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The Investigation of Biodegradability of Dissolved Organic Nitrogen in Effluent of Wastewater Treatment Plant[#]

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Abstract: Dissolved nitrogen in wastewater treatment plant (WWTPs) effluent includes inorganic (ammonia, nitrite and nitrate nitrogen) and organic forms. Dissolved organic nitrogen (DON) becomes an important portion of WWTP effluents, because of high inorganic nitrogen removal is able to achieve in these plants. Biodegradable dissolved organic nitrogen (BDON) is a portion of DON that can be mineralized by an acclaimed mixed bacterial culture. In this study, the fate of DON and BDON in effluent of wastewater treatment plant including 4-stage Bardenpho process was investigated. DON values were determined between 4.1-19.7 mg/L in effluent. The biodegradability of WWTP effluent samples were determined by using a mixed bacteria culture and identified between 41%-98% for different sampling time. BDON/total dissolved nitrogen ratio was found in 7%-81% ranges.

Keywords: *Dissolved organic nitrogen, biodegradable dissolved organic nitrogen, effluent of wastewater treatment plant.*

Introduction

The amount and diversity of water pollutants is increasing due to technological advances, consumption patterns and rapid population growth. Therefore wastewater treatment plants (WWTPs) effluents discharges are important source for nutrient loading to aquatic environments. WWTPs's effluents include inorganic nitrogen (ammonia, nitrite and nitrate nitrogen) and organic nitrogen forms. High dissolved inorganic nitrogen (DIN) removal (more than 95%) was able to achieved in WWTPs equipped with nitrification/denitrification processes, hovewer these plants have a lower efficiency of dissolved organic nitrogen (DON) removal. DON represents a significant portion of the total dissolved nitrogen (TDN) in WWTPs's effluent (Pehlivanoglu and Sedlak, 2006). Because of its complexity, DON may act as a nitrogenous disinfection by-product precursor, a nutrient for bacterial, algal growth and consume dissolved oxygen in the receiving waters; can participate in reactions that lead to membrane fouling, eutrophication and other nitrification issues (Pehlivanoglu and Sedlak, 2004; Krasner et al. 2009). As a result of these concerns, management and control of DON is important issue for wastewater treatment practices.

Biodegradable DON (BDON) is a portion of DON that can be mineralized by an acclaimed mixed bacterial culture (Khan et al, 2009). Some fractions of DON can be bioavailable direct algal uptake or after bacterial degradation (Pehlivanoglu and Sedlak, 2004; Simsek et al., 2013). Sattayatewa et al. (2009) reported that bioavailability and biodegradability of effluent DON (including 4-stage Bardenpho process) was found about 28-57%. BDON/DON ratio was determined as 51-69% at effluents of different treatment units in WWTP including 2-stage trickling filters (BOI and nitrification trickling filters) (Simsek et al., 2012). BDON/DON ratio was determined as 26% and 62% in different WWTP's effluent (Simsek et al., 2013). Biodegradability of effluent DON was identified as 52% (Simsek et al., 2012) and 45% (Simsek et al., 2013). Bioavailability of WWTP (including trickling filter) effluent was determined as 40% for only algae and as 60% for together algae and bacteria culture (Urgun-Demirtaş et al., 2008).

In this study biodegradability of WWTP (including screen, grid removal, primary sedimentation, 4-stage Bardenpho process for organic carbon and partial nitrogen degradation, secondary sedimentation, disinfection, sludge thickener and anaerobic sludge digestion units) effluent was investigated.

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Material and Method

Wastewater samples were obtained from effluent of WWTP (before disinfection) in August, September and October 2015. WWTP has a design flow of 200 000 m^3/day and consists of preliminary treatment, a modified Bardenpho process for organic carbon removal and partial nitrogen degradation, followed by disinfection, sludge thickener and anaerobic sludge digestion units. Bardenpho aeration basins consist of 2 anoxic and 2 oxic zones.

