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Primary Factor affecting the Rate of Nitrification during Treatment of Wastewater in Skenderaj

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Abstract: Water use by the company for all sorts of systems such as those industrial, domestic, of agricultural and rain waters, characterized by changes in physical composition, chemical and biological where wastewater formed. Such water must be collected and appropriately cleaned and returned back to nature without harming the environment. Wastewater treatment using biological methods trickling filters is a very important field of research in the environment because of its advantages and applicability. This wastewater treatment based biochemical conversion made or destruction of organic matter on which microorganisms act, whether the soluble pollutants are resistant to microbial action, then they are destroyed by biochemical units. Through this study we monitor and analyze physical parameters comprising the wastewater in order to increase the rate of removal of nitrogen in the first plant for wastewater treatment in the Republic of Kosovo, this plant works with system by trickling filters. The main purpose of the operation of treatment systems with trickling filters is to remove ammonia and nitrates from water systems.

Key words: Wastewater treatment, trickling filters, wastewater characteristics, Nitrogen removal, physical parameters.

1. Introduction

Selecting the plant for waste water treatment in Skenderaj be biological trickling filters system is made because these processes are the most feasible and cost effective for the removal or reduction of organic and inorganic compounds of industrial waste water, as is shown in Figure 1. However, the use of these methods may be limited by the presence of toxic organic compounds.

The goal of all biological wastewater treatment systems is to remove the non-settling solids and the dissolved organic load from the effluents by using microbial populations. Biological treatments are generally part of secondary treatment systems. The microorganisms used are responsible for the degradation of the organic matter and the stabilization of organic wastes. With regard to the way in which they utilize oxygen, they can be classified into aerobic (requires oxygen for their metabolism), anaerobic (grow in absence of oxygen) and facultative (can proliferate either in absence or presence of oxygen although using different metabolic processes). Most of the micro-organisms present in wastewater treatment systems use the organic content of the wastewater as an energy source to grow, and are thus classified as heterotrophes from a nutritional point of view. The population active in a biological wastewater treatment is mixed, complex and interrelated. In a well-functioning system, protozoas and rotifers are usually present and are useful in consuming dispersed

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bacteria or non-settling particles. More extensive description and treatment of the microbiology of wastewater treatment systems are given elsewhere [1].

In fresh water systems there are two common methods used to remove ammonia: ion exchange and biological filters. In brackish or salt water systems ion exchange is not a viable alternative because salt in the culture water quickly (usually in a matter of minutes) saturates all of the adsorption sites on the ion exchange media. Thus, biological filters are the only widely used method of removing ammonia and nitrite from all types of aquacultural systems.

Fig. 1 View from the water treatment plant waste in Skenderaj.

There are four main sources of waste nitrogen, urea, uric acid, and amino acid excreted by fish, organic waste from the bodies of dead and dying, uneaten food and feces, and nitrogen gas from the atmosphere. Trickling Filters handling systems consist of several solid media that serves as a surface on which bacteria can attach and live. Water containing ammonia and or course nitirite on this plastic filter media (and bacteria attached). The bacteria remove ammonia from wastewater and use it as a source of energy to run their life processes. These bacteria derive nitrates, require oxygen and produce carbon dioxide as other derivative for their breathing. A diverse group of bacteria left nitratete and they turn into nitrate. These bacteria convert nitrate used in nitrate to a power source, they use nitrates and oxygen, and produce nitrate and carbon dioxide. Ammonia conversion to nitrate produces hydrogen and uses up alkalinity. Although many species of bacteria may participate in these shëndrrime usually assumed that ammonium nitrate conversion is performed mainly by nitrosomona sp. and converting nitrite to nitrate by nitrobacter sp. [2].

