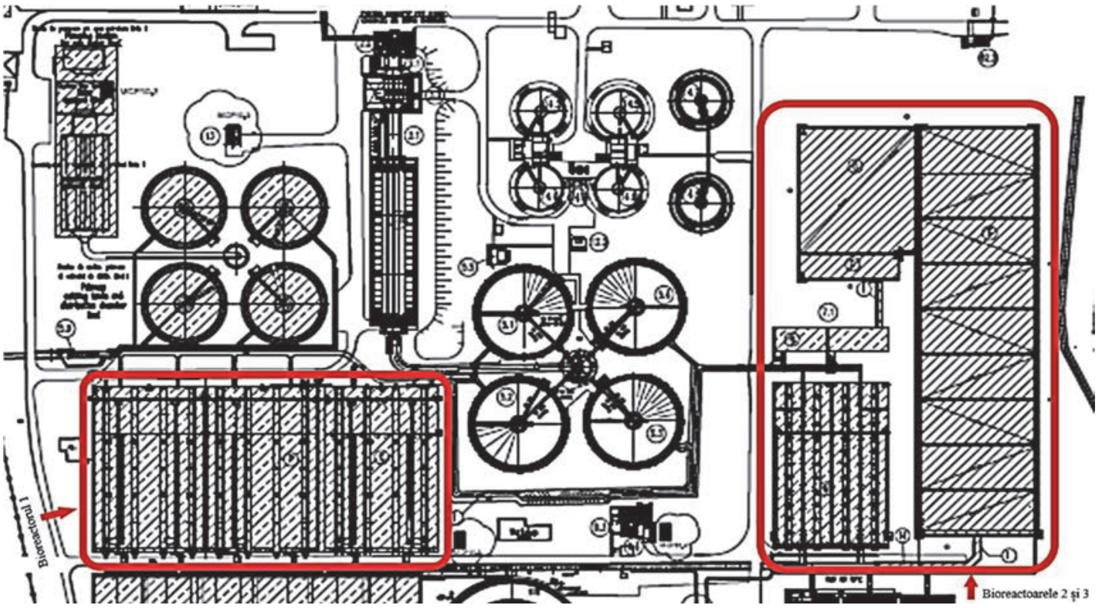


Fig. 2. The Iasi city WWTP (the bioreactors)

Alternatively, the compartment Q (Fig. 3a) is functional, and after inspections and monitoring, no operational deficiencies were found.

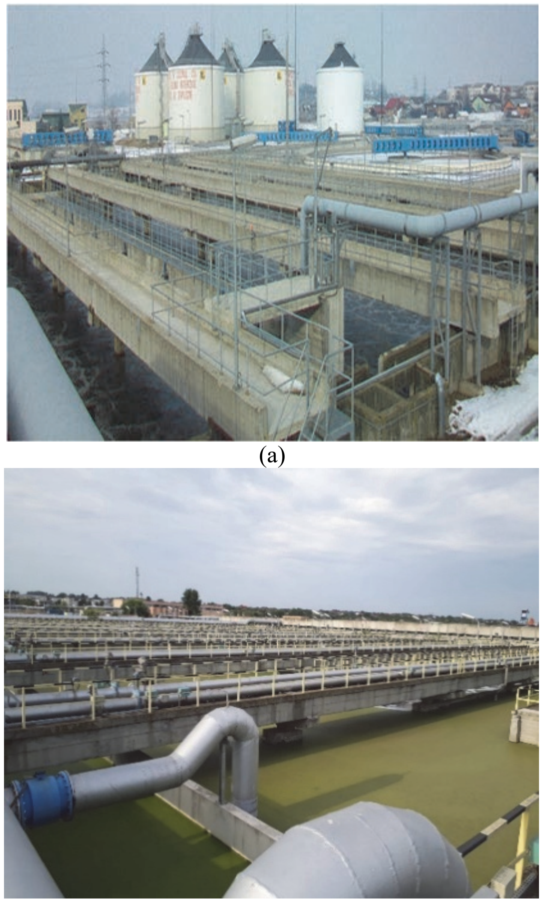
Bioreactor no. 2 (Fig. 4) is in the same situation as compartment P in the bioreactor no. 1.

Bioreactor no. 3 (Fig. 5) was commissioned after modernization works and final tests, but since then the following deficiencies occurred (Fig. 6):

- dislodged porous diffusers (Fig. 6a);
- in the area of dislodged porous diffusers, fluid agitation is violent, which affects the sludge inside the bioreactor (Fig. 6a);
- the wastewater flowing regime inside the bioreactor is uneven (Fig. 6b);
- the wastewater flow distribution inside the bioreactor is uneven (Fig. 6b);
- large areas, unprotected by porous diffusers, remain unaerated (Fig. 6c-d);
- the distribution of wastewater in the oxic zone is uneven (Fig. 6b);
- large volumes of sludge stagnate in the anoxic zone;
- "dead water" zones occur in the oxic zone (Fig. 6c-d).