Wastewater samples were supplied from WWTP effluent before disinfection unit and filtered through 0.2 μm hydrophilic polyethersulfone membrane filters. Dissolved nitrogen species (Kjeldahl, ammonia, nitrite and nitrate nitrogen) were analyzed before incubation.

Dissolved Kjeldahl, ammonia, nitrite and nitrate nitrogen analysis were performed by Standard Method 4500-N_{org}-B-Macro-Kjeldahl method, 4500-NH_3-B-C-Preliminary distillation step-titrimetric method, 4110-B-Ion chromatography with chemical suppression of eluent conductivity, respectively (APHA/AWWA/WEF, 2005). DON was calculated from differences between Kjeldahl and ammonia nitrogen.

28-day incubation procedures for to determine the biodegradability of wastewater samples was carried out using BDON determination procedure developed by Khan et al. (2009) and modified by Simsek et al. (2012). After incubation dissolved nitrogen species (Kjeldahl, ammonia, nitrite and nitrate nitrogen) were analyzed for all wastewater samples and control samples (using same procedure for deiyonized water). BDON was calculated from differences between DON concentrations before and after incubation as shown by the following equation (Simsek et al., 2013). DON_i and DON_f are dissolved organic nitrogen concentration before and after incubation; DON_{bi} and DON_{bf} are dissolved organic nitrogen concentration before and after incubation for control samples.

$$BDON = (DON_i - DON_f) - (DON_{bi} - DON_{bf}) \qquad (1)$$

Results and Discussions

Distribution of nitrogen species of WWTP's effluent before incubation procedures for different sampling time was given in Figure 1. Ammonia and organic nitrogen are dominant species in total dissolved nitrogen for all samples. The percent of ammonia nitrogen for August and October wastewater samples were determined as 81.7% and 71.2% respectively. Organic nitrogen was determined as 16.1% and 26.4% of total dissolved nitrogen in August and October wastewater samples, respectively. However, organic nitrogen was determined as 82.7% of TDN for September sample. Nitrite nitrogen concentrations were determined under detection limits and nitrate nitrogen concentrations were determined between 0.56-1.31 mg/L.

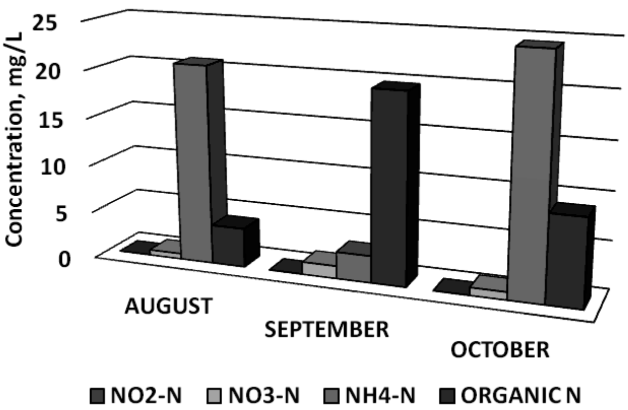

Figure 1. The distribution of nitrogen species for different sampling time before incubation

Carbon oxidation, nitrification and denitrification were achieved in 4-stage Bardenpho processes. Internal and endogenous carbon sources were used for denitrification procedure (Metcalf and Eddy, 2003). In this study, wastewater samples were taken from WWTP designed for carbon and partially nitrogen removal. Sattayatewa et al. (2009) studied the distribution of nitrogen species in 4-stage

Bardenpho basin's different zones and reported that the dominant specie was ammonia nitrogen before the first aerobic zone and was nitrate nitrogen after this zone. Ammonia nitrogen wasn't detected secondary anoxic zone because of ammonium was completely nitrified to nitrate.