2. Methodology and Materials

Systems of treatment with trickling filters can be an effective tool for the control of ammonia; compared with water flushing to control ammonia levels. In the treatment plant wastewater in Skenderaj there are two groups that perform nitrification. These are generally categorized as autotrophic chemosynthetic bacteria because they derive their energy from inorganic compounds compared with heterotrophic bacteria deriving energy from organic compounds. Ammonia oxidizing bacteria take their energy from catabolizing un-ionized ammonia nitrate and include bacteria of the genera Nitrosomonas, Nitrosococcus, Nitrosospira, Nitrosolobus, and Nitrosovibrio. Nitrate oxidizing bacteria oxidize nitrite to nitrate, and include bacteria of the general Nitrobacter, Nitrococcus, Nitrospira, and Nitrospina. Nitrifying bacteria are mostly obligate autotrophs, which consume carbon dioxide as the main source of carbon, and to obligate aerobes that require oxygen to grow. Treatment systems with trickling filters, nitrifying bacteria usually coexist with heterotrophic microorganisms such as heterotrophic bacteria, protozoa, and micrometazoa that metabolize organic compounds biologically degradable. Heterotrophic bacteria grow significantly faster than nitrifying bacteria and nitrifying bacteria prevail over competition for space and oxygen in biofilters, when concentrations of dissolved and particulate organic matter are high. For this reason, it is imperative that the water source for biofilters to be as clean as possible with minimum concentration of total solids.

In a real world system, the individual unit processes are usually linked together as the water flows through each process (circulation). Usually 5%-10% of the discharge from the culture tank is removed from the center drain and because of a "tea cup" effect has a high solids loading. Some form of settable solids removal device (swirl separator, settling basin, etc) pretreats this flow stream, which is then combined with the remaining 90%-95% of the discharge from a side outlet. The remaining suspended solids are then removed usually by a rotating microscreen filter. The water then flows to some form of biofiltration, such as a trickling tower, bead filter, fluidized sand filter, moving-bed bioreactor etc, where the ammonia is converted to nitrate by bacteria. At high loading densities, a carbon dioxide stripping column is then used to remove excess CO_2 and aerate the water to saturation. Finally an oxygenation device is employed to supersaturate the flow to provide sufficient oxygen for the high levels of stocking used in commercial systems. In some cases, a UV or Ozone system is added to disinfect the returning water stream as part of a biosecurity program.

Ammonia is produced as the major end product of the metabolism of protein catabolism and is excreted by fish as unionized ammonia across their gills. Ammonia, nitrite, and nitrate are all highly soluble in water. Ammonia exists in two forms: un-ionized NH_3, and ionized NH_4^+. The relative concentration of each of these forms of ammonia in the water column is primarily a function of pH, temperature and salinity. The sum of the two (NH_4^+ + NH_3) is called total ammonia or simply ammonia. It is common in chemistry to express inorganic nitrogen compounds in terms of the nitrogen they contain, i.e., $NH_4^+ - N$ (ionized ammonia nitrogen), $NH_3 - N$ (un-ionized ammonia nitrogen), $NO_2 - N$ (nitrite nitrogen) and $NO_3 - N$ (nitrate nitrogen). This allows for easier computation of total ammonia-nitrogen (TAN = $NH_4^+ - N + NH_3 - N$) and easy conversion between the various stages of nitrification.

Nitrification is a process that occurring in the two-step, first ammonium nitrate oxidized in nitrat and then oxidized to nitrate. Two steps in the reaction are normally carried out sequentially. Since the first step has a higher rate of reaction kinetics that second step, the overall kinetics usually controlled by oxidation of ammonia and as a result there is no significant amount of nitrate accumulation. Equations 1 and 2 show the basic chemical conversions that occur during oxidation of Nitrosomonas and Nitrobacter.

Nitrosomonas:

$$NH_4^+ + 1.5\ O_2 \rightarrow NO_2^- + 2\ H^+ + H_2O + 84\ \text{kcal/mole ammonia} \quad (1)$$

Nitrobacter:

$$NO_2^- + 0.5\ O_2 \rightarrow NO_3^- + 17.8\ \text{kcal/mole nitrite} \quad (2)$$