Studies have revealed that a significant part of the energy consumption (90%–92%) in a WWTP, is under aeration system, while the remaining energy is in the form of mechanical energy and chemical energy (Khatri et al., 2020), and in a bioreactor of such dimensions, deficiencies such as those mentioned above are not recommended, their impact on technological processes leading to increased operational costs (Khatri et al., 2019).

Aeration efficiency is increased using high-efficiency aeration devices and by improving the aeration control strategy (Strazzabosco et al., 2019). The aeration performance is related to the concentration of Mixed Liquor Suspended Solids (MLSS) and the operational DO concentration (Khatri et al., 2020a, 2020b), and diffusers used are high efficiency devices, but if they are damaged (Fig. 6a) their efficiency decreases, and this inconvenience affects not only the nitrification process, but also the suspended solids from bioreactor.



(a)

(b)

Fig. 3. (a) Compartment Q – Bioreactor no. 1 (b) Compartment P – Bioreactor no. 1

Fig. 4. Iasi WWTP – Bioreactor no. 2

Fig. 5. Iasi WWTP – Bioreactor no. 3

In Table 4 and Fig. 7 observing the DO values in the bioreactor no. 3, its concentration having to be between 1 and 3 mg/L. The DO concentration was measured for 5 days (17.12.2018-21.12.2018) in 22 measurement points (11 on the left side and 11 on the right side of the bioreactor). In Fig. 6b is represented the flow variation on the entire length of the weir in the oxic zone of the bioreactor, the difference being obvious. The variation of the flow at the weir is given by the lateral supply of the bioreactor oxic zone, by means of the submerged weir. These deficiencies not only look bad, but affect technological parameters such as HRT, SRT, nitrification or denitrification processes, the same being true for ”dead water” zones.

(a)

(b)

(c) (d)

Fig. 6. (a) Dislodged porous diffusers; (b) Flow regime in bioreactor; (c) ”Dead water” zones in bioreactor; (d) ”Dead water” zones in oxic zone

3. Results and discussion

3.1. Ansys Discovery Live Student

The Ansys Discovery Live Student software allows the determination, modeling, optimization and analysis of various engineering works during the design stage, manufacturing and during their operational stage. Ansys Discovery Live Student makes possible to model fluid behavior without the need to achieve network elements and nodes and makes those simulations available to engineers who are unprofessional analysts (https://www.ansys.com).

3.1.1. Analysis procedure

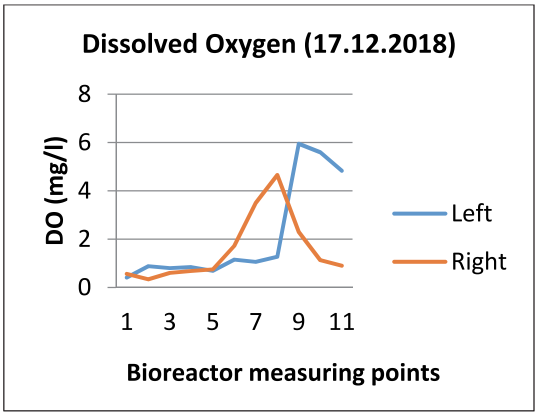
When icon ”Ansys Discovery Live Student program” (Fig. 8a) is accessed, a start page opens (Fig. 8b), page from where the domain, the model or the template in which we want to work can be selected. From here we can create or open a new document, we can open an already created template as to easily find a solution or we can create the desired model in ANSYS SPACECLAIM. In this case we select a pre-defined model, as to easily find a solution (Fig. 9). Once the pre-defined model is opened, the working data must be entered (Fig. 10).

After work data are entered, the software will run (Fig. 11) the modeling (at every modification, the modeling will automatically restart over), Fig. 11a represents the beginning of the simulation after the introduction of the variables, Fig. 11b shows the running of the simulation and the flow distribution in the anaerobic and anoxic zone of the bioreactor, Fig. 11c shows the flow distribution in the bioreactor in the streamline form, and Fig. 11d shows the variation of the flow in the bioreactor in the particles form.

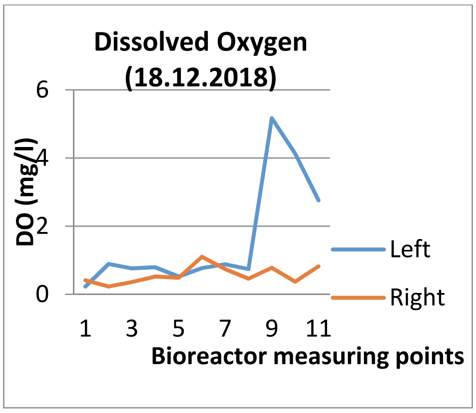
The Issue of mixing efficiency in bioreactors has drawn serious concern in many industrial processes, and on the basis of Ansys Fluent Discovery Live software package, flow characteristics in a bioreactor are predicted (Li and Xu, 2017a). Since the suspension of floating particles is sensitive to the geometrical and operating conditions, many studies have been focused on the effects of bioreactors geometry and operating parameters on the dispersion of floating solids. Researchers investigating the floating particles and found the influence of solid loadings on the critical speed of suspension is insignificant, while the effect of stirrer types is compelling (Li and Xu, 2017b).