Therefore in this study, the presence of ammonia nitrogen in WWTP effluent (for August and October months) indicates that there was an insufficient nitrification process in biological treatment unit. Nitrification-denitrification process is effected by some operating parameters as solid retention time, F/M ratio, temperature, disoolved oxygen level, pH, BOD/Total Kjeldahl nitrogen etc. (Toprak, 2000). To resolve present problems in this plant, it is suggested that controlling of the industrial wastewater discharge, F/M rate and regulation of sludge age, setting desired value of dissolved oxygen and removal of nutrient deficiency. DON concentration in influent of biological treatment unit was determined very high (56.76 mg/L) in September month than August and October months's samples (1.9-8.6 mg/L). It was believed that this increasing associated with industrial effluents. Although DON removal was achieved as 65% in biological treatment unit for this sample, effluent's DON value was very high (19.7 mg/L).

The distribution of nitrogen species after 28-day incubation time for WWTP effluent was given in Figure 2. Nitrite nitrogen concentrations were under detection limits for all samples after incubation. The increase of nitrate nitrogen concentration is associated with the nitrification of ammonia existing in wastewater sample and/or forming from ammonification of organic nitrogen during incubation (Simsek et al., 2013). However nitrate nitrogen concentrations were very low in this study, compared with other studies. Simsek et al. (2012) reported that, the nitrite nitrogen values was determined as 25.2 and 22.9 mg/L for before and after primary sedimentation basin after incubation, and nitrate nitrogen values 3 and 4.6 mg/L for same sampling points, respectively.

Ammonia nitrogen was determined as the highest portion of total dissolved nitrogen in all samples after incubation. Ammonia nitrogen values were detected under detection limits after incubation due to the nitrification process in literature (Simsek ve ark., 2012). On the other hand, incubation procedures performed with only bacteria, only algae or together with bacteria and algae, ammonia nitrogen was detected in some wastewater samples after incubation indicated that some fractions of DON wasn't available for algal consumption without bacteria during incubation (Simsek ve ark., 2013). Therefore ammonia nitrogen wasn't nitrified sufficiently during incubation similarly in the real WWTP in this study. DON values was decreased after incubation procedures in all samples and this decreasing indicated that biodegradability of DON was high and non-biodegradable DON forms was very low.

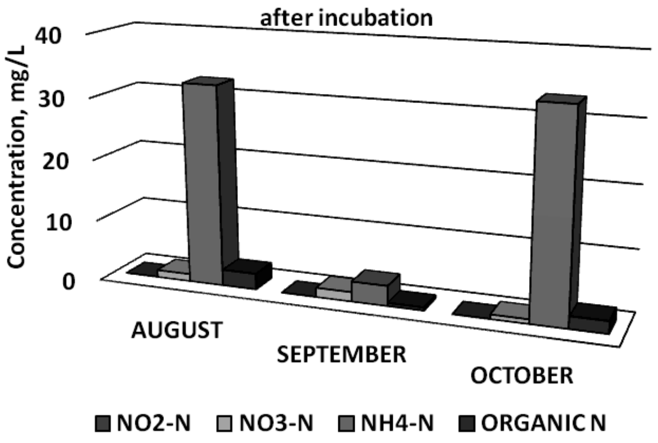

Figure 2. The distribution of nitrogen species for different sampling time after 28-day incubation time

BDON concentrations for different sampling time in WWTP effluent were given in Figure 3. The highest BDON concentration was determined as 19.39 mg/L at September month. The highest dissolved organic nitrogen influent (56.76 mg/L) was observed in this month at WWTP. BDON concentration was determined as 6.2 and 1.8 mg/L for WWTP including 2-stage trickling filter for raw wastewater and effluent of plant, respectively (Simsek et al., 2012). Figure 4 represents the BDON/DON and BDON/TDN ratios for WWTP effluent at August, September and October months.