Overall:

$$NH_4^+ + 2\ O_2 \rightarrow NO3^- + 2\ H^+ + H_2O + \text{energy} \quad (3)$$

Using the stoichiometric relationship for each g ammonia-nitrogen converted to nitrate-nitrogen, 4.18g dissolved oxygen, alkalinity and 7.05g (1.69g inorganic carbon) is consumed and microbial biomass 0.20g (0.105g organic carbon) and 5.85g of CO_2, (1.59g inorganic carbon) is produced. It should be noted that both the consumption of oxygen and alkalinity is less than what is normally reported, 4.57g and 7.14g O_2 alkalinity for each g ammonia-nitrogen converted because in this equation some of ammonia-nitrogen is converted in biomass. Traditionally, this biomass has not been involved in stoichiometric relationship because it is small compared with other factors. Alkalinity should be kept at 50 to 100 mg/L $CaCO_3$ via the addition of chemicals containing the hydroxide, carbonate or bicarbonate ions. Sodium bicarbonate (baking soda) is commonly used because it is relatively safe, easy to get and dissolves quickly and completely in water [3].

The ability of biological nitrification to adequately control ammonia and nitrite in recirculating aquacultural systems depends on a variety of factors that limit nitrifier growth. Studies on the kinetics of nitrification show how effective nitrifiers are under ideal experimental conditions, i.e., oxygen and alkalinity are sufficient and ammonia is the only limiting factor. However, under normal operating conditions, there are a variety of factors that individually or in combination with each other, will reduce the efficiency of biofilter operation. One important consideration about biofilter performance is acclimation.

Nitrogen plays an important role in the structure and make-up of all living organisms. In the aquacultural environment, nitrogen exists in the inorganic forms of nitrate, nitrite, ammonia, and nitrogen gas and in many forms of organic nitrogen. The nitrogen cycle in recirculating system aquaculture can be described pictorially by Figure 1. Nitrogen originates from the atmosphere primarily in the form of nitrogen gas. Animals excrete nitrogen in the form of ammonia, aminoacids, urea, and uricacid. Plants excrete nitrogen in the form of aminoacids and proteins. Also, nitrogen is released through decomposition of dead animals and plants, uneaten feed, and bacterial cells and wastes.

Ammonia, nitrite, and nitrate are all highly soluble in water. Ionized ammonia, NH_4, exists at equilibrium with un-ionized ammonia, NH_3, in water. The relative concentration of ionized and un-ionized ammonia depends primarily on temperature and pH the higher the temperature and pH, the higher the concentration of un-ionized ammonia. Unless otherwise noted in the text, ammonia will refer to total ammonia, which is the sum of ionized and un-ionized ammonia (often referred to as total ammonia nitrogen or TAN). Nitrite exists at equilibrium with nitrous acid in water, with the relative concentration again depending on pH and temperature. Nitrite, when mentioned in the text, will refer to the sum of nitrite and nitrous acid. Nitrate is the conjugate base of nitric acid, a strong acid. Since strong acids usually dissociate completely in water, nitrate exists in its conjugate base form only.

As well seen scored above analysis Nitrogen contaminated water is found as nitrite, nitrate and ammonia. Their concentrations vary depending on the prevailing conditions (i.e., low oxygen or high). Total Nitrogen (TN) also affects the pH and oxygen concentration of water. This test must be measured using AQUANALTM-professional Spectro-1000 or AQUANALTM-spectral photometer 3.

The method of determining the nitrogen-General in wastewater is done by filling the first 5 ml sample in a container empty, add a spoonful of solvents, reagents (persulfate), close the container with a tap and then mixed well, this mixture digested in the thermos-reactor for 60 minutes at a temperature of 100 °C, after 60 minutes, remove the vessel from left thermo-reactor and cool to room temperature.

The following sections will discuss in the major factors affecting the rate of nitrification, which include: pH, temperature and oxygen.

The interactions of pH, nitrification, and water quality can be quite complex. Ingeneral, nitrification is most efficient at pH levels ranging from about 7.5 to 9.0. At the higher pH ranges (8.5-9.0), nitrification rates are fastest given sufficient ammonia. However, at the low ammonia concentrations usually found in aquacultural systems, operating at a pH of about 7.0 can be efficient. Because pH also effects the relative concentration of ionized and un-ionized ammonia in water and nitrifying bacteria use the ionized form, operating at a pH of about 7.0 usually increases the efficiency of the recirculating aquacultural system. Another positive effect of operating at the lower pH is that the toxicity of ammonia to fish increases with increasing pH, so operating in the lower range also reduces ammonia toxicity.

