BIOLOGICAL REMOVAL OF AMMONIUM FROM DRINKING WATER

A CASE STUDY

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ABSTRACT

The municipality of Targu Carbunesti constructed in the year 2015/16 a new biofiltration plant for biological nitrification of drinking water with hydraulic flow of 3.300 m³/d. Since start up in 2016 the plant works with high efficiency for full nitrification with inlet concentrations up to 10 mg/l NH_4 and outlet concentrations below 0,1 mg/l NH_4 without adding of chemicals. Beside Ammonium removal the biofiltration eliminates also iron, manganese and turbidity with about 50% of efficiency. The operation costs are low and no continuous staffs are required for plant operation.

This article presents the innovative technology of biological upflow filtration as adapted solution for economic ammonium removal from drinking water and demonstrates practical results of existing plant.

Keywords: drinking water treatment, nitrification, biofiltration

• INTRODUCTION

In the city of Targu Carbunesti (Romania, Gorj county) in 2011 the only water sources were seven deep hydro geological wells. This water from wells did exceed the concentration limits settled in the European Drinking Water Directive [1] for ammonium (0,5 mg/l) and manganese (50 µg/l) and therefore it was necessary to upgrade the existing drinking water plant with an ammonium removal step. The ammonium concentrations of untreated water were observed during several years depending on the well in the range of 6-10 mg/l NH_4.

Ammonium is an indicator parameter of recent organic pollution. Its sudden increase at a certain moment, as in the present case, indicates the intervention of a pollution that can be of both natural and artificial origin. An ammonium concentration in drinking water above 0.5 mg / l NH_4 can cause changes in taste and smell of the water [2]. Ammonium does not directly harm the human body in typical pH values (6.5 to 9.5) applied in drinking water treatment. However, it may form nitrite ions under oxidative conditions. Nitrite in drinking water is a toxic component, because it disables the enzyme lactase in the blood cells, causing serious health problems [3].

Beside the possible nitrite formation, the other issue related to the presence of ammonium in drinking water is the decrease of the chlorination disinfection efficiency. The ammonium reacts with chlorine forming chloramines, and thus reducing the amount of the disinfectant available for microorganism inactivation. The less efficient disinfection may cause secondary water pollution in the distribution system. Moreover, the resulting chloramines cause the unpleasant smell, which may lead to customer complaints.

The former existing treatment plant of Targu Carbunesti, built in 1975, included an aeration line and a sand filtration line which were not able to reduce the ammonium to the parameters imposed by European standards.

Breakpoint chlorination as possible solution for ammonium removal has been rejected because of high operation costs [4]. As economic solution a biological ammonium removal technology by biological upflow filtration has been constructed in the years 2015/2016.

• TECHNOLOGY OF BIOLOGICAL FILTRATION

The biological filtration process presents a biological filter with co-current upflow of air and water, evenly distributed in a filter body. It combines biological treatment and retention of suspended solids in one and the same unit. The biological filter is loaded with natural filter material (burnt clay granules) which has a long lifetime and high specific surface of about 1.000 m^2/m^3. The filter material in contact with water and air serves as settlement area for nitrification bacteria (nitrosomonas/nitrobacter) that perform the treatment process of nitrification.

In order to remove the retained suspended solids as well as the grown biomass the biofilter are backwashed by determined backwash program with air and water once a day or every two days depending on actual load. Due to the porosity of the support media (burned clay) a basic bacteria mass stays always on the material and is not eliminated by backwash. Like this the biological activity (nitrification capacity) of the biofilter does not lower because of backwash.

The biological aerated upflow filter has a high volumetric nitrification efficiency depending on water temperature up to about 1 kg $NH_4/(m^3.d)$ [5]. The technology is a modern method for water treatment, a fully automated process with small reactor volumes requiring little space and low operational and maintenance efforts. Dimensioning of filters are done according to German ATV design guidelines.

Biological nitrification of drinking water does not require the input of chemicals to the waters, except low quantity of phosphorus for biological growth.

• DRINKING WATER PLANT TARGU CARBUNESTI

The extension of drinking water plant Targu Carbunesti with biofiltration has been designed for a hydraulic inflow of 3.300 m^3/d with an ammonium concentration of 10 mg/l NH_4 representing an ammonium load of 33 kg/d NH_4. The temperature of inlet waters is about 15°C.

The raw waters from the wells are conducted to a first raw water reception tank. This tank with volume of 60 m^3 serves for mixing and homogenization of the waters. From the raw water tank 2 parallel biological filters with diameter 3,40 m and total high of 6 m are feed (see figure 1). The treated waters from outlet of biofilter are partially recycled back to reception tank in order to homogenize the waters and to allow stable conditions in biofilter for adapted growth of bacteria.

After biofiltration the waters are given by hydraulic flow towards the existing sand filtration and chlorination step.

Figure 1: Biofiltration plant Targu Carbunesti with 2 biofilter during construction

- RESULTS

The biological filtration in Targu Carbunesti is in operation since 2016. The results of the plant during 3 months of operation in year 2017 are shown in table 1 as mean values. The ammonium concentration at inlet varied between about 2 and 4,5 mg/L NH_4 with a mean concentration of 3,6 mg/l NH_4.

