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AUTOTROPHIC NITRIFICATION OF MUNICIPAL WASTEWATER

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Abstract: Municipal wastewater contain significant amounts of organic and inorganic nitrogen and phosphorus compounds. Nutrients such as nitrogen and phosphorus, if they are present in increased concentrations in aquatic ecosystem, they stimulate the growth of algae and other photosynthetic organisms, which affects the acceleration of the process of eutrophication. In order to prevent the negative impact of nitrogen present in the used water to aquatic ecosystems, water is required prior to discharge purified to a suitable degree.

The subject of this paper was biological treatment of municipal wastewater and removal of substances with nitrogen with autotrophic nitrification. The paper describes the biological treatment of municipal wastewater. In experiment was used activated sludge from wastewater treatment plant. In the autotrophic nitrification, where autotrophic bacteria use inorganic carbon source, initial concentration of the NH_4-N from 29.06 mg/l NH_4-N decreased on value of 6.73 mg/l. Oxidation of ammonia (ammonia converted into NO_3-N and NO_2-N) is followed by decomposition of organic matter (COD). Influent COD concentration was 745 mg/l, while the effluent COD, after biological processes,was 65.25 mg/l, which is highly favorable for environmental protection.

Keywords: *municipal wastewater, autotrophic nitrification, denitrification, biological treatment.*

INTRODUCTION

Used wastewater with organic and inorganic substances or contaminants, is discharged into streams, lakes or the sea. Pollution threaten the biological balance of aquatic ecosystems, and depending on the amount and type of contamination can jeopardize their survival. What characterizes the largest number of inhabited places in the Federation of Bosnia and Herzegovina is the lack of a unified system for collecting (and treatment) of wastewater, and the fact that the sewage and storm water are usually colected by combined sewage systems and in the shortest possible route discharge to the closest recipient.

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Municipal wastewater is wastewater from households or mixture of domestic wastewater with industrial wastewater and/or rain water (Direktiva o odvodnji i pročišćavanju komunalnih otpadnih voda, 1991.). Composition of waste in the household water depends on several causes, especially on lifestyle, climate, construction of water supply system and the available quantities of water. Fresh domestic sewage are gray-brown in color, with a characteristic odor. The temperature of the wastewater is increased in relation to the water, because of heating in kitchens, bathrooms, laundries, etc. (Europska agencija za okoliš, 1998). Flow in the sewer network, after biodegradation progresses, the color of water turns dark and distinctive odor of rotten eggs, because of the content of hydrogen sulphide. Utilities used water containing significant amounts of organic and inorganic nitrogen and phosphorus compounds. The main sources of nitrogen and phosphorus compounds are agricultural land and discharge of untreated or insufficiently purified water use. In order to prevent the negative impact of nitrogen present in water used in aquatic ecosystems, water is required prior to discharge purified to the appropriate level.

Biological processes purification of water are the basic procedures for the treatment of municipal water. Secondary or biological treatment includes biological processes in which microorganisms remove dissolved organic material and inorganic compounds, which particulates remaining after primary treatment. The most widely used process for purification of communal water is aerobic method with suspensions microflora-activated sludge. It is conducted in the aeration bioreactor where aerobic microorganisms with their biochemical activity oxidize the organic matter present in the wastewater[2]. Activated sludge consists of a bacteria, protozoa, algae, yeast and metazoans associated with suspended particles in clusters called flakes or floes .

Method for removing organic compounds from wastewater using biodegradability follow three successive reactions: oxidation, synthesis of the microbial biomass and the endogenous respiration[3]. The process of treatment with activated sludge processes today are made of nitrification, biological nitrogen removal and biological phosphorus removal. Biological nitrogen removal from wastewater is achieved using the process of aerobic ammonia oxidation or aerobic autotrophic nitrification and anoxic (optional-anaerobic) denitrification. The ammonia oxidizing bacteria (AOB), like *Nitrosomonas*, *Nitrosospira* and *Nitrosococcus*, translations ammonia to nitrite. Nitrite oxidizing bacteria (NOB), such as *Nitrobacter*, *Nitrosospira*, *Nitrococcus* and *Nitrospina* converted nitrite to nitrate (Henze et al., 2002).

The subject of this paper was biological treatment of municipal wastewater and removal of substances with nitrogen with autotrophic nitrification. In experiment was used activated sludge from wastewater treatment plant, in which was with the technique of accumulation of nitrificants and denitrificants prepared mixed microbial cultures which showed the ability of nitrification.

[2] Čurli, 2008

[3] Chughtai and Krushid, 1991, Nicholas, 1996

MATERIAL AND METHOD

In this work was used municipal wastewater, which is significantly burdened organically. In experiments was used native culture of microorganisms from municipal wastewater, which is enriched with microbial cultures of nitrificants and denitrificants, which were prepared in the laboratory of Biotechnical Faculty of Bihać. Native culture with the addition of nitrificants was shown the ability of biodegradation of municipal wastewater. The activity of the microbial culture for the removal of constituents with nitrogen was determined by measuring the concentration of ammoniacal nitrogen, nitrite, nitrate, pH, dissolved oxygen and the concentration of the microbial biomass. The nitrification process was carried out under aerobic conditions.

Characteristics of wastewater are mainly organic pollution, whose impact on the wastewater quality it follow through specific parameters such as suspended matters, COD, BOD, the concentration of ammonium ions and salts, nitrates and nitrites. Determination of physical and chemical parameters of the quality of the sample of wastewater was done according to standard methods (APHA, 2000) and the Regulation on conditions for discharging wastewater into natural recipient[4].

RESULTS

The paper presents the results of measurements during biological treatment of municipal wastewater. In Table 1 are given physical and chemical parameters that determine the quality of the wastewater to the Regulation on conditions for discharging wastewater into natural recipients and public sewer systems (*Sl. novine FBiH*, broj *04/12*).

Table 1. Results of wastewater analysis

Parameter	**Results of the analysis of wastewater prior to treatment (influent**	**Results of the analysis of wastewater after treatment (effluent)**	**ELV[5] of wastewater discharged into surface water bodies**	**ELV of wastewater discharged into the public sewer system**
Color	Gray	Light gray		
Flavor	Strong odor	Lower intensity		
Temperature (°C)	19.3	21.4	30	40
pH	8.2	7.9	6.5 – 9.0	6.5 – 9.5
Conductivity (µS)	876	876		

[4] *Sl. novine FBiH* broj *04/12*

[5] ELV - The emission limit value means the mass specific parameters, concentration and/or level of emissions that can not be exceeded during one or more periods of time.

Turbidity (NTU)	497	497		
Oxygen saturation (%)	16.9	11.2		
Dissolved oxygen (mg/L)	7.5	5.1		
Evaporated residue (mg/L)	1964	1964		
Suspended solids (mg/L)	391	391	35.0	400
Annealed rest (mg/L)	1636	1636		
p- alkalinity (mg/L)	0	0		
m – alkalinity (mg/L)	125	125		
Consumption of $KMnO_4$ (mg/L)	42.98	42.98		
Nitrites (mg/L)	0.14	0.16		
Nitrates i (mg/L)	0.7	14.8	10	50
Ammonia (mg/L)	29,06	6,73	10	40
COD (mgO_2/L)	745	65,25	125	700
BOD (mgO_2/L)	405	40,5	25	250
Phosphates (mg/L)	4.60	4.60	2.0	5.0