Temperature directly affects growth and nitrification rates of nitrifying bacteria. Jones and Morita isolated anammonia oxidizing bacteria capable of nitrification and grow that temperatures of -5^{o}C. Optimal growth occurred at 22^{o}C for cells grown at 5^{o}C and lethal temperatures were about 29^{o}C. Cells grown at 25^{o}C had optimal growth temperatures of 30^{o}C and lethal temperatures of 38^{o}C [4]. Basically, research on temperature and its effects on nitrification show that nitrification occurs and can be acclimated to conditions that are also favorable to aquatic species. Nitrification rates are slower at lower temperatures and increase linearly through the range of temperatures found in most aquacultural applications [5].

Dissolved oxygen is critical for nitrification to occur. As dissolved oxygen levels decrease to1.0mg/Linbiological trickling filters, dissolved oxygen rather than ammonia becomes the growth limiting factor. To prevent dissolved oxygen from becoming a limiting factor, water entering a biofilter should have minimum oxygen levels of 2.0 mg/L [6]. Biofilter designs using trickling benefit from natural oxygenation occurring as air flows past media covered with biofilms.

3. Results

In this chapter we will present the analysis of the results for the last six months of 2014 of main factors affecting the rate of nitrification. The purpose of this paper is the determination of these parameters in order to achieve optimization of biological process of treatment of urban waste water and achieve the desired rate of nitrification. The report of the results achieved at the treatment plant wastewater in Skenderaj and their impact in removing nitrogen are shown in the following figures.

In Figure 2, we present the results obtained in the laboratory of plant of Skenderaj, analyzing the relationship between pH and the degree of nitrification. Figure 3 shows the reflection of another report between temperature and degree of nitrification.

Figure 4 presents the latest coverage of this work is finished the relationship between DO and the nitrification rate.

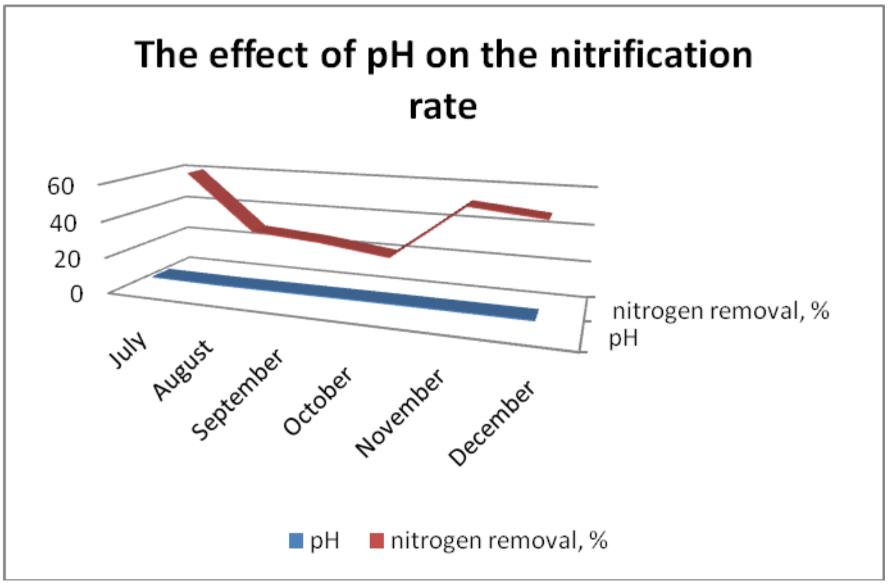

Fig. 2 The influence of pH on the rate of nitrification.