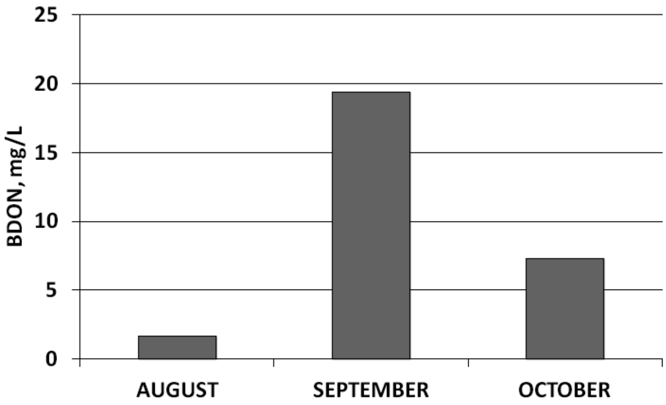

Figure 3. BDON concentrations for different sampling time

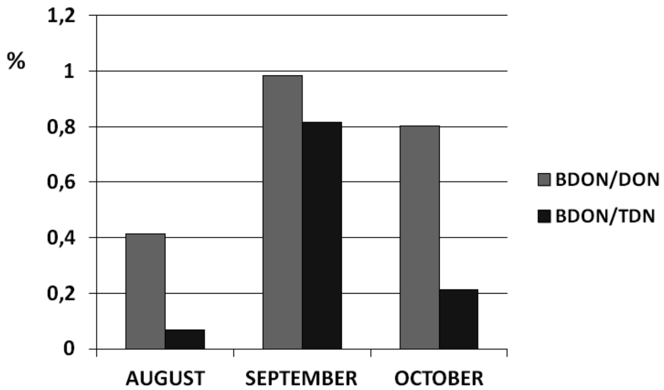

Figure 4. BDON/DON and BDON/TDN ratios for different sampling time

Biodegradability of wastewater effluent was determined as 41%, 98% and 80% for August, September and October months respectively. BDON/DON ratio was determined between 51-69% at different sampling point of treatment train of WWTP including 2-stage trickling filter (Simsek et al., 2012). Biodegradability of effluent of WWTP was calculated as 52% (Simsek et.al, 2012) and 45% (Simsek et al. 2013) for different biological treatment procedures in literature. The biodegradability of DON was decreasing through the treatment train (Simsek ve ark., 2012; Simsek ve ark., 2013). The biodegradable organic nitrogen to total dissolved nitrogen ratio has been similar trend with BDON/DON. This lowest ratio was determined as 7% at August month. BDON/TDN was determined as 81% and 21% for September and October months, respectively.

Conclusions

Ammonia and organic nitrogen are dominant species in total dissolved nitrogen for all wastewater samples before incubation. The percents of ammonia nitrogen for August and October month's wastewater samples were determined as 81.7% and 71.2% respectively. However, organic nitrogen was determined as 82.7% of TDN for September sample. The presence of high ammonia nitrogen in WWTP effluent indicates that there was an insufficient nitrification process in biological treatment unit. Ammonia nitrogen was determined as the highest portion of total dissolved nitrogen in all samples after incubation. Nitrite nitrogen concentrations were under detection limits for all samples after incubation. Therefore ammonia nitrogen wasn't nitrified sufficiently during incubation similarly in the real WWTP. DON values was decreased after incubation procedures in all samples and this decreasing indicated that biodegradability of DON was high and non-biodegradable DON forms was very low. The highest BDON concentration was determined as 19.39 mg/L at September month. The highest dissolved organic nitrogen influent (56.76 mg/L) was observed in this month at WWTP. Biodegradability of wastewater effluent was determined as 41%, 98% and 80% for August, September and October months respectively. In this WWTP, domestic and industrial wastewaters can be changed the characteristics of influent wastewater. Therefore the DON concentration and ratio to TDN may be variable and this problem effected to biodegradation of DON in WWTP effluent. To resolve this problem in this plant, it is suggested that, industrial influents were controlled more stringer and monitored the influent and effluent to observe the vacillation of the nitrogen content of wastewater for a long time.

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