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Investigate the Removal Efficiency of Nitrogen and Phosphate Compounds from AL Hussein bin Talal University Wastewater Treatment Plant (AHUP)

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ABSTRACT

This study investigates nitrogen and phosphate compounds concentrations in inlet and outlet of AL Hussein bin Talal University wastewater treatment plant (AHUP). We worked on the efficiency of nitrogen species and phosphate removal in AHUP. Biological system in this site was included, all stages of the treatment were studied. Two hundred samples (both inlet and outlet) were collected from AHU wastewater treatment plant weekly intervals for five years, under closely controlled and maintaining similar conditions. The removal percentage of nitrate is 94% within the plant. Phosphates removal is 77%, while whole organic nitrogen is removed by 66%. This efficiency has been observed and it was confirmed that the process used in such plant can be considered as an efficient method for removal of nitrogen and phosphate.

Keywords: nitrogen removal, phosphate removal, wastewater treatment, Jordan

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INTRODUCTION

Untreated municipal wastewater contains high level of nutrients of nitrogen and phosphate compounds. Discharging these contaminants to the environment can alter the situation by causing eutrophication phenomenon in acquired waters, adopted by algal and plant growth and reduction in oxygen concentration followed by toxicity in water bodies. This will likely rationale aesthetic issues as good as some other problems in water use, notably for domestic and leisure functions. Moreover, excessive solubility of ammonia in water could affect aquatic life, exceptionally fish replication. Eutrophication phenomenon may additionally impact aquatic system leading to some illnesses [1-3]. Accordingly, it is indispensable that wastewater be dealt with prior to discharge into the atmosphere. Specific methods used to remove nitrogen compounds from nitrification, denitrification, dissolved air floatation, chlorination to breakpoint, ion alternate, and reverse osmosis [4-7], which located a low application in view that of their cost, requiring chemical addition and producing toxic compounds [7]. However, biological methods are rather low cost for nitrogen and phosphate compound removal. Up to date experiences have proven the biological procedures to be strong methods on nutrient, especially nitrogen, removal. They may be able to be viewed as a particulate progress approach in which the microorganisms are saved particulate and organic compounds of wastewater are changed to CO_2 or microbial mass [8, 9].

Assessment of wastewater biological treatment system efficiency on nutrient removal and their variation process in different treatment levels are very important for the purpose of good maintenance and effluent quality promotion

[10]. As a result, we aimed to identify the nitrogen and phosphate compounds and estimate the removal efficiencies due to the treatment plants system in AL Hussein bin Talal University wastewater treatment plant (AHUP).

MATERIALS AND METHODS

Two hundred samples (both inlet and outlet) were collected from AHU wastewater treatment plant weekly intervals for five years, under closely controlled and maintaining similar conditions. Wastewater samples before (inlet) any treatment and after (outlet) biological treatment were analyzed for of total nitrogen, ammonia, nitrate, organic nitrogen, and phosphates.

Wastewater samples analyses

Total dissolved nitrogen was measured with the standard persulfate digestion method [11]. Nitrate concentrations were measured with ion chromatograph (equipped with IonPac AS-14 4x250mm column), after conversion of all the nitrogen forms to nitrate instead of the standard Cd-column reduction method [11]. Nitrate in undigested samples also were measured with the aforementioned ion chromatographic method. Ammonium (NH_4^+) was measured with the standard phenate method [11]. Organic nitrogen was calculated as the difference between the total nitrogen and the sum of inorganic nitrogen species (i.e., NO_3^+, NH_4^+).

Total phosphorus was determined according to a digestion method proposed by Hach Co. (reagents : mixture of sulfuric acid 97% and hydrogen peroxide 30%, 2,4-dinitrophenol indicator, potassium hydroxide) [12].

The removal rate of the pollutant were calculated as the percentage (%) of removal for each parameters: [13].

Removal (%) = Total concentration (inlet) –Total concentration (outlet) / Total concentration (inlet) X 100%

Data analysis

Statistical analysis of the data to evaluate the performance differences was carried out using the two-sample t-test and analysis of variance (ANOVA). The performance differences were deemed to be significant if $P < 0.05$.All statistical analyses were performed using SPSS 14.0 software (SPSS Inc. 2005. Chicago, Illinois, USA).

RESULTS AND DISCUSSION

The results exhibit colossal variations in nutrient elimination in different point of AHU WWTP. The average amounts as well as standard deviation of total nitrogen, ammonia, nitrate, organic nitrogen, and phosphates (mg/l) are presented in Table 1. A relatively steady trend can be visible to prevail, except some values due to the fact that of the introduction of some high loads, known to take place finally, had been abnormally high. These high amounts should not considered when calculating average amounts.