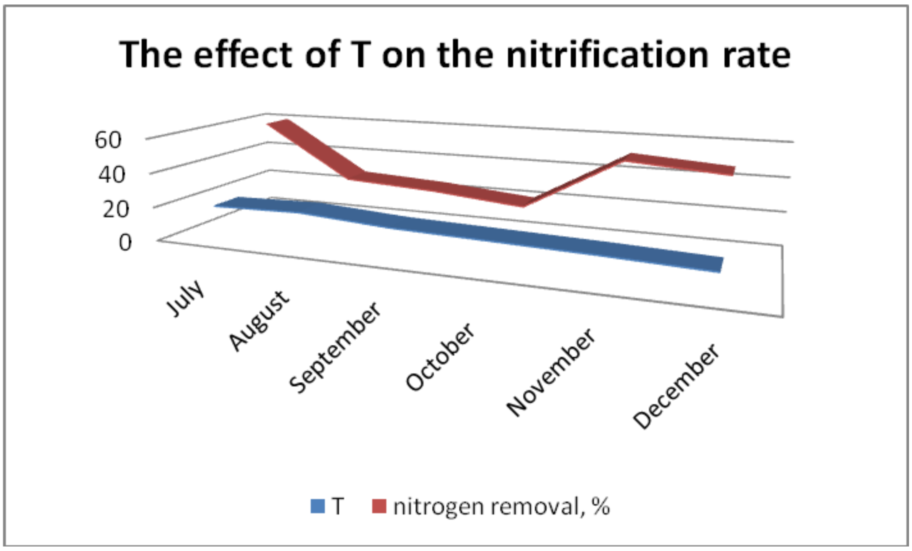

Fig. 3 Influence of temperature on the rate of nitrification.

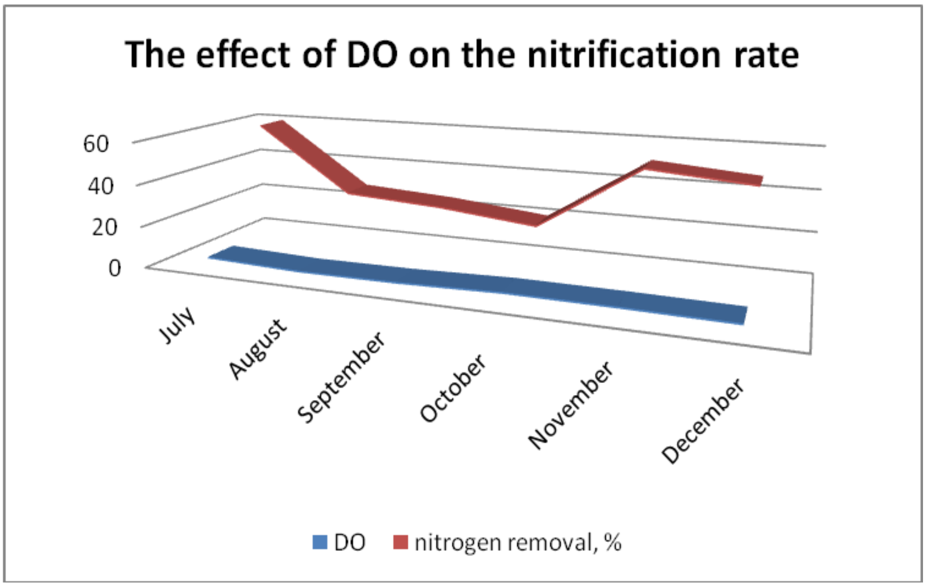

Fig. 4 Impact of DO at the rate of nitrification.

4. Conclusion

The most recent results suggest that the optimum range of pH for nitrification can range from 7.0 to 9.0 [7-8].

The optimum pH for Nitrosomonas ranges from 7.2 to 7.8 [9-10] and from 7.2 to 8.2 for Nitrobacter. Nitrifying of trickling filters have been operated over a much broader range from 6 to 9, due to the adaptation of the bacteria in a filter to actual operating conditions. It is probably a good idea to maintain pH near the lower end of the optimum pH for the nitrifying bacteria to minimize ammonia stress on the cultivated fish species. In addition, rapid changes in pH of more than 0.5 to 1.0 units over a short time span will stress the filter and require time for adaptation to the new environmental conditions.

As shown by the results achieved temperature plays a significant role in the nitrification reaction rate in suspended growth systems as it does in all chemical and biological kinetic reactions, although limited research is available to quantify the effects of temperature on fixed film nitrification rates.

Oxygen can become the rate-limiting factor in certain biofilters, because of the low levels in the influent and the competing demands of the heterotrophic bacteria. For every gram of ammonia-nitrogen oxidized to nitrate-nitrogen, 4.57g of oxygen is required.

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