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DYNAMICS OF TRANSFORMATION OF NITROGEN AND PHOSPHORUS COMPOUDS IN THE WASTEWATER IN THE PROCESS OF BIOLOGICAL TREATMENT

The denitrification, phosphorylation and dephosphorylation dynamics in activated sludge systems was studied in the lab conditions. It was shown that the dephosphorylation took place mainly in between 30 min and 60 min of aeration time. The denitrification rate is defined by nitrates concentration in mixed liquor and depends on the current conditions – availability of dissolved oxygen, volatile organic compounds and others.

Introduction. Currently, while designing and reconstructing urban wastewater treatment plants, the task of primary importance is to remove biogenic elements – nitrogen and phosphorus. Biological treatment technology for municipal sewerage, specially designed to remove these biogenic elements is able to prevent eutrophication of water entities.

Biological removal of nitrogen from the wastewater is based on the processes of nitrification and denitrification. Biological treatment of wastewater from phosphorus compounds occurs due to its removal with biomass of abundant activated sludge containing bacteria that can accumulate phosphorus in amount much greater than the needs of the bacteria themselves.

The processes of nitrification, denitrification and biological dephosphotation take place to some extent on biological treatment plants, but every biological system has its own characteristics, due to the composition of wastewater, treatment conditions, etc. Therefore, the study of biological processes of nitrogen and phosphorus removal from wastewater remains relevant.

The aim of the work was to study the dynamics of denitrification and biological dephosphotation in the process of biological wastewater treatment. The course of denitrification was monitored by reduction of nitrates concentration in the wastewater in the absence of aeration. Biological dephosphotation was determined taking into account reduction of phosphate phosphorus content in the liquid phase of mixed liquor in the aeration conditions. Furthermore, the release of phosphate phosphorus from biomass of activated sludge was evaluated while curing without aeration, previously incubated in aerobic conditions of mixed sludge.

Main part. The objects of study were: sludge liquor, collected from the last quarter of the fourth passage-way of aerotank MOS-1, the third nitrifier and the third denitrifier MOS-2, and clarified effluents collected at the exit of the primary clarifier. At MOS-1 classical aeration basins are functioning; at MOS-2 bioreactors are separated and isolated from each other: anaerobic zone and three alternating nitrification and denitrification zones.

Trial designs for processes of biological dephosphotation and denitrification are shown in Fig. 1, 2.

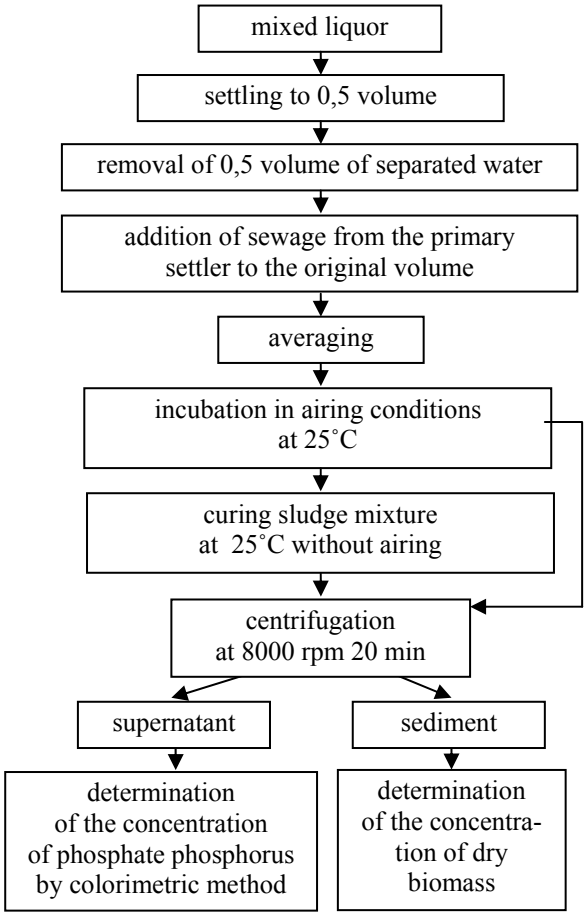

Fig. 1. Trial designs of the process of biological dephosphotation

In the first case, the sludge liquor and clarified wastewater ratio was 1 : 1, in the second case the clarified wastewater (in the ratio 3 : 1) was added

to the activated sludge as a source of easy degradable organic substances for the microorganisms-denitrificators. While studying dephosphotation process, incubation was performed in shaker-incubators Environmental Shaker-Incubator ES-20. The entire volume of the flask for denitrification of studied sludge liquor was filled and incubated in thermostat. Centrifugation was performed in a centrifuge OPN-8UHL4.2 for complete precipitation of organisms of activated sludge while the concentration of dry biomass was established by gravimetric method. The concentration of phosphate phosphorus was determined by colorimetry on FEC-M at a wavelength of 820 nm by adding of a mixed reagent (10 cm^3 of 2,5% ammonium molybdate solution, 10 cm^3 of a 10% solution of ascorbic acid and 30 cm^3 of 2n. of sulfuric acid). Determination of nitrates concentration was carried out by colorimetry using salicylic acid on the FEC-M at a wave length of 410 nm.

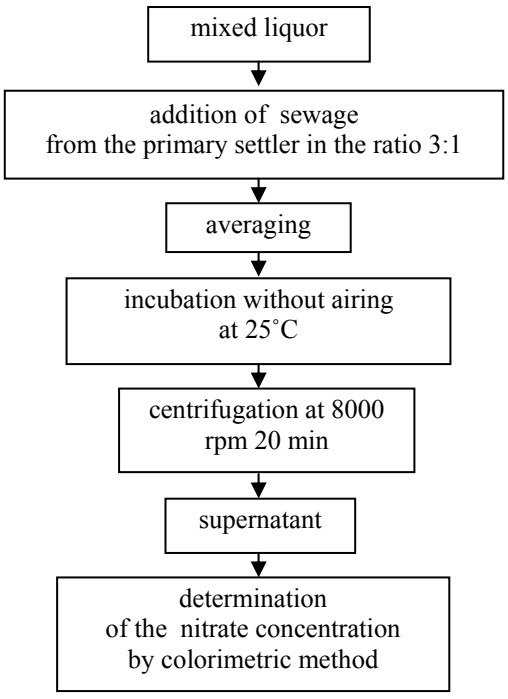

Fig. 2. Trial design of denitrification process

Absorption of phosphorus phosphate by activated sludge vigorously proceeds during 0.5–1 h of aeration, after which the phosphorus phosphate concentration in the liquid phase practically does not change. For the samples of activated sludge from MOS-1 collected at different times the value was ranging from 0.2 to 0.7 mg/dm^3 (Fig. 3), for the activated sludge from MOS-2 – from 0.2 to 1.8 mg/dm^3 (Fig. 4). It should be noted that the initial content of the phosphorus phosphate in the samples of mixed liquor collected at MOS-1 is much higher than in samples from MOS-2 because sampling was done from the first section of the aeration tank where the effluent from the excess activated sludge thickening process enters.

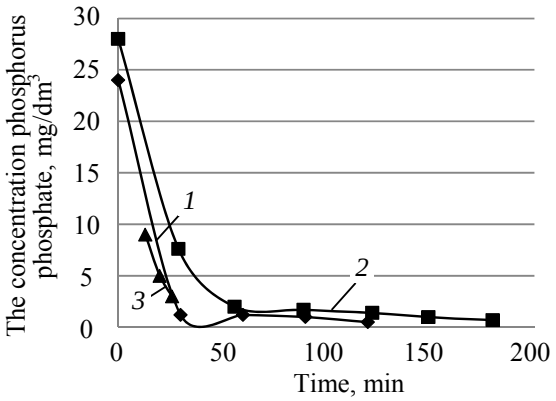

Fig. 3. Dynamics of biological dephosphotation by incubating of the mixed liquor with aeration (MOS-1):
1 – sample from 25.03.13; *2* – sample from 24.04.13; *3* – sample from 18.03.13.

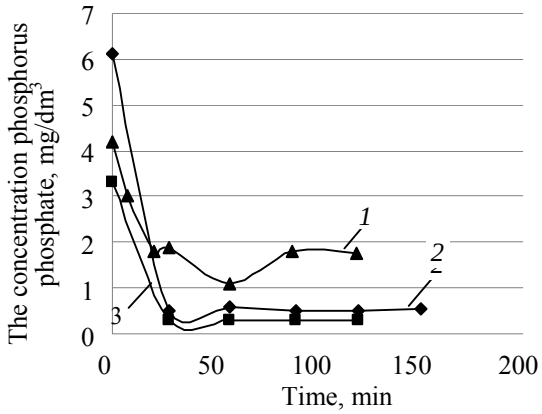

Fig. 4. Dynamics of biological dephosphotation by incubating of the mixed liquor with aeration (MOS-2):
1 – sample from 15.04.13; *2* – sample from 08.04.13
3 – sample from 26.04.13

After pre-incubation of aerobic mixed liquor for 0.5 h, the reverse process of biological dephosphotation, i.e. the release of phosphorus by activated sludge into wastewater, proceed rapidly between 1.5–2.5 hours after extinction of air supply (Fig. 5). It should be noted that at the initial stage of incubation of mixed liquor in the absence of aeration, phosphate phosphorus concentration in separated water sometimes even decreased (a sample from 03/18/13). This may be due to the sufficient oxygen content for the process of dephosphotation.