Despite important variations of ammonium concentration in untreated water at inlet in the range between 3 and 4,5 mg/l NH_4, the observed outlet concentration was stable below 0,1 mg/l NH_4 (see figure 2).

Beside full nitrification the biofilter eliminates also about 50% of turbidity, manganese and iron by oxidation and filtration. The elimination of manganese and iron in the biofilter releases the downstream sand filtration. The hardness and the pH value of water stay in the same range than the untreated waters (see table 1 and figure 3).

Figure 4 shows the volumetric nitrification rate BR in kg NH4/[m^3.d] of filter media. During the test period a maximum ammonium volumetric load of Br = 0,35 kg NH_4 /(m^3.d) could be observed. The results show that the maximum ammonium volumetric load is not achieved (see figure 4).

Table 1: Results of biofiltration plant Targu Carbunesti as mean value (April – June 2017)

	unit	in	out
Turbidity	**NTU**	5,3	2,2
NH4	**[mg/l]**	3,6	0,1
NO3	**[mg/l]**	8,4	18
Iron	**[µg/l]**	57,9	20,5
Manganese	**[µg/l]**	51,7	32
pH	**pH**	7,5	7,6
Hardness	**°dH**	17,8	17

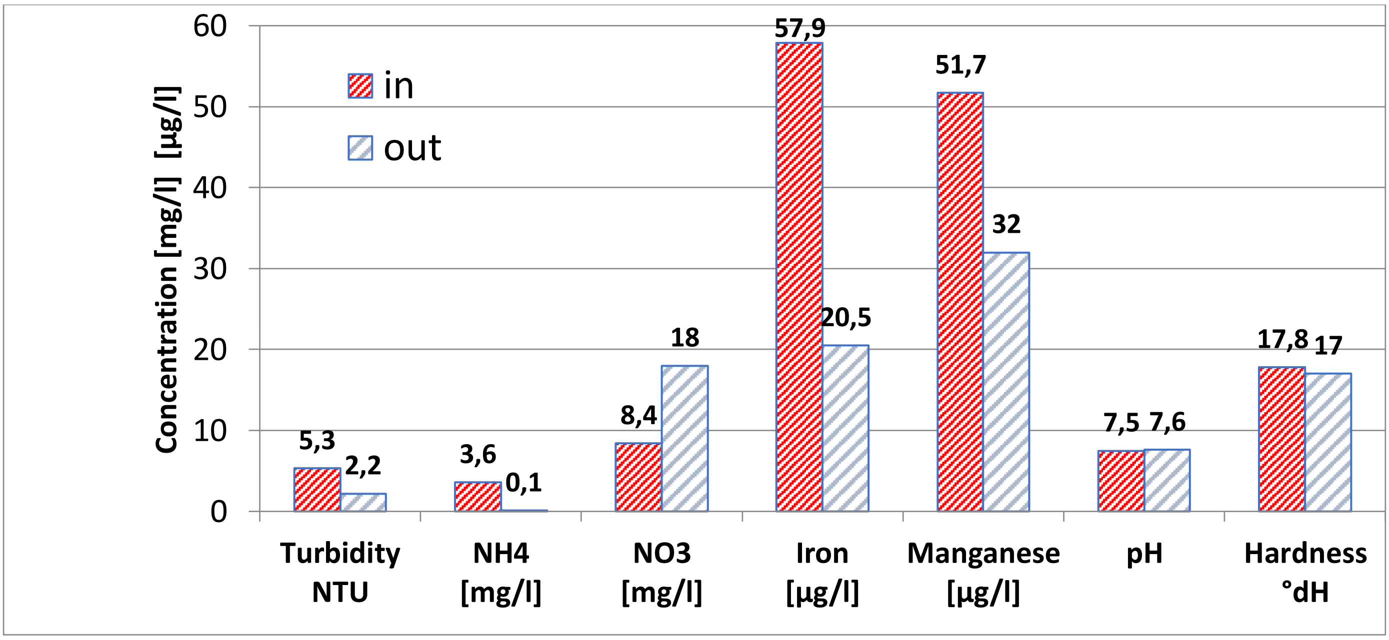

Figure 2: Variation of inlet and outlet concentrations in Targu Carbunesti in the period march to June 2017

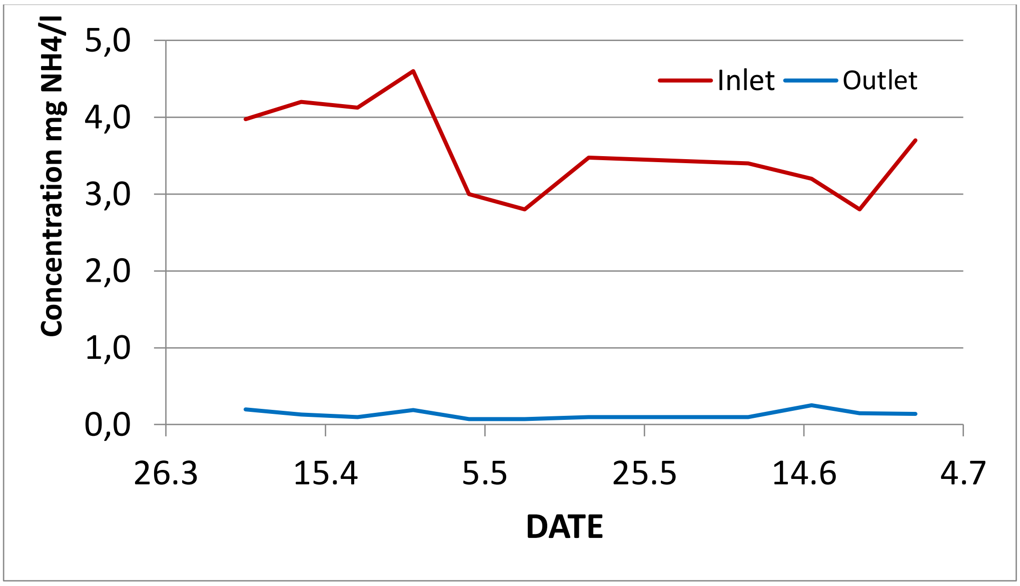

Figure 3: Results of biofiltration plant Targu Carbunesti as mean values (April – June 2017)

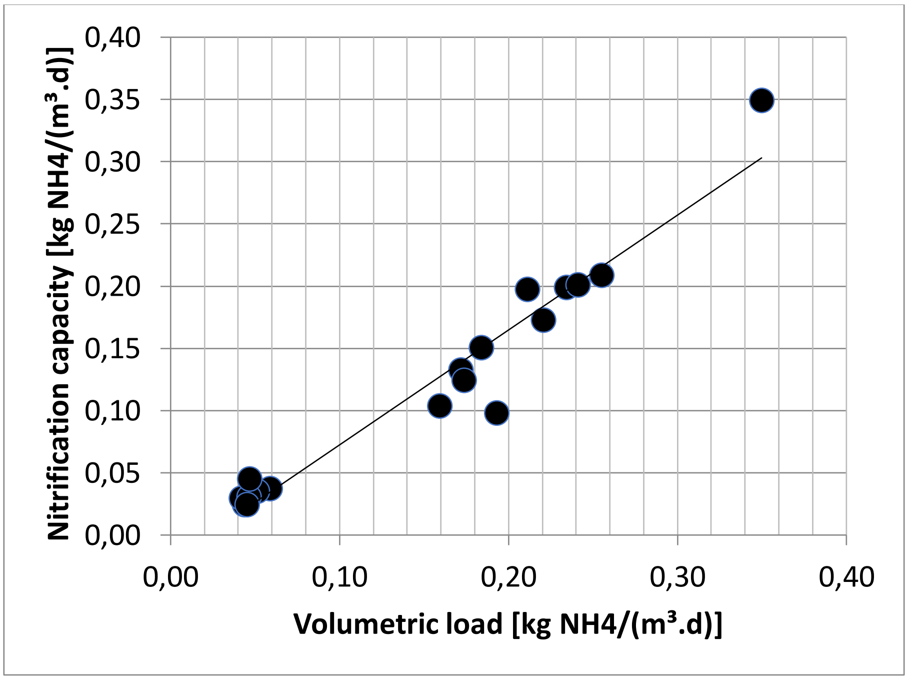

Figure 4: Volumetric ammonium load and nitrification capacity of biofiltration plant Targu Carbunesti

- CONCLUSION

The city of Targu Carbunesti uses 7 wells to supply water to his residents. The raw water from the wells contains ammonium concentrations up to 10 mg NH4/l. In order to achieve the necessary low ammonium concentration according to EU standards of < 0,5 mg/l a treatment step was necessary. Biological filtration has been chosen as economic and reliable solution.

The biological treatment with biofiltration decrease the ammonia concentration to below 0,1 mg/l NH_4 even at important variations of ammonium in untreated waters. In the same time the water turbidity as well as the iron and manganese concentration are eliminated at about 50%. This elimination releases the downstream sand filtration. The biofiltration plant does not require permanent staff. The operational costs are low. No chemicals - except low quantity of phosphorus- are required.

Literature

[1] Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption

[2] Guidelines for drinking water quality, 2nd edition: Addendum - Microbiological agents in drinking-water, World Health Organization, 2002, ISBN: 9241545356

[3] Daniel KIM-SHAPIRO, D. (2005): "The Reaction between Nitrite and Hemoglobin: The Role of Nitrite in Hemoglobin-mediated Hypoxic Vasodilation", Journal of Inorganic Biochemistry

[4] SZABOLCS T. (2012): “Ammonium removal from drinking water - comparison of the breakpoint chlorination and the biological technology”; BME Department of Sanitary and Environmental Engineering

[5] RÜDIGER A. (1999): “Experiences with biofiltration in waste water treatment”, Fourth BNAWQ Scientific and Practical Conference, Water Quality Technologies and Management in Bulgaria, 17.-19. Feb. 1999, Sofia, Bulgaria, Conference Preprints

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