MATEC Web of Conferences **112**, 10018 (2017) DOI: 10.1051/matecconf/201711210018
IManE&E 2017

Peculiarities of clarifiers' reconstruction at waste water treatment plants

Nikolay Makisha[1,*], and *Artem* Kulakov[2]

[1]Moscow State University of Civil Engineering (MSUCE), Yaroslavskoye Shosse, 26, Moscow, 12933, Russia
[2]Vologda State University (VSU), Lenina Street., 15, Vologda, 160000, Russia

Abstract. The article reveals the ways in which the reconstruction of clarifiers for wastewater treatment plant can be performed. One of the most common method is bioflocculation that means use of corresponding properties of excess activated sludge or biofilm, which both have in its composition so called extracellular biopolymers that determine the spatial structuring and bioflocculation of cell formations. Multiple researches showed that use of surplus sludge as bioflocculant provides increased efficiency of sedimentation in any waste water up to 85-90 % and reduce biochemical oxygen demand (BOD) in the clarified water by 40-50 %. The other method to be implemented for reconstruction of clarifying facilities is thin-layer modules to raise the efficiency of settling. Thin-layer modules can be used in a wide range of capacity of sewage works. The possibility of application depends on the structural size and condition of building structures, the amount of suspended solids and other parameters.

1 Introduction

Sedimentation is the easiest, cheapest and least energy intensive method to remove out of wastewater suspended impurities with a density different from the density of water. Under the action of gravity the particles of dirt settle on the bottom of the tank or float to the surface.

The relative ease of settling facilities determines their wide application in various stages of wastewater treatment and further handling of the produced sludge. Depending on its purpose and location in technological schemes of wastewater treatment clarifiers may be classified into the following structures: settling tank - primary, secondary and tertiary (contact tank); sludge thickeners.

2 Types of clarifiers

Primary settling tanks are located in the technological scheme of wastewater directly after a sand traps and used for separation of suspended solids from waste water. Achieved effect 40-60% leads to a 20-40% decrease of BOD in the clarified wastewater to the original value

[*] Corresponding author: nmakisha@gmail.com

[1,2].

In order to avoid the increased growth of activated sludge in the aeration or biofilm in the biofilters residual concentration of suspended solids in the clarified effluent after primary clarifiers should not exceed 100-150 mg/l. Influent concentrations of suspended solids in the waste water that are normally of 200-500 mg/l, that determines the choice of the most reasonable technology for primary clarification and the desired duration of settling.

Secondary clarifiers are the second part of the biological treatment facilities that is located in the treatment sequence after the phase of biological oxidation and serves to separate the activated sludge from the biologically treated water discharged from the aeration tanks, or to hold the biofilm supplied with water from a biofilter. The efficiency of the secondary clarifiers determines the final effect of water purification from suspended solids [1-3].

In technological schemes of biological treatment in the aeration tanks secondary clarifiers may also determine the volume of the aeration facilities, that depends on the concentration of the return sludge and the degree of recycling, the ability of the clarifiers to effectively separate the high-concentrated sludge mixture.

Sludge thickeners. The sequence of slaudge treatmetn determines how the thickening may be applied: for residues from primary clarifiers; for excess activated sludge; for mixture of residue and sludge; for flotation sludge; for sludge after stabilization.

The growth of activated sludge depends on the content of dissolved and suspended (mainly organic) media in the purified water and the efficiency of the primary clarifiers. The better primary sedimentation tanks work, the smaller is the amount of excessive active sludge [4,5].

3 Methods of intensification

Wide scope of studies conducted through years in MSUCE and VSU helped to develop and test different methods of intensification of processes of sedimentation of sewage and the thickening of the produced sludge. The most popular known method of intensification of primary settling for the treatment of municipal wastewater is associated with the use of bioflocculation properties of excess activated sludge and biofilm, which has in its composition extracellular biopolymers that determine the spatial structuring and bioflocculation of cell formations.