If the preliminary incubation of mixed liquor in the aeration conditions was carried out for 1 or 2 hours, then the same sample of mixed liquor was left without aeration. After some time phosphorus was absorbed by the activated sludge and then

there was only slight (0.10–0.15 mg / dm^3) phosphorus phosphate excretion in the liquid phase.

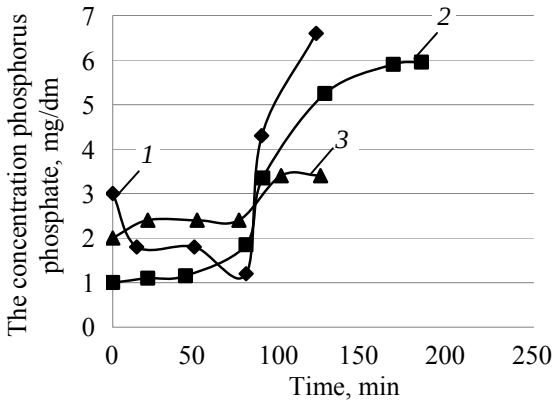

Fig. 5. Dynamics of phosphate phosphorus at preliminary incubating of mixed liquor with aeration for 0.5 h:
1 – sample from 18.03.13; *2* – sample from 01.04.13 (MOS-1); *3* – sample from 15.04.13 (MOS-2)

The results obtained show that the sharp decrease in the phosphorus phosphate concentration by incubating the mixed liquor for 0.5–1 hour is due to its sorption on the surface of the flakes. At this stage, it is possible to remove it from wastewater [1].

Curing mixed liquor which was preliminary aerated for half an hour, without aeration leads to the release of phosphate (desorption) and increasing the concentration of phosphate phosphor in a liquid phase.

Under longer preliminary incubating with aeration, phosphates are used by microorganisms to synthesize phosphorous-containing cell components or stock up with cells. The subsequent curing of the mixed liquor without aeration may occur desorption of phosphates in the water which are not included in the cells.

Fig. 6 shows the dynamics of denitrification of mixed liquor samples, collected from areas of nitrification and denitrification. The denitrification rate was from 30 to 60%, while nitrification and denitrification processes are more expressed at MOS-2 than at MOS-1.

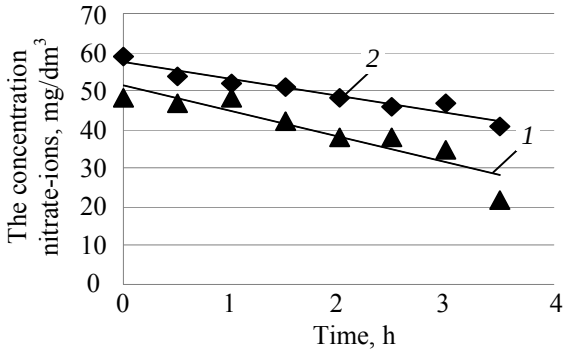

Fig. 6. Dynamics of denitrification under incubating of mixed liquor samples:
1 – sample from 18.04.13 (third nitrifier);
2 – sample from 26.04.13 (third denitrifier)

There is no significant difference in the degree of denitrification of activated sludge collected from zones of the nitrification and denitrification. Apparently, the working parameters of activated sludge system in these areas have to be more accurately adjusted.

Conclusion. Intensive phosphorus phosphate removal occurs within 0.5–1 hour of the activated sludge and wastewater contact by sorption processes. Absorbed in this way phosphates release easily into the liquid phase in the absence of aeration. While prolonged aeration, phosphates are used by microorganisms of activated sludge for the synthesis of phosphorus-containing components of cells or stocking cells. Its release becomes much slower in these conditions.

The denitrification rate is determined by the concentration of nitrates in the mixed liquor, depending on the prevalent conditions: the presence of dissolved oxygen, the availability of readily degradable organic compounds, and others.

The data obtained can be used to improve processes of nitrogen and phosphorus removal in biological wastewater treatment.

References

1. Степанов А. С. Удаление биогенных элементов из городских сточных вод // Водоочистка. 2010. № 8. С. 46–56.

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