Table 1: The average amounts and standard deviation of total nitrogen, ammonia, nitrate, organic nitrogen, and phosphates (mg/l)

Years	T-N		N-NH_3		N-NO_3		N-Org		PO_4	
	inlet	outlet	inlet	outlet	inlet	outlet	inlet	outlet	inlet	outlet
2010	147.54 ± 26.09	47.30 ± 12.07	10.00 ± 0.77	7.07 ± 1.09	0.46 ± 0.06	0.04 ± 0.01	137.08 ± 25.73	40.20 ± 11.92	1.82 ± 0.84	0.64 ± 0.19
2011	154.38 ± 22.92	50.08 ± 10.41	10.08 ± 0.87	6.95 ± 0.84	0.45 ± 0.06	0.04 ± 0.01	143.85 ± 22.30	43.09 ± 9.89	1.66 ± 0.99	0.60 ± 0.05
2012	151.23 ± 26.45	50.35 ± 10.67	16.58 ± 0.26	0.80 ± 0.03	0.64 ± 0.01	0.04 ± 0.00	134.01 ± 26.41	49.52 ± 10.67	5.69 ± 0.22	0.79 ± 0.03
2013	160.83 ± 31.54	47.15 ± 9.64	16.66 ± 1.06	0.89 ± 0.43	0.66 ± 0.09	0.04 ± 0.00	143.51 ± 31.15	46.22 ± 9.48	5.88 ± 0.14	0.81 ± 0.03
2014	153.30 ± 22.87	50.27 ± 10.19	14.27 ± 4.38	0.61 ± 0.30	0.69 ± 0.23	0.04 ± 0.00	138.34 ± 24.49	49.63 ± 10.23	5.62 ± 0.75	0.71 ± 0.16

As can be noticed from table 1, inlet values exhibit a extensive variant, which seems to be diminished at the outlet. The removal percentage of nitrate is ranged between 89.6 and 97.8% (average 94%) within the plant (Fig 1). Phosphates removal varies between 30 and 93% (average77%) (Fig 2), while whole organic nitrogen is removed by 53 to 85% (average 66%) (Fig 3).