Excess activated sludge and biofilm are the natural bioflocculation agents to be appeared during biological wastewater treatment. Use of their bioflocculation properties is advisable as one of the most efficient methods that has certain physical and chemical effects on the formation of agglomerations of fine suspension in the process of its sedimentation [1, 2, 5-7].

Research in the field of sedimentation and hydrodynamic conditions of its implementation helped to develop and optimize technology of primary clarification of wastewater using surplus sludge as bioflocculant, which provides increased efficiency of sedimentation in any waste water up to 85-90 % and reduction of BOD in the clarified water by 40-50 %. Possible scheme of implementation of this technology in radial primary sedimentation tank is shown in Figure 1.

Area of bioflocculation located in the central part of the radial clarifier to ensure waste water effective contact between the particles and fine suspension of active sludge during 20-minutes stay.

Air input flow supplemented by the aerator device in the form of perforated pipes, which together provides the area of bioflocculation with required gradient of mixing speed of 50-60 sec (Figure 2, curve 1).

DOI: 10.1051/matecconf/201711210018

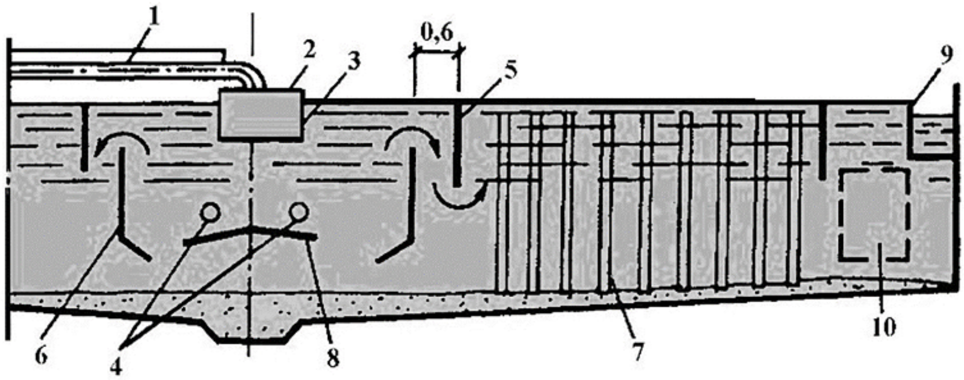

Fig. 1. Scheme of primary clarifier with bioflocculation chamber: 1 — inlet of waste water and sludge; 2 — distribution chamber; 3 — bioflocculation zone; 4 — perforated aerators; 5 — semi-submerged partition wall; 6 — submerged walls; 7 — low-rate mixer; 8 — protection shield; 9 — collection weir; 10 — thin-layer blocks

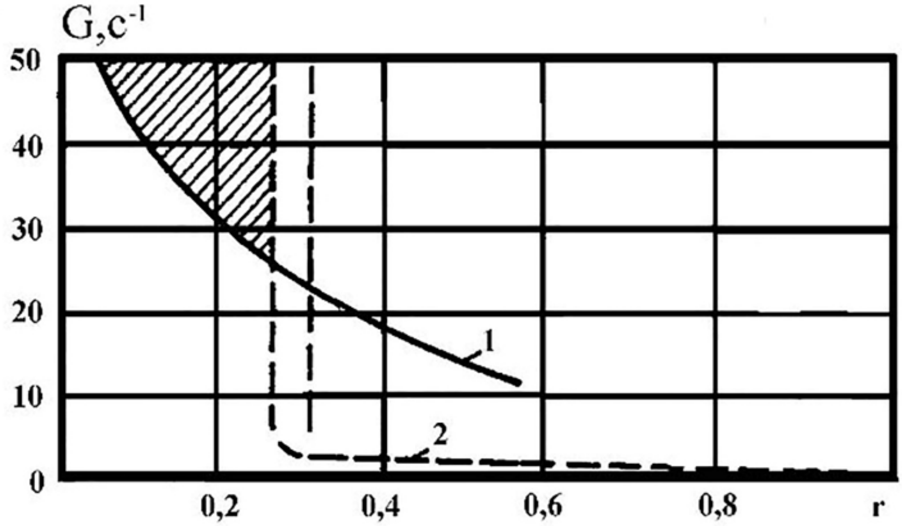

Fig. 2. Distribution of rate gradients before (curve 1) and after the reconstruction (curve 2)

After the bioflocculation waste water passes under the baffle zone of air separation, where the adhering air bubbles separated to prevent possible degradation of the sedimentation conditions [8].