Table 4. DO variation in Bioreactor no. 3

DO variation (mg.l)										
Day	***17.12***		***18.12***		***19.12***		***20.12***		***21.12***	
Side Points	***Left***	***Right***	***Left***	***Right***	***Left***	***Right***	***Left***	***Right***	***Left***	***Right***
1	0.41	0.56	0.23	0.41	0.42	0.64	0.28	0.31	0.29	0.41
2	0.88	0.34	0.89	0.23	0.26	0.36	0.69	0.21	0.61	0.42
3	0.8	0.6	0.76	0.36	0.33	0.7	0.63	0.39	0.81	0.53
4	0.84	0.68	0.79	0.52	0.14	0.76	0.51	0.34	0.31	0.7
5	0.69	0.75	0.52	0.48	0.24	1.71	0.64	0.19	0.43	0.72
6	1.15	1.72	0.77	1.1	0.66	7.27	1.85	0.33	0.47	1.08
7	1.06	3.5	0.88	0.74	0.89	5.84	6.48	0.48	5.8	1.37
8	1.27	4.66	0.74	0.46	1.01	5.56	6.08	0.28	7.1	1.38
9	5.95	2.3	5.17	0.78	5.79	5.48	5.22	0.28	6.31	2.86
10	5.6	1.13	4.13	0.37	5.65	4.62	5.28	1.3	5.79	4.23
11	4.83	0.9	2.76	0.82	5.51	5.62	5.48	2.54	7.01	4.82



(a)



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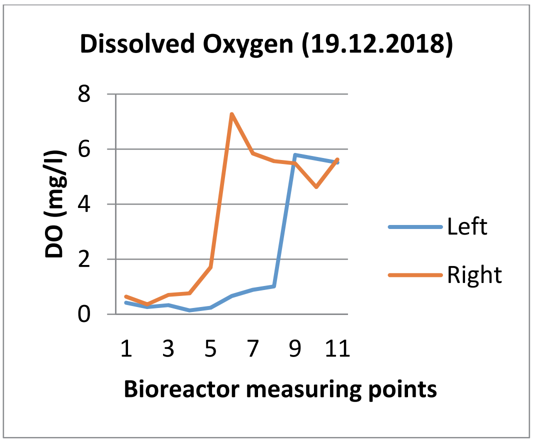
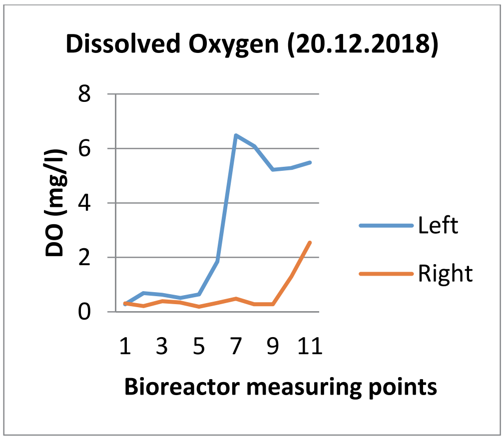
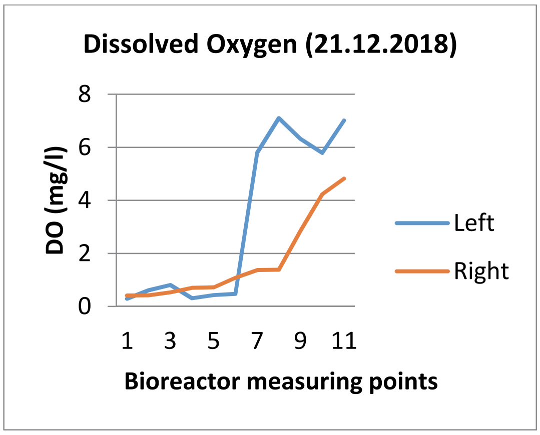


(c)



(d)



(e)

Fig. 7. (a) DO variation in bioreactor no. 3 – 17.12; (b) DO variation in bioreactor no. 3 – 18.12; (c) DO variation in bioreactor no. 3 – 19.12; (d) DO variation in bioreactor no. 3 – 20.12; (e) DO variation in bioreactor no. 3 – 21.12