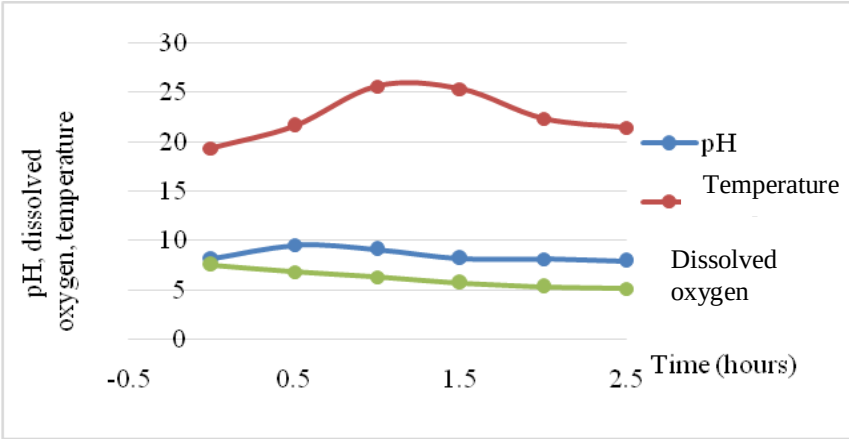

Figure 1. Changes in pH value, dissolved oxygen and temperature during the biodegradation of municipal wastewater

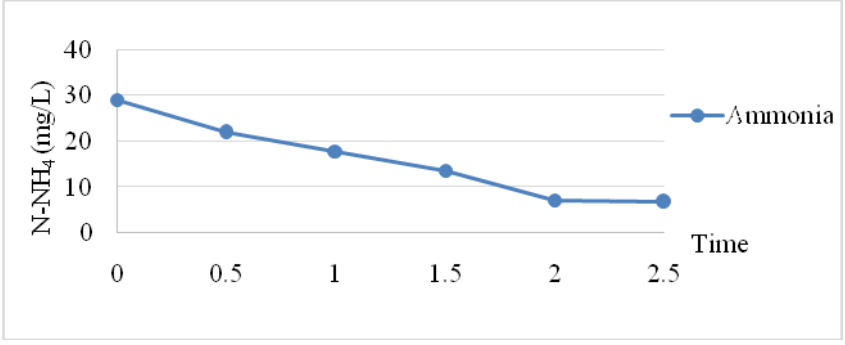

Figure 2. Changes in the concentration of ammonia during biodegradation of municipal wastewater

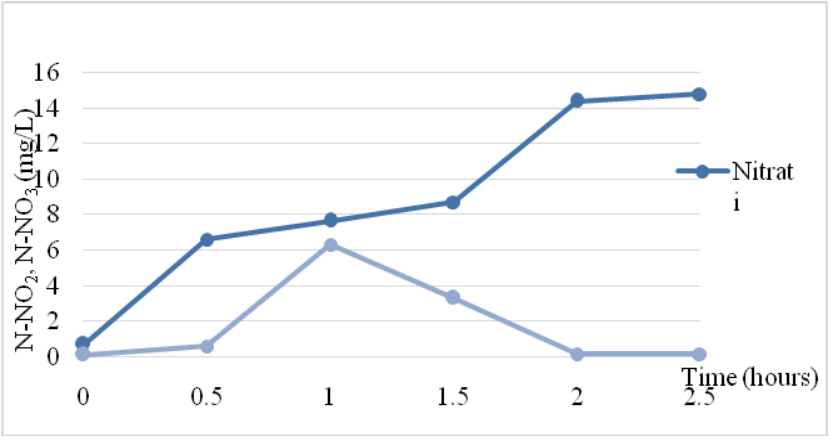

Figure 3. Changes in concentrations of nitrite and nitrate during the biodegradation of municipal wastewater

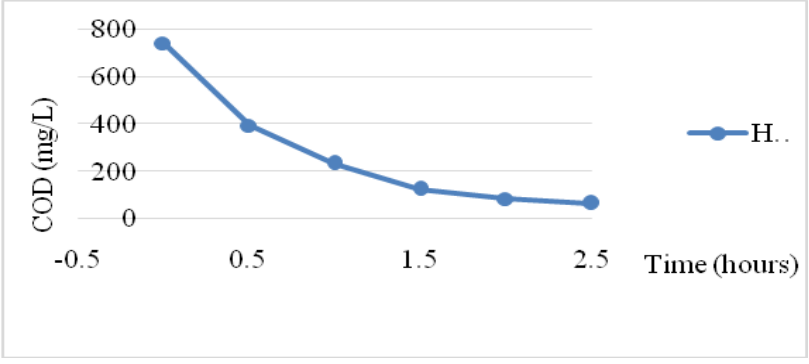

Figure 4. Changing the concentration of COD values during biodegradation of municipal wastewater

DISCUSSION

The paper describes the biological treatment of municipal wastewater by activated sludge. In experiments was used activated sludge from wastewater treatment plant. The implementation process of autotrophic nitrification, where autotrophic bacteria use inorganic carbon source, initial concentration of the NH_4-N from 29.06 mg/l NH_4-N decreased on value of 6.73 mg/l. During the two and a half hours the speed of oxidation of ammonia was 10.96 mg/l,h. Removing ammonia reduces the organic matter content expressed via COD. The influent COD concentration was 745 mg/l, while the effluent COD was 65.25 mg/l, which is very favorable from the viewpoint of environmental protection. The rate of decomposition of organic substances, expressed as COD value was 271.9 mg/l,h. Oxidation of ammonia is followed by accumulation of nitrites and nitrates. The highest concentration of nitrite was

measured in the first hour of the experiment and the amount of 6 mg/L. After that nitrite is oxidate to nitrate. After two and a half hours of the experiment the nitrate concentration was 14.8 mg/l. The process of autotrophic nitrification leads to a decrease in pH, due to reduced buffering capacity, but also to reduce the concentration of dissolved oxygen.

CONCLUSION

Based on the results obtained after treatment of municipal wastewater, biological purification process, here are the following conclusions:

- The implementation process of autotrophic nitrification, in which autotrophic bacteria use inorganic carbon source, decreased the initial concentration of N-NH_4 from 29.06 mg/l to 6.73 mg/l, as shown in Table 1.
- In terms of autotrophic nitrification, with initial concentration of the NH_4-N 29,06 mg/l, the oxidation rate of ammonia was 10.96 mg/l,h of the removed N-NH_4. During the nitrification process ammoniacal nitrogen can be carried out in nitrite, which is less harmful form of nitrogen for wildlife watercourses.
- Removing ammonia reduces the organic matter content expressed via COD. The influent COD concentration was 745 mg/l, while the effluent COD was 65.25 mg/l, which is very favorable from the viewpoint of environmental protection.
- Research has shown that the control of nitrogen in the wastewater can be achieved in the most efficient processes with unified nitrification and denitrification (Šćiban et al., 2013).

AUTOTROFNA NITRIFIKACIJA KOMUNALNIH OTPADNIH VODA

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Apstrakt: Komunalne otpadne vode sadrže značajne količine organskih i neorganskih dušikovih i fosfornih jedinjenja. Nutrijenti kao što su dušik i fosfor, ako su prisutni u povećanim koncentracijama u akvatičnim ekosistemima stimulišu rast algi i drugih fotosintetskih organizama, što utiče na ubrzanje procesa eutrofikacije. Kako bi se spriječio negativan uticaj dušika prisutnog u upotrebljenim vodama na akvatične ekosisteme vodu je prije ispuštanja potrebno prečistiti do odgovarajućeg stepena.

Predmet ovog rada je biološka obrada komunalnih otpadnih voda, odnosno uklanjanje tvari sa dušikom metodom autotrofne nitrifikacije. U radu je prikazana biološka obrada komunalne otpadne vode. U pokusima je korišten aktivni mulj sa uređaja za prečišćavanje otpadnih voda. Provedbom postupka autotrofne nitrifikacije, gdje autotrofne bakterije koriste anorganski izvor ugljika, smanjena je početna koncentracija NH_4-N 29,06 mg/l na vrijednost NH_4-N 6,73 mg/l. Brzina oksidacije amonijaka iznosila je 10,96 mg/l/h uklonjenog NH_4-N. Uklanjanjem amonijaka smanjuje se i sadržaj organske materije izražen preko HPK. Kod influenta koncentracija HPK je iznosila 745 mg/l, dok je kod efluenta HPK 65,25 mg/l, što je vrlo povoljno sa stanovišta zaštite životne sredine.

Ključne riječi: *komunalna otpadna voda, autotrofna nitrifikacija, denitrifikacija, biološka obrada*

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