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Short communication

Influence of the nitrification stage of biological treatment to the levels of nitrogen compounds in wastewater treatment

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Introduction

The growing urban population in the cities consequently leads to a steady increase in activities in industrial sector, especially in agriculture and farming, thus influence the increased sewage and wastewater generation, respectively. These activities, pose a threat to human health, generating excessive content of pollutants with different chemical compositions in wastewater. Among many pollutants, the ones with bonded nitrogen atoms in form of organic compounds, ammonia and nitrite/nitrate ions, interconvert in wastewaters causing an eutrophication of the aquatic eco-systems (Wang et al., 2010). Furthermore, reduction of nitrates into nitrites is associated with nitrosamines generation, which increase the prevalence of liver cancer, for example (Hosseini et al., 2011). The extent of the wastewater treatment is estimated based on the correlation of the inlet parameters of an influent (wastewater before treatment) and the outlet parameters of an effluent (treated wastewater). The extend of fluctuation in water flow, chemical composition and temperature, due to weather conditions annual variations, impacts the capacity for chemical and biological treatment of wastewater in the wastewater treatment plant. Designing mathematical models based on Linear Regression analyses using the correlated data sets of influent and effluent offer opportunity for prediction SWOT analyses for the efficiency of treatment of the nitrogen compounds (The Nitrates Directives 91/676/EEC) in the wastewater that obey to biological treatment (Morsy et al., 2020). The presented study reveals how the monitoring of the water quality of the surface watercourses across the municipality of Kumanovo impact the public health. This activity is carried out by the subsidiary unit of the National Public Health Institute in R. N. Macedonia, and contributes to setting up a correlation of the nitrogen pollutants and nitrification stage of wastewaters before and after the biological treatment in the regional wastewaters plant. This approach that complies to the Law on waters (2010) of the R. N. Macedonia, adds value to the mission for integrated water management (Framework Water Directive 2000/EC2).

Material and methods

Sanitary, hygiene inspection and collection of the water samples were carried out at the sites for influent (pre-treatment) and effluent (after treatment) points in the wastewater treatment plant in Kumanovo, during 2020-2022. Regarding to the main location of the industrial facilities in the municipality Kumanovo that are located along the bank of river Kumanovka, the wastewater from industry is dispatch to watercourse of this river, hence the locations for collection of the samples were: river Pchinja, before the river Kumanovka flows into it (M1), and after wastewater and sewage from river Kumanovka dispatch (M2), and the water supply walls and drinking tap water in villages Pchinja and Studena Bara, respectively. Health and environmental assessment of the water quality, safety of the tap drinking water, and risk management of the efficiency of treatment of the wastewaters (effluent/influent) was performed in accredited laboratory for quality of food and waters (No. LT-011/2009 issued by IARNM, EA MLA according to MKC EN ISO/IEC 17025:2018), which is subsidiary unit of the National Health Institute, by using validated analytical methods. Spectrophotometric assay was applied for determination

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of nitrates, nitrites and ammonia, while Winkler titrimetric methods are used for determining the Chemical Oxygen Demand (COD) and the Dissolved Oxygen (DO) as well for the Biochemical Oxygen Demand (BOD_5).

Result and discussion

Decreasing concentration of ammonia ion (NH_4^+) from 18.6 mg/L to 1.65 mg/L indicates its oxidation into a form of nitrite ion (NO_2^-), that consequently undergo additional oxidation to nitrate ion (NO_3^-). The first and second stage of oxidation of ammonia are catalyzed by two species of the autotrophic ammonia-oxidizing bacteria (first stage, *Nitrosomonas*, *Nitrosococcus*, *Nitrosospira*, *Nitrosolobus*, and *Nitrosorobrio* and for second stage, *Nitrobacter*, *Nitrococcus*, *Nitrospira*, and *Nitroeystis*). The outcome of these reactions is accumulation of nitrates, amount of 6271 µg/L in the samples of effluent (after treatment) comparing to 4899 µg/L nitrates in influent (pretreatment) samples. This two-stage process is known as nitrification, starts in the presence of dissolved oxygen, at the end of the process of carbonization, and its duration is proportionally depended by the temperature. Prior the biological treatment, the influent wastewater undergoes mechanical treatment that encompasses primarily precipitation of the sediment. Excessive BOD_5 of 0.84 mg/L in the influent up to 1.2 mg/L in the effluent is due to its consumption in soluble form by the aerobic bacteria which participate in the first stage of the biochemical decomposition of organic compounds which are transformed to carbon dioxide during the 20 days at 20 ^oC treatment. All samples of water sampled at M1 site reveal absence of ammonia, while nitrites were detected only in the samples taken in 2021, with the fluctuation of the nitrates content (227.6 µg/L, 458.8 µg/L and 323.2 µg/L in 2020, 2021 and 2022, respectively). This concentration range classifies these waters in class I-II. The samples taken from site M2, present annual average values for the presence of ammonia of 1320 µg/L, 1070 µg/L, and 70 µg/L for 2020, 2021 and 2022, respectively, as well the 54.7 µg/L and 24.3 µg/L nitrites in 2021 and 2022, respectively. This indicates that watercourse of river Pchinja, after dispatching wastewaters from the river Kumanovka, belong to II-IV class of waters. In addition, the water quality on site M2 is confirmed by the 466 µg/L, 1196 µg/L and 1491 µg/L annual average values for nitrates in 2020, 2021 and 2022, respectively.

Samples of drinking tap water taken from the schools in villages Pchinja shows that concentrations of nitrates, 82.3, 76.64 and 209.9 µg/L, do not exceed the maximum allowed concentration of 50000 µg/L in 2020, 2021, and 2022, respectively. In addition, the samples of drinking tap water from the water supplying site in the school in the village Studena Bara, follows the same trend of increased nitrate concentration from 83.3 µg/L in 2020 to 111.2 µg/L in 2021. In terms of microbiology quality, water samples both from the villages Pcinja and Studena Bara, show the presence of coliform bacteria and *E. coli.*

Conclusion

It is evident that the quality of effluent waters is impaired by present pollutants that increases the nitrogen compounds concentrations during the utilization of this watercourse for water supply. Analyzed samples of effluent confirm that wastewater after biological treatment meets the regulatory requirements included into the Categorization Decree for surface watercourses, according to which wastewater of the river Kumanovka belong to class III, while entire watercourse of the river Pchinja after the biological treatment within the second - nitrification stage, meet the criteria for class II.

The comprehensively environmental impact on the water quality to the health and welfare would be feasible by application of technologies for continuous monitoring of water quality.

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