Assessment of the efficiency of nitrogen removal from municipal wastewater

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8th GLOBAL NITROGEN CONFERENCE
30. MAY – 3. JUNE 2021 | BERLIN, GERMANY

Introduction

One of the biggest risks to surface waters is the deterioration of their quality as a result eutrophication. The main reason for eutrophication of waters is the local increase in population density, the increasing amount of municipal wastewater (WW) as well as the intensification of agricultural production (Smoroń, 2012). According to Klimiuk et al. (1995) it is estimated that about 45% of nitrogen and 70% of phosphorus discharged into waters in Poland is of wastewater origin. It is therefore important to maintain high efficiency in the removal of nutrients from wastewater. In small and medium-sized wastewater treatment plants (WWTP) in Poland, achieving normalized concentrations of nitrogen in treated sewage often creates problems. The aim of the article is to analyze the factors influencing the low efficiency of N removal from wastewater and to define methods of counteracting it.

Keywords: eutrophication, nitrogen removal from wastewater

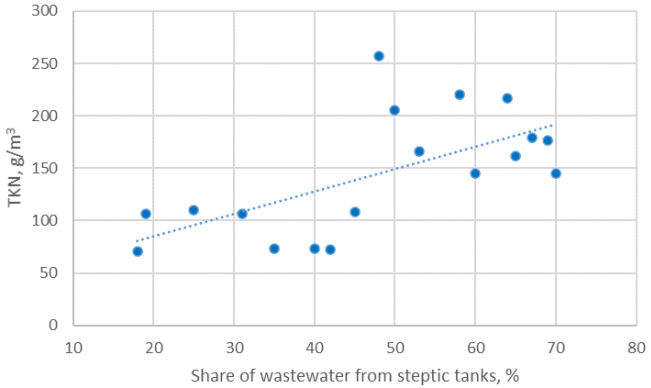


Fig. 1. Influence of the amount of WW from septic tanks supplied to the WWTP on the concentration of TKN

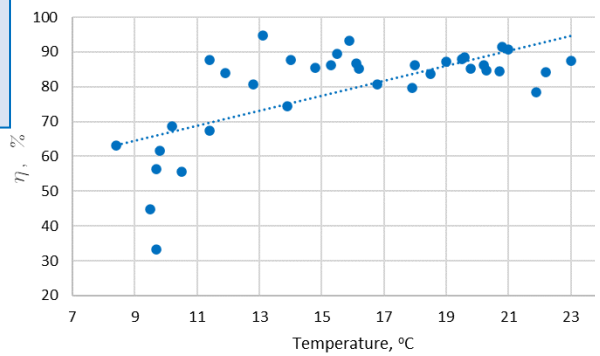
Results and discussion

The main reasons contributing to the low efficiency of WWTP for 5 to 50 thousand inhabitants in Poland include the high share of wastewater from septic tanks supplied to the treatment plant and the lack of appropriate infrastructure that would enable their control, as well as initial mineralization and retention (Figure 1). Another important factor that poses a big problem for small and medium-sized WWTP in Poland is the cooling of wastewater in biological reactors in periods of low temperatures, while the degree of aeration in the biological reactor and the amount of internal and external recirculation are not controlled (Figure 2a). An equally important factor is the periodically unfavorable BOD_5/TKN ratio in the wastewater, which can be easily kept within the desired ranges when using an external carbon source dosing plant (Figure 2b). In addition, it was noted that in WWTP cooperating with a combined network, in which the technological system does not have a retention reservoir, during periods of heavy rainfall, deterioration of the treatment plant's operation and nitrogen removal efficiency are observed. Heavy rainfall leads to the dilution and cooling of the wastewater as well as the washing out of the activated sludge microorganisms from the biological reactor and the secondary settling tank. Another noted factor is the adverse effect of industrial wastewater, which, without an appropriate level of treatment, is discharged into the sewage system, causing large fluctuations in nitrogen loads on the inflow to the WWTP.

Funding
This publication contributes to Project UNCNET (Urban nitrogen cycles: new economy thinking to master the challenges of climate change) is supported under the umbrella of JPI UE – CHINA call by the National Science Centre, Poland and National Natural Science Foundation of China, China and Austrian Research Promotion Agency, Austria.

Materials and methods

The analysis of factors influencing the effectiveness of nitrogen compounds removal from wastewater was determined on the basis of actual and literature data of the operated Polish wastewater treatment plants.
During the analysis, the physico-chemical composition of raw and treated wastewater (BOD_5, COD, TKN, suspension, pH, temperature), the type of sewage system and technological solutions were considered.



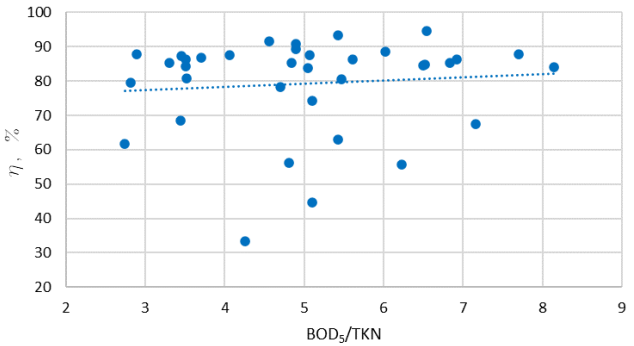


Fig. 2 a. Influence of temperature on nitrogen removal efficiency **Fig. 2 b.** Influence of BOD_5 on nitrogen removal efficiency

Conclusion

Based on the data analysis, it was found that the factors significantly affecting the deterioration of the efficiency of nitrogen removal from wastewater in mechanical-biological wastewater treatment plants with activated sludge with a size of 5 to 50 thousand inhabitants are:

- ✓ High share of wastewater from septic tanks supplied to the sewage treatment plant
- ✓ Cooling down the biological reactor during periods of low temperatures
- ✓ Unfavorable BOD_5/TKN ratio
- ✓ Obsolete technical solutions (no measurement of the biological reactor with sensors of oxygen, ammonium and nitrate nitrogen)
- ✓ No pretreatment of industrial wastewater (high nitrogen fluctuations in the inflow to the biological part)
- ✓ High share of rainwater and infiltration sewage periodically flowing into the treatment plant

The solution for such treatment plants is their modernization, which however, often exceeds the financial capacity of operators. Nevertheless, the use of simple and inexpensive technological changes, such as: construction of a sewage discharge point from septic tanks with a retention-mineralization reservoir, introduction of an additional carbon source to the sewage, control of internal and external recirculation, control of the amount of oxygen in the biological reactor, protection of the biological reactor against cooling down, can significantly improve the efficiency of the process.

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