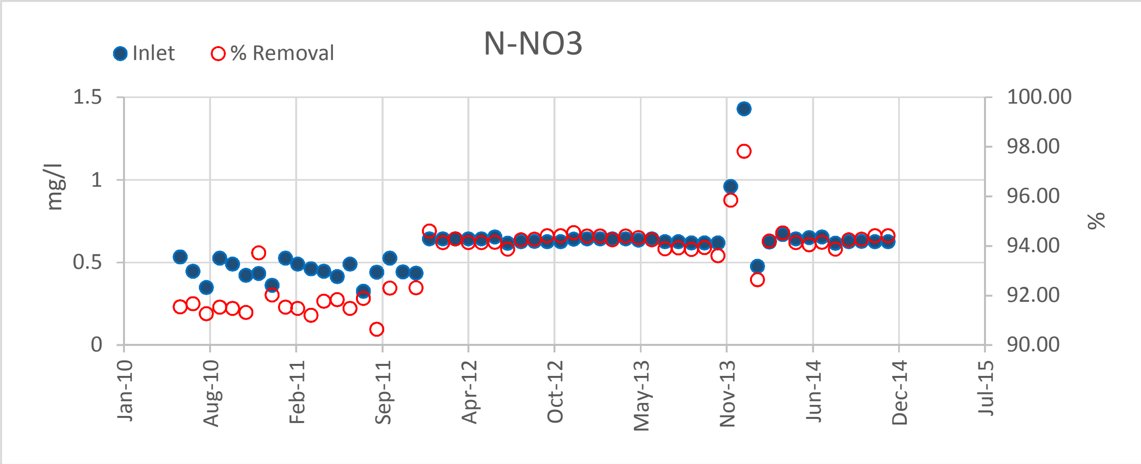

Figure 1: Removal percentage (%) of nitrate within the AHU plant

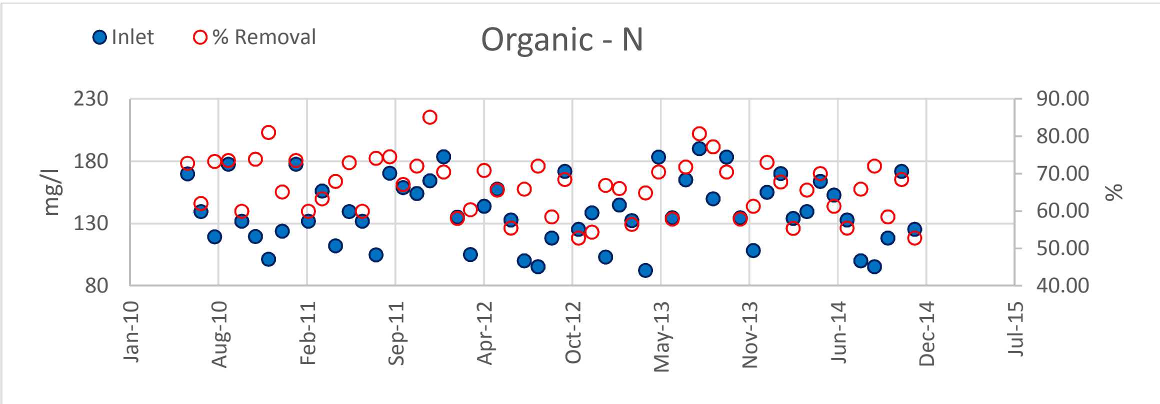

Figure 2: Removal percentage (%) of organic nitrogen within the AHU plant

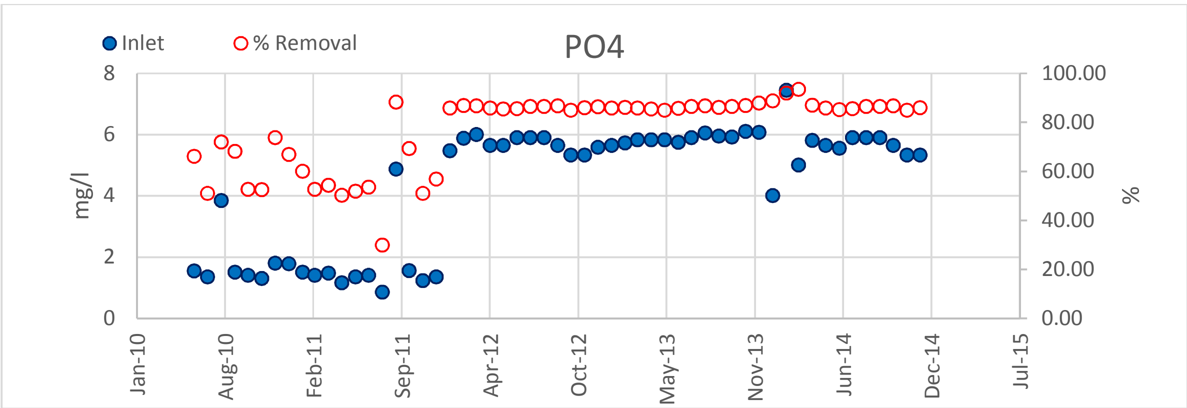

Figure 3: Removal percentage (%) of phosphate within the AHU plant

These findings are similar with removal percentages in literature, some studies found that total phosphorus is removed by about 15%[6], (Henze)[14], and (Metcalf and Eddy)[2]reported that 10-25% for phosphorus removing for the period of secondary therapy.

Organic nitrogen removal in AHUP probability due to nitrogen mineralization and its sedimentation [15,16]. Additionally, hydrolysis to ammonia interferes in decreasing the organic nitrogen amount in AHUP [17]. Other mechanisms for nitrogen removal in AHUP are nitrification and denitrification procedures. To start with, ammonia is modified to nitrite and nitrate as a result of the nitrification process in aerobic levels of ponds, leading to reduce in nitrite level. Nitrate produced is utilized by algae and they sink to the bottom of ponds after dying. Some of algal bodies are non-biodegradable, which makes the nitrogen stays nondissolved in the pond sediments. Nevertheless, the nitrogen in biodegradable constituents of algae is again to wastewater in the type of dissolved nitrogen [17]. For this reason, nitrogen compound concentrations have a significant variation in pond effluent, and measuring the nitrate degree in pond effluent is much less primary. Additionally, some materials of nitrate produced in anaerobic or anoxic layers are modified to N2 due to the denitrification method after which launched to the atmosphere.

Some study confirmed that the WSPs had low efficiency in nitrogen removing [18]. Similarly, within the current study nitrogen removal rate were low. Ammonia is modified to the new algal mass in facultative and whole ponds. (Santos and Oliveria) studied nitrogen transformation and removal in WSPs anaerobic, facultative and whole ponds in three sequence. It was proven that biological removing of nitrogen most likely happened in summer [15]. In Australia a survey of the fundamental methods for nitrogen removal in WSPs was done and suggested that the more nitrogen removing took place at very delayed times, excessive oxygen, and excessive chlorophyll conditions [19].

Other studies showed that the TKN, ammonia, nitrite, and nitrate removal effectivity in all stages of wastewater treatment processes have been lower than 71%, attaining to 90% [20]. However, in the present study, TN and nitrate removal rates are less than those results that could be due to processes of plant in special weather conditions, inlet characteristics, and designing issues.

Comparable to nitrogen removal, most phosphate removal occurred in AHUP probably due to sedimentation mechanism as a result of the high residence time [17]. Phosphate removal of the whole process in this study used to be 77% (average). Nonetheless, (Ghazy et al) had found that the removal rate 68.4% [21]. Depending on the various study results, the efficiency of phosphate removal isn't substantial and the situation of the complete ponds after digestion has been prompt to take away lots of the phosphate in treatment process, so the phosphate quantities in the plant outlet have a reduce that having the most influence [17].

The removal phosphate rate in the plant depend on the level phosphate in inlet to the plant. During In facultative ponds, the sedimentation removing a portion of phosphate by algae. Other portion of phosphate go back to wastewater by mineralization and re-dissolution processes. The particulate phosphates which are non-biodegradable parts of algae, like nitrogen, will stay [17].

Authorized theory toward greater biological phosphate removal is that, consecutive anaerobic-aerobic intervals pose to aggressive capability in substrate consumption and in addition microbial progress. In organic phosphate removal, inlet phosphate is absorbed by the organism biomass and subsequently is removed from system as abundantmud[17]. In this work, both phosphate and nitrogen removal were built-in through incorporating anaerobic and aerobic processes. Our finding is in agreement with other reports [22, 23].

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