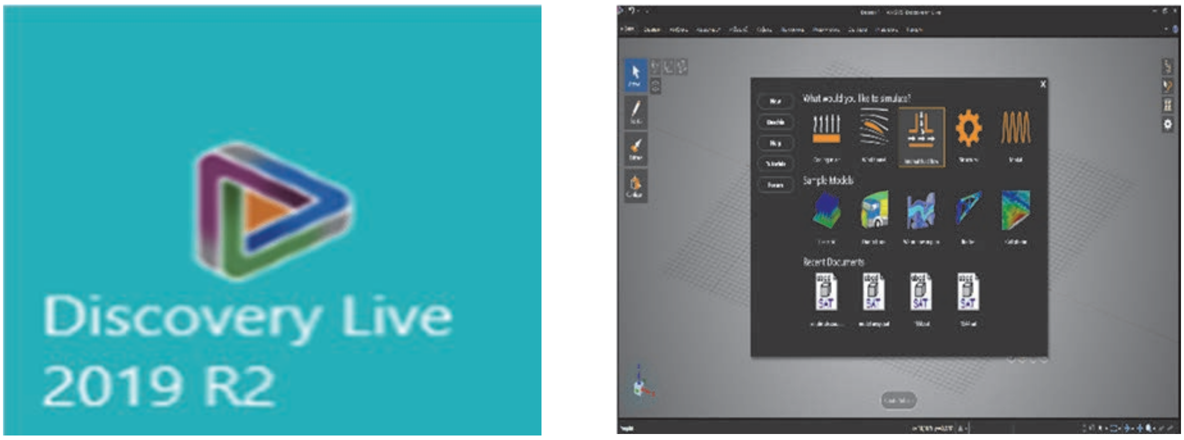
Simulations of processes based on coupling between continuous and discrete phases require large computational power owing to the need for tracking individual particles or droplets inside a computational domain (Wang et al., 2017).

3.1.2. Governing equations

Azimi et al. (2018) present numerical simulation to solve the flow field of a non-compressible fluid in the Cartesian coordinate system the continuity equation and Reynolds-averaged Navier-Stokes equations are used as follows:

$$V_F \frac{\partial \rho}{\partial t} + \frac{\partial(\rho u A_x)}{\partial x} + \frac{\partial(\rho v A_Y)}{\partial y} + \frac{\partial(\rho w A_z)}{\partial z} = R_{SOR} \quad (1)$$

$$\frac{\partial u}{\partial t} + \frac{1}{V_F}\left(u A_x \frac{\partial u}{\partial x} + v A_y \frac{\partial u}{\partial y} + w A_z \frac{\partial u}{\partial z} \right) = -\frac{1}{\rho}\frac{\partial p}{\partial x} + G_x + f_x \quad (2)$$



(a) (b)

