Biological Remuval of Nitrogen and Phosphorus using Activated Sludge Treatment in Meat Processing Wastewaters

Anisa Myrtaj (Rexhepi)[1], Acad. Assoc. Ilirjan Malollari[2]

[1]Department of Chemistry, Faculty of Technical Sciences, "Ismail Qemali" University, Vlora, ALBANIA
[2]Department of Industrial Chemistry, Faculty of Natural Sciences, Tirana University, Tirana, ALBANIA

Abstract*—The main purpose of this study was to identify the best treatment techniques for wastewater discharged from meat processing. The organic matters in the meat industry wastewater are considerable and complex. To identify the organic component of wastewater we use the parameters to classify it. The most common parameters are the oxygen demand values. We have evaluated the two most common oxygen demand methods, the biochemical oxygen demand and the chemical oxygen demand. In this investigation thorough pretreatment studies were done using the activated sludge treatment.*

This treatment was performed at optimal pH using different dosages of activated sludge.

Minimization of wastewaters discharges consist on keeping under continuous control: the quality of wastewaters; their treatment and disposal in an environmentally manner, optimization of processes, maintenance and respective design.

Keywords*—W*astewater, activated aludge, treatment, COD, BOD_5.

I. INTRODUCTION

The processing of meat and meat by-products requires large quantities of potable water, and nearly all of this is discