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Removal of Ammonium Nitrogen from the DAF-Pretreated Poultry Slaughterhouse Wastewater by *Lemna minor*

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Abstract

In this study, ammonium, COD, color and turbidity removal with using *Lemna minor* (duckweed) was searched in Poultry Slaughterhouse (PS) wastewaters. Reason of Poultry Slaughterhouse Wastewaters (PSW) contains high concentration of organic compounds, ammonia and fats. Wastewater was taken from effluent of Dissolved Air Flotation (DAF) unit, then using MAP process, upper phase was given to reactor which *Lemna minor* was being. COD, ammonia, color, turbidity parameters were analyzed after hydraulic retention time of 7 days. The result of the study showed that *Lemna minor* is effective in treatment of poultry slaughterhouse wastewaters. In this study especially ammonia removal was investigated. At the same time COD, color and turbidity removal were researched. In this study, ammonia removal efficient was around % 30.08 ± 4.67, *Lemna minor* was effective in COD, color and turbidity removal as 26.58 ± 8.35; 35.06 ± 15:20; and 51.07 ± 18.77 respectively removal.

Key words

Lemna minor (duckweed), Poultry slaughterhouse wastewater

1. INTRODUCTION

The poultry slaughtering industry has enormous economic importance as the quickly developed among Turkey's other industries. According to the Ministry of Food, Agriculture and Livestock, consumption has grown from 10.5 kg/person in 2002 to 20.3 kg/person in 2015 [1].

The poultry slaughtering industries generate large volume of wastewaters containing very high concentrations of organic matter [2] and [3]. Slaughterhouse wastewaters contain different kinds of chemical substances, including dissolved organic compounds and total suspended solids (TSS) including fat, grease, feather, manure, flesh, grit, hair, and undigested feed as well [4] and [5]. Slaughterhouse wastewaters contain high concentrations of ammonia with many pollutants and direct discharge of these waters cause serious environmental problems. Discharge of such wastewater leads to undesirable aquatic growth and eutrophication. For this reason, these wastewaters should be given receiving conditions after the appropriate criteria are provided according to the characteristics and legislation to be discharged by the treatment.

Biological processes are economical and effective in this type of wastewater treatment. But it needs large area and long hydraulic retention time. Physico-chemical treatments are sometimes preferred for some wastewater treatment, due to the shorter hydraulic retention time. Physico-chemical processes such as dissolved air flotation (DAF) and coagulation–flocculation (CF) are widely used for the removal of TSS, colloids, and fats from slaughterhouse wastewaters [6]. In PS wastewaters, which are also very rich in nitrogen concentration, lowering nitrogen concentrations can prevent possible eutrophication problems in the receiving environment. If PS wastewater is kept in "polishing units" as *Lemna minor* pools in the last stage of the process, nitrogen levels could be decreased to much lower levels. Duckweed is a low-cost process and efficient method for the treatment of water and wastewater. The purpose of this work is to use duckweed in treating poultry slaughterhouse wastewater after DAF and MAP process. Purification mechanisms such as sedimentation, adsorption, bacterial decomposition and vegetal use are effective in the treatment process with water plants. Organic matter removal is increased by providing surface area for both oxygen and bacterial growth by *Lemna minor* [7]. Ammonium is the primary source of nitrogen in *Lemna minor* [8]. Earlier studies have shown the possibility of simultaneously removing of TSS, BOD and COD from slaughterhouse wastewaters. It was tested successfully removal rate of NH4 and COD 41-48% and 17-20%, respectively [9]. In another study conducted with urban wastewater, the COD removal rates in three parallel units were 61%, 72% and 63%, respectively and TSS removal rate of 82% and 80% was observed [10]. Reference [8] investigated *Lemna minor* activity was at laboratory scale in the treatment of campus wastewater. The last settling basin in *Lemna minor* was compared to the last settling basin in which there is no *Lemna minor* basin. In the last sedimentation pool located in *Lemna minor*; COD removal yield was found to be 15%, BOD5 removal yield 25%, ammonium removal yield 35%, and phosphate removal yield 45% higher [11]. Although studies have been carried out to remove a wide range of wastewater with *Lemna minor*, there is not yet a study in the literature on PS wastewater.

In the present work, *Lemna minor* was used to treat the polishing units and to remove the fine oxide particles. Experimental conditions of the process and effluent wastewater quality before and after treatment were determined. The main objective of the present study was to examine the feasibility of *Lemna minor* after the DAF unit process in treating PS effluent before discharge into urban sewer.

2. MATERIALS AND METHODS

2.1. Characterization of PS Wastewater

PS wastewater was obtained from a local poultry processing plant (Mudurnu Pilic) located in Dilovasi, Izmit (TURKEY). The wastewater samples were taken from the effluent of the dissolved air flotation (DAF) unit at the poultry processing plant (Table 1).