Fig 8. (a) Software icon; (b) Discovery Live start page

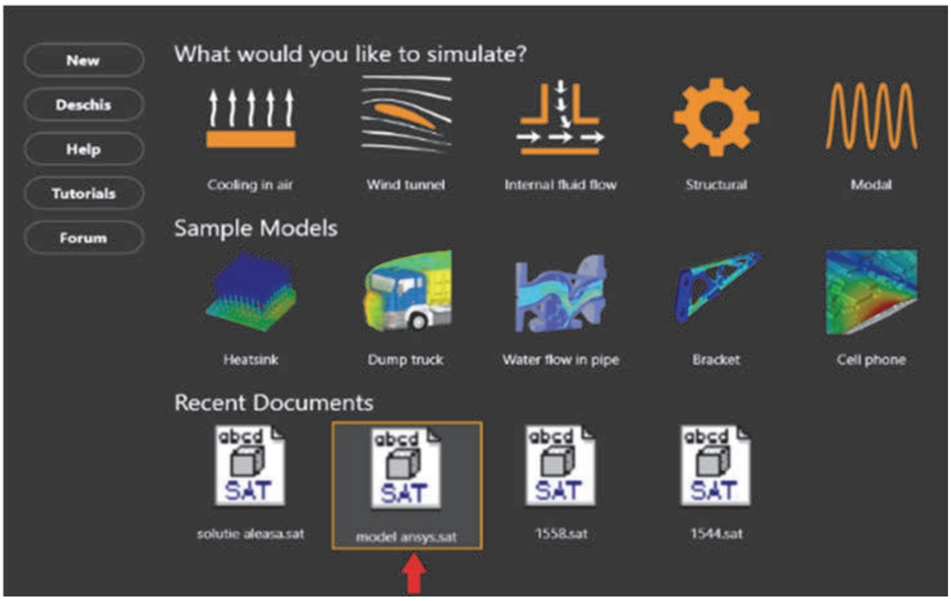


Fig. 9. The pre-defined model

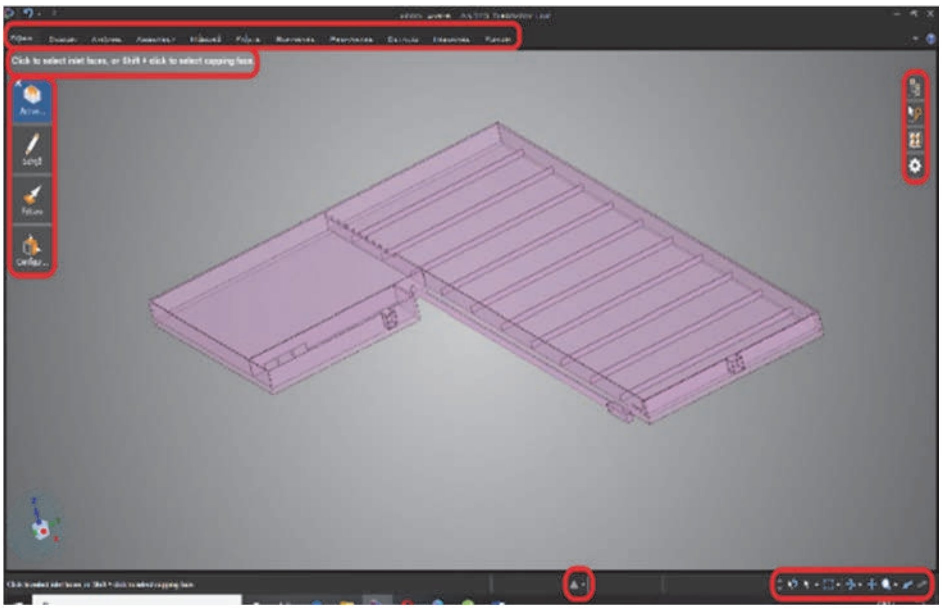


Fig. 10. The pre-definied model and the tool bars for entering work data

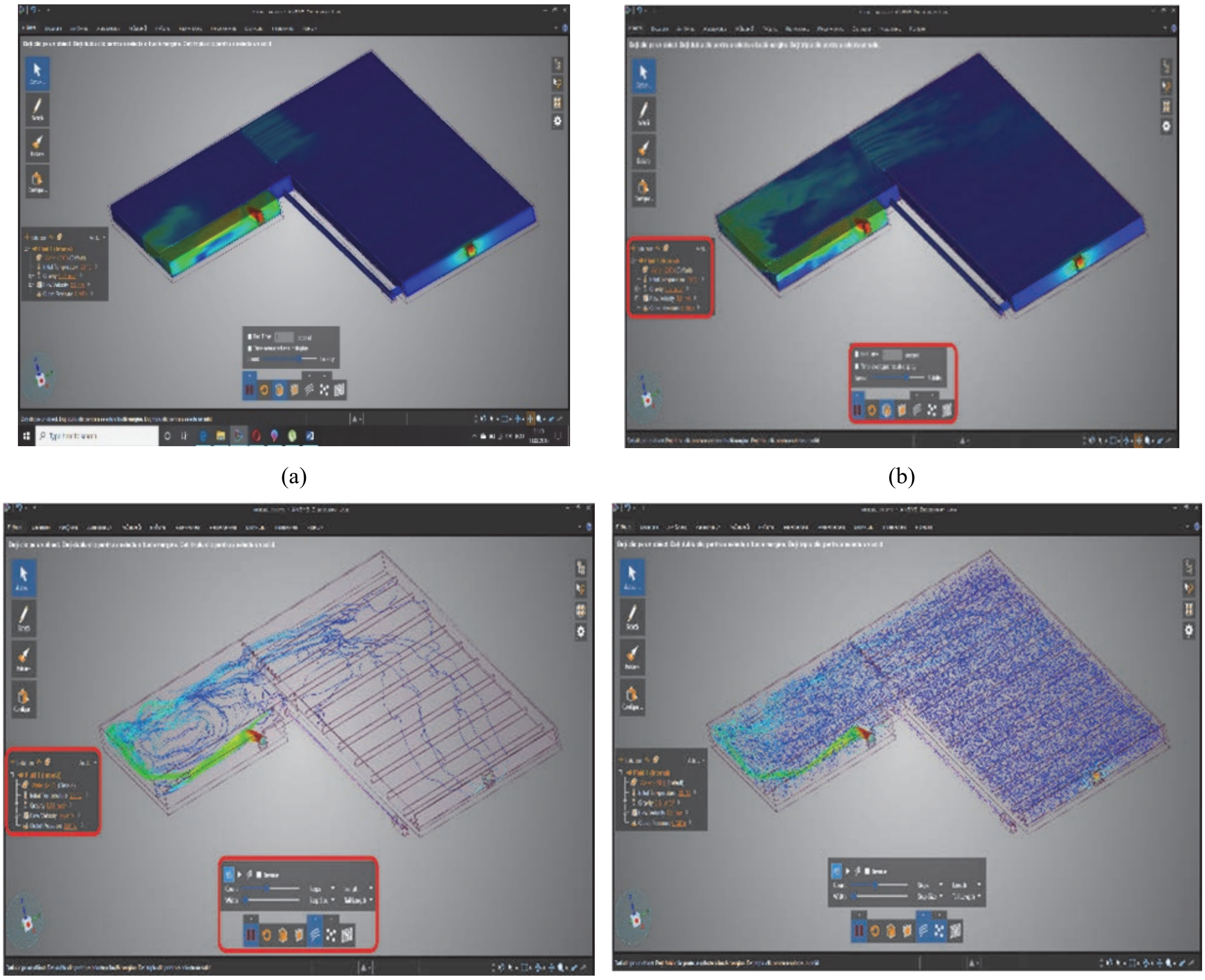


Fig. 11. (a) Begining of the simulation; (b) Running of the simulation; (c) Flow distribution in streamline mode; (d) Flow distribution in particle mode

$$\frac{\partial v}{\partial t}+\frac{1}{V_F}\left(uA_x\frac{\partial v}{\partial x}+vA_y\frac{\partial v}{\partial y}+wA_z\frac{\partial v}{\partial z}\right)=-\frac{1}{\rho}\frac{\partial p}{\partial y}+G_y+f_y \quad (3)$$

$$\frac{\partial w}{\partial t}+\frac{1}{V_F}\left(uA_x\frac{\partial w}{\partial x}+vA_y\frac{\partial w}{\partial y}+wA_z\frac{\partial w}{\partial z}\right)=-\frac{1}{\rho}\frac{\partial p}{\partial z}+G_z+f_z \quad (4)$$

where: (u, v, w), (A_x, A_y, A_z), (G_x, G_y, G_z), and (f_x, f_y, f_z) are the velocity components, the fractional area opens the flow, the gravitational forces and the acceleration due to the viscosity in the x, y, z directions, respectively. Also, t, ρ, R_{SOR}, p and V_F are time, density, the term of the source, pressure, and the fractional volume open to the flow, respectively.

3.2. The selected solutions

3.2.1. Input data

The bioreactor no. 3 of the Iasi Municipal Wastewater Treatment Plant is sized at a maximum daily flow of 2.2 m^3/s, features an average flow of 1.2 m^3/s, an inner sludge recirculation for denitrification of 295% of input average flow, an external recirculation for active sludge biomass recovery of 75%, the active sludge age is 8.7 days. The sludge age in the oxic zone is 6.62 days, the sludge volume index is 110 cm^3/g, wastewater retention in the bioreactor is 4.2 h at maximum daily flow, and in the anaerobic area is 0.7 hours. The concentration of active sludge is 3.7 g/dm^3, the nominal volume of reactor number 3 is 43.622 m^3, the baseplate level is 34.48 m, the level of the inner recirculation pipe axis is 35.48 m, the level of the passage hole from the anaerobic zone to the anoxic zone is 35.98 m. The same level is found at walls that divide the area in 11 sectors. The inlet channel's baseplate level is 35.85 m, and the level of effluent channel is 35.10 m, while the level of the anoxic zone outlet is 37.63 m. The level of the outlet to the oxic zone is 37.92 m, the level of ground around the bioreactor is 37.8 m, the level of tank's upper edge is 38.6 m, the level of wastewater in the anaerobic area is 38.09 m, the same level in the anoxic zone is 38.06

m, and in the oxic zone it 38.03 m. The velocity of wastewater entering the bioreactor is 0.85 m/s (Database APAVITAL, 2017).

3.2.2. Bioreactor no. 3

To analyze the bioreactor, the tank was drawn under AUTOCAD program, and afterwards the file was exported to ANSYS software, in an accepted format. For more conclusive results and due to the sheer size of the bioreactor, we divided the bioreactor into two zones, to choose the optimal solution for the analyzed bioreactor. The division of the tank is as follows:

• the anaerobic tank, with the anoxic tank and the inner recirculation pipe constitute the first analyzed zone (Fig. 12 and 13);

• the oxic tank forms the second zone to be studied (Fig. 14).

For each zone, the wastewater inputs and outputs were entered, and the gravitational acceleration and the wastewater velocity on the tank's inlet. All these data are defining the wastewater motion inside the tank.

Due to this software, we can view one of the most serious issues in the anoxic zone and the uneven distribution along the anoxic zone's outlet (Figs. 12 - 13).

Fig. 14 shows the second study zone (also, a view of the wastewater flow uneven distribution).

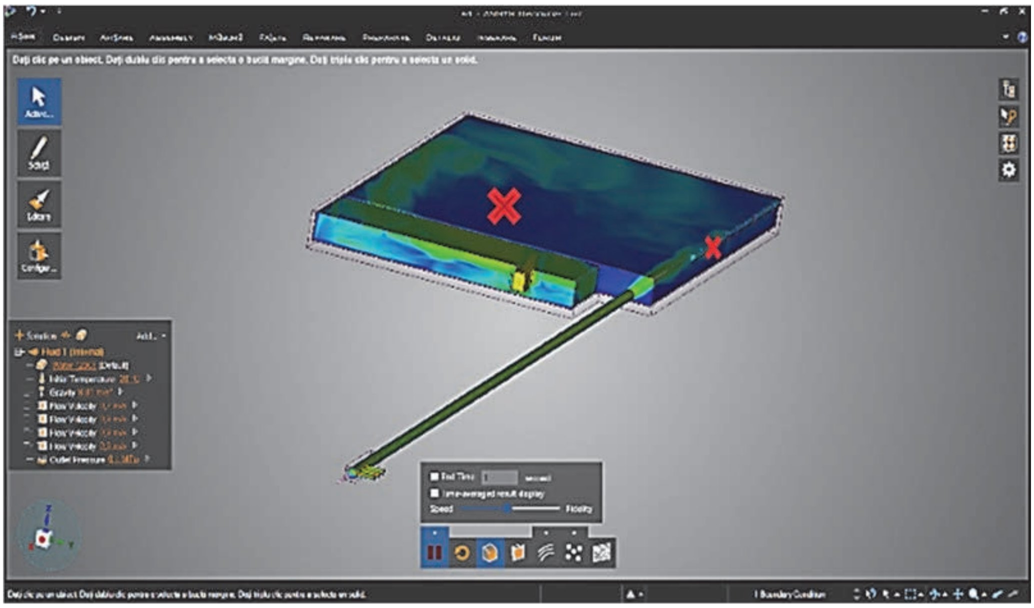


Fig. 12. The deficiency zones inside the anoxic area – viewed with ANSYS software (for the first studied zones)

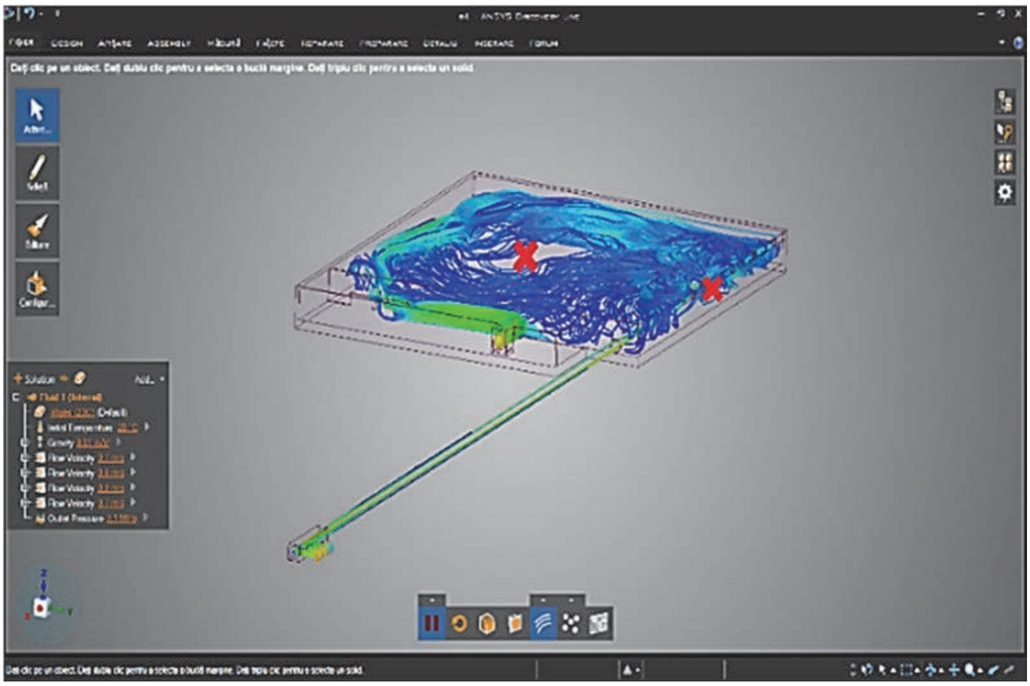


Fig. 13. The deficiency zones inside the anoxic area – viewed with ANSYS software (seen as streamlines)

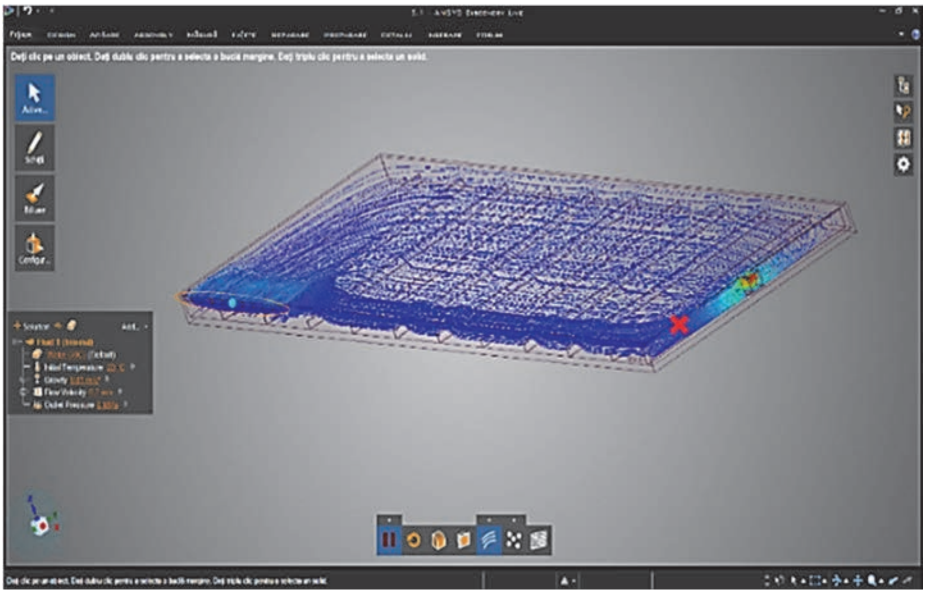


Fig. 14. The deficiency zones inside the oxic area – viewed with ANSYS software (seen as streamlines)

3.2.3. The selected solution

Following the deficiencies found and the analysis conducted on different models under ANSYS program, the corrective chosen solution was the emptying of bioreactor no. 3, the wastewater was transferred into bioreactor no. 2, by pumping. After emptying the bioreactor, the problem areas will be inspected and the aforementioned issues will be remedied.

3.2.4. Procedure

As mentioned above, in the biological stage, only bioreactor no. 3 and compartment Q of bioreactor no. 1 are operational. The total nominal volume of biological stage is 85.800 m^3, out of which only 51.200 m^3 are used. The bioreactor no. 3 features a volume of about 40.000 m^3, while the compartment Q of bioreactor no. 1 has a volume of about 11.200 m^3, resulting in a useful volume of 51.200 m^3. The volume of bioreactor no. 1 (P + Q) is about 33.700 m^3, and the volume of bioreactor no. 2 is about 12.100 m^3, those summed volumes, resulting in a total volume of 45.800 m^3. At first sight, one would say that the full emptying the bioreactor no. 3 is not possible, because there would be a gap of 5400 m^3 that cannot be taken over in case that bioreactors 1 and 2 are running. However, if we consider that the biological stage, like the treatment plant has the capacity to mechanically and biological process an amount of $2Q_{ww\ influent}$, and the fact that emptying the bioreactors is usually done during summertime (when groundwater levels are low, this meaning flows of about 1.2 m^3/s, and this being about half of the $Q_{ww\ day\ max\ flow}$), it comes up that the emptying the bioreactor no. 3 is possible.

Before starting the emptying of bioreactor no. 3, the bioreactors no. 1 and no. 2 must be primed and put into operation, to avoid pollution of the emissary (Bahlui river). Once the process is launched in the two bioreactors, the emptying of the bioreactor no. 3 will be started.

The emptying of bioreactor no. 3 will be conducted with two pumps, one placed in the anoxic zone of the tank, and the other one in the tank's oxic zone. The pumps will provide a head of 5 mWC and a pumping flow rate of 270 L/s, to ensure a minimum drainage time.

The bioreactor no. 3 will not be fully drained off, precisely to be kept in balance, the emptying process being conducted as it follows: one of the two above-mentioned pumps will be installed in the drainage compartment of the anoxic zone, hence the wastewater and sludge mixture will be discharged toward the inlet of bioreactor no. 2. In bioreactor no. 2 will enter a volume of water of approximately 22.600 m^3 from bioreactor no. 3, volume that includes the entire volume of the anoxic and anaerobic zones and the volume of wastewater from the oxic zone outlet's level up to the partition level in the same zone (this being possible due to the inner recirculation pipe that connects the anoxic and oxic zones).

After drainage of the respective volumes of wastewater, the deficiencies in the anaerobic area, anoxic area and compartment 11 of oxic zone, will be remedied. During the emptying of bioreactor no. 3, the air distribution in the oxic zone will not be stopped, to prevent sludge fermentation in the oxic zone and at the same time to keep the bioreactor primed. Moreover, to prevent sludge fermentation, a cofferdam weir will be installed on the channel that connects the bioreactors and secondary clarifiers, in the inlet area of the secondary clarifier no. 1 on process line 2. After emptying the above-mentioned areas, the 11 compartments will also be drained off one by one, (the pump installed in the drainage tank of each compartment shall discharge water into the adjacent compartment).

After emptying each compartment of oxic zone, repair works will be started. After repairs are completed, the bioreactor will be restarted or left in a standby/balanced status.

4. Conclusions

The paper, which presents an integral analysis of the bioreactors from Iasi city WWTP, illustrated the hydrodynamic movement of the wastewater-sludge mixture in bioreactor. The bioreactors are part of the biological stage of the treatment plant and consists of three united tanks, in series, having an L shape, the first being the anaerobic tank, the second is the anoxic tank for denitrification processes and the third, the oxic tank is intended for nitrification.

The research and analysis conducted on bioreactor no. 3 with the ANSYS software concluded that there is need for emptying the bioreactor no. 3, followed by a checkup of each area inside the bioreactor, a verification of all porous diffusers inside the 11 oxic compartments, a replacement of all damaged porous diffusers, after which all needed repairs will be performed. Next, the porous diffusers are to be checked under pressure tests. After all defects have been repaired, the bioreactor will return to normal parameters and designed efficiency.

The process of emptying the bioreactor no. 3, without evacuating the entire volume of wastewater and by keeping it in balance during repair works will increase the treatment efficiency after commissioning, due to the fact that "dead water" areas will disappear, and there will be no more areas with violent aeration, due to diffusers replacement. Following the modeling and simulations performed, the following results and conclusions resulted:

- the shape of the bioreactor no. 3 favors the formation of dead zones in the bioreactor;
- hydrodynamic analysis confirmed the results of the experiments;
- the 3D model studied, indicated during the simulations the same dead zone as in Fig. 6c- d;
- the same happened in the case of the wastewater flow distribution at the exit of the wastewater from the bioreactor (Fig. 6b);
- the uneven distribution of the flow in the bioreactor is also due to its shape.

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