In the settling zone of the clarifier sedimentation is stimulated by discordantly mixing, which for G=1-2 sec^{-1} provides optimal conditions for deposition of suspended particles and compaction of sediment formed. Cross-scheme thin-layer blocks located on the periphery of the sedimentation tank clarify water in the final stage before it reaches the collection tray. Acquired experience of MSUCE and VSU researchers in operation of the primary clarifiers, modified under this scheme, showed its high effectiveness to settle suspended solids with 60 to 80% and reduce BOD in the clarified water by 40-70%. The disadvantage of this method of intensification is the material demand for thin-layer blocks.

Under optimal supply of activated sludge 160-200 mg/l, the efficiency of the clarification of suspended solids and BOD were respectively 75-80 % and 50-70 %, while the moisture content of the mixture of sludge and excess sludge discharged from the clarifier was 96.0-96.5 per cent [9, 10].

Intensification of the primary clarifiers is also possible through the use of continuous sediment pumping with its subsequent thickening. The advantages of this technology is keeping of almost zero (not more than the height of the scrapers) layer of sediment on the bottom of the settler, thereby enhancing the effect of water clarification. Quick removal of drop-down sediment, by means of bottom scrapers, allows avoiding deposits of sludge with subsequent anaerobic decay and input of hardly settled compounds into the treated water.

It is necessary to improve the construction of devices that removes floating materials from the water surface of the radial settling tanks (the most typical solution for wastewater treatment plants). Swinging entrance bunkers, when truss scraper passes over them, collect a floating substance along with a significant amount of water to provide humidity of the mixture at about 97 % [11-13].

4 Sedimentation with thin-layer modules

The essence of the method, advantages and disadvantages. A thin layer (tubular or plate) clarifiers used to increase the efficiency of settling. At shallow depth sedimentation occurs rapidly, which helps to reduce the size of the tanks. The efficiency of tubular and plate sedimentation tanks is nearly similar. The height of the thin-layer space is recommended to be of 1-2 m, the distance between the plates — 25-200 mm, length — 0.6-1 m Thin-layer blocks can be installed in case of conventional clarifiers (Figure 3) [5, 14, 15].

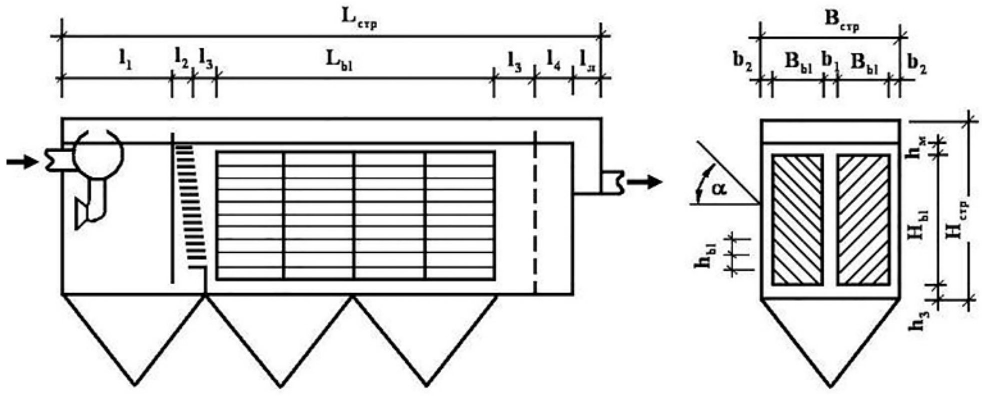

Fig. 3. Clarifier with thin-layer module

Application of thin-layer elements can significantly reduce the duration of settling and consequently the volume of the tanks (the duration of the treatment is 4-10 min). Thin-layer sediment tanks allow intensifying of suspended solids sedimentation process, together with 60 % reduction of necessary volume and 25-30 % increase of the purification effect if compared to the commonly used clarifiers. As with conventional clarifiers, they do have zones of water distribution, sedimentation and collection and zone of accumulation of sediment.

The settling area of shelf sections or tubular elements is divided into a number of shallow layers (to 15 cm). Shelf sections are assembled from flat or wavy plates, easy to operate. The tubular sections have greater rigidity, which provides stability of dimensions throughout its length and higher flow speed than the shelf section. On the other side tubular modules could be faster bulked with sediments (and hardly cleaned) and require greater material consumption [4, 6, 16].

The hydraulic mode of operation of the clarifiers has a significant impact on the effect of their work. The better the design of the clarifier, the higher the efficiency of the detention of suspended solids that is connected to the way how water enters the sedimentation tank i.e. the speed of water inlet and depth of partition wall in a horizontal settler. Hydraulic mode of operation is estimated by the coefficients of volumetric use and useful actions of the settlers.

The other advantage of thin-layer sediment tanks is that parallel plates in cross-section of the clarifier provides more regular distribution the incoming water flow and maintains this distribution throughout its length. Therefore, volumetric use is much higher in multilevel clarifiers [17, 18].

Thin-layer sedimentation tanks are classified according to the following criteria: design of blocks – tubular and shelving; mode of operation – periodic (cyclic) and continuous; mutual movement of clarified water and with displaced sediment — direct-flow, counter-flow or combined motion.

The cross section of the tubular sections may be rectangular, square, hexagonal and round. Shelf sections assembled from flat or corrugated sheets have a rectangular cross-section. They are made of steel, aluminum and polymers (polypropylene, polyethylene, fiberglass etc.). Normal flow rate for shelf elements is 5-10 mm/s and up to 20 mm/sec for tubular. Tube can be installed with low (to 5°) and large (up to 45-60°) slope. Tubular elements with a slight tilt work intermittently. The sedimentation is conducted first following by residue removal.

Thin-layer modules (Figure 4) can be used in a wide range of capacity of sewage plants. The possibility of application depends on the structural size and condition of constructions, the amount of suspended solids and other parameters [19, 20].

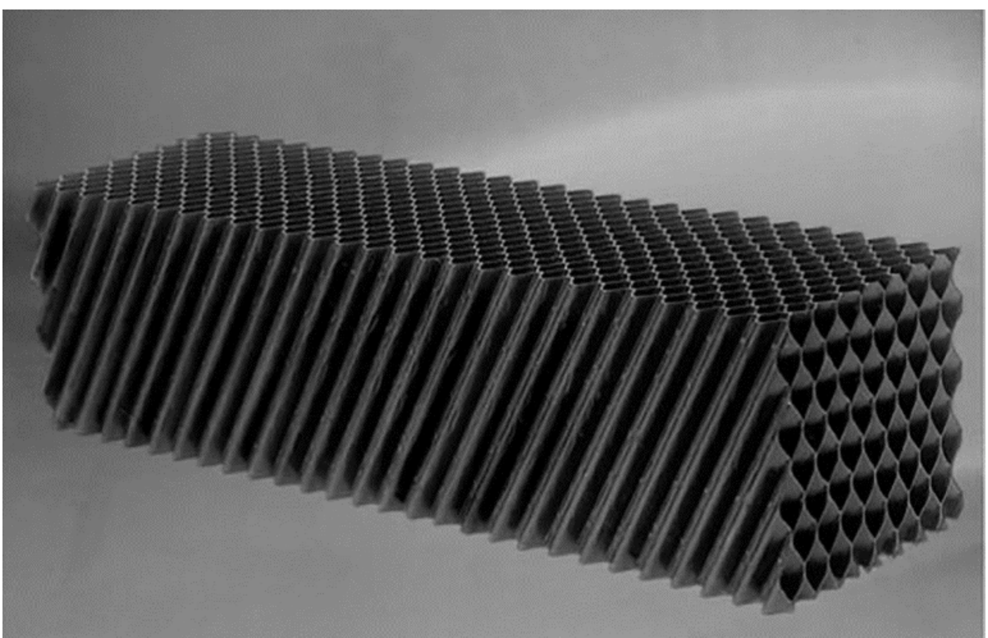

Fig. 4. Thin-layer module

The best results can be reached if the method of thin-layer settling applied for the secondary clarifiers that helps not only to improve significantly suspended solids removal efficiency but also to make a slight reduction contamination of BOD.

When using thin-layer blocks they should be regularly regenerated by means of mechanical, hydraulic, pneumatic or combined methods, as they can accumulate particles of suspended solids on the modules' surface when operating. The frequency of regeneration of thin-film modules is determined in the process of operation, but not less than 1 time in 10 days.

5 Conclusions

1. Within the process of clarifiers reconstruction the most important properties of these facilities, which largely depends on the hydraulic factors and their peculiarities should be considered.
2. Violation of waste water flow speed, flow distribution, settling velocity and other hydraulic parameters of clarifiers may eventually lead to malfunction of the biological treatment facilities and sludge treatment.
3. Methods of reconstruction such as bioflocculation and thin-layer modules application help to achieve a significant reduction of suspended solids and BOD concentration in waste water

References

1. A.G. Pervov, A.P. Andrianov, T.P. Gorbunova, A.S. Bagdasaryan, Petr. Chem. **55** (10), 879-886 (2015)
2. I. Gulshin, A. Kuzina, IJAER **10** (21), 42618–42623 (2015)
3. E.S. Gogina, O.V. Yantsen, O.A. Ruzhitskaya, AMM **580-583**, 2354-2357 (2014)
4. A. Volkov, V. Chulkov, R. Kazaryan, M. Fachratov, O. Kyzina, R. Gazaryan, AMM **580-583,** 2281-2284 (2014)
5. A.G. Pervov, A.P. Andrianov, E.B. Yurchevskiy, Petr. Chem. **55** (10), 871-878 (2015)
6. E. Gogina, A. Pelipenko, MATECCONF **73,** 03007 (2016)
7. V.N. Varapaev, S.A. Doroshenko, A.Y. Trotsko, A.V. Doroshenko, IJAER **10** (21), 42588-42592 (2015)
8. O. Kuzina, E. Pankratov, V. Tkachev, MATECCONF **86,** 05023 (2016)
9. V. Orlov, A. Andrianov, AMM **580–583**, 2398-2402 (2014)
10. V.N. Varapaev, A.V. Doroshenko, I.Y. Lantsova, Pr. Eng. **153**, 816-823 (2016)
11. E.S. Gogina, O.A. Ruzhitskaya, O.V. Yantsen. AMR **919–921**, 2145–2148 (2014)
12. N. Makisha, E3sconf **6**, 01002 (2016)
13. A.G. Pervov, A.P. Andrianov, DWT **35** (1-3), 2-9 (2011)
14. E. Gogina, I. Gulshin, AMM **580-583**, 2367-2369 (2014)
15. A. Volkov, O. Kuzina, Pr. Eng. **153**, 838-843 (2016)
16. N. Makisha, Pr. Eng. **165**, 1087-1091 (2016)
17. A.A. Volkov, A.V. Sedov, P.D. Chelyshkov, D.A. Lysenko, A.V. Doroshenko, IJAER **10** (22), 43269-43272 (2015)
18. N. Makisha, Pr. Eng. **165**, 1092-1097 (2016)
19. E. Gogina, I. Gulshin, Pr. Eng. **153**, 189-194 (2016)
20. A.G. Pervov, A.P. Andrianov, V.A. Chukhin, R.V. Efremov, IJAER **10** (22), 43517-43525 (2015)