Table 1. Characteristics of the DAF pretreated PSW

Constituent	Value (mean ± S.D.)
Total Chemical Oxygen Demand, TCOD (mg/L)	1032.57 ± 5.35
Volatile Suspended Solids, VSS (mg/L)	49 ± 17.4
Total Suspended Solids, TSS (mg/L)	58 ± 15.63
Alkalinity (mg $CaCO_3$/L)	205 ± 12.8
Ammonium Nitrogen, NH_4^+-N (mg/L)	123.75 ± 4.23
pH	7.1 ± 0.20

2.2. $MgNH_4PO_4.6H_2O$ (MAP) Precipitation Tests

Due to high NH_4^+-N and COD in PS wastewater may causes some toxic effect on the *Lemna minor*, in order to the toxic effect was studied MAP precipitation. After the precipitation of the MAP, the values of COD 300-350 mg/L and NH_4^+-N 60-70 mg /L were obtained.

Amounts of chemicals used to precipitate the ammonium nitrogen in the wastewater of slaughterhouse in MAP form were determined according to Equations (1) - (3) and as a source of magnesium and phosphate were added to the PSW at stoichiometric ratio (Mg^{2+}: NH_4^+-N: PO_4^{3-} P = 1: 1: 1).

$$MgCl_2.6H_2O + KH_2PO_4 + NH_4^+ \rightarrow MgNH_4PO_4.6H_2O^- + K^+ + 2Cl^- + 2H^+ \quad (1)$$

$$MgSO_4.7H_2O + Na_2H_2PO_4.2H_2O + NH_4^+ \rightarrow MgNH_4PO_4.6H_2O^- + Na^+ + SO_4^{2-} + 2H^+ + 7H_2O \quad (2)$$

$$MgOHCO_3 + 85\% H_3PO_4 + NH_4^+ \rightarrow MgNH_4PO_4.6H_2O^- + H_2O + HCO_3^- \quad (3)$$

2.3. *Lemna minor*

Lemna minor was collected from Istanbul University Botanical Garden, Istanbul-Turkey (Figure 1). Working with the *Lemna minor* plant was started immediately, but it was kept in a container with the original water for one day before starting to work.

Figure 1. Image of Lemna minor with stereomicroscope (Prior-James Swift, 240V.AC, F80 mA)

2.4. Analytical Procedure

The pH of wastewater samples was measured by a pH meter (Jenway 3040 Ion Analyser). Ammonium nitrogen (NH_4^+-N), total chemical oxygen demand (TCOD), total suspended solids (TSS), volatile suspended solids (VSS), and alkalinity were conducted by the procedures described in the Standard Methods [12]. Samples were ignited at 550°C by using an ashing furnace (Lenton) for VSS analyses. Absorbance values were recorded at 425 nm by using a spectrophotometer (Pharmacia Biotech LKB Novaspec® II) for NH_4^+-N analysis. Color and Turbidity were measured by the HACH LANGE DR5000 spectrometer.

2.5. System Design

In the study, a reactor with a volume of 6 L and an active volume of 5.6 L was used from Plexiglas material. A weir structure has been placed between the wastewater so that the wastewater can be delivered equally to the system. Sluice was placed in order to ensure mixing and better distribution in the reactor. At the exit of the reactor, a wire plate was placed in the outlet pipe to prevent the *Lemna minor* escaping. During the study conducted under this work, a modulated fluorescent lamp (Panlight daylight lamps, 3011 T8 36W) was used as artificial light in the cultivation experiment setting. The system was operated in a daily continuous mode by feeding with a SEKO® peristaltic pump. Hydraulic retention time (HRT) was set to 7 days for reactor. A detailed schematic of the experimental set-up is depicted in Fig. 2.

Fig.2. A detailed schematic of the experimental set-up.

3. RESULTS AND DISCUSSION

3.1 NH_4^+-N and COD Removal of MAP

Table 2 shows the NH_4^+-N and COD values obtained as a result of MAP sedimentation in the samples taken from the DAF unit of slaughterhouses wastewater.

Table 2. NH_4^+-N and COD values of MAP

Parameter	*MAP Infflu**ent***	*MAP Effluent*	*Removal Rate %*
NH_4^+-N	*123.75±4.23*	*83,6±23,1*	*32.44±3.97*
COD	*1032.57±5.35*	*348,1±40*	*66.29±2.58*

3.2. NH_4-N, COD, Color and Turbidity Removal of Lemna Minor

Table 3 shows the NH_4^+-N, COD, color and Turbidity values after *Lemna minor*.

Table 3. NH_4^+-N, COD, Color and Turbidity values of Lemna Minor

Parameter	*Inffluent*	*Effluent*	*Removal Rate %*
COD	*348,1±40*	*255.57±25.07*	*26.58±8.35*
NH_4^+-N	*83,6±23,1*	*58.45±5.06*	*30.08±4.67*
Color	*72.83±12.29*	*24.33±16.62*	*35.06±15.20*
Turbidity	*25.01±2.72*	*12.22±4.54*	*51.07±18.77*

4. CONCLUSIONS

High ammonia concentrations are a problem for wastewater if the receiving environment standards are low. This type of wastewater needs to be well treated before the discharge. Existing methods add cost in the treatment plants. Low-cost systems added to the output of existing plants are getting interest. The use of *Lemna minor* pools, which is a natural method, provides an important treatment without energy cost. With this study, it was demonstrated that *Lemna minor* pools can be used as a "polishing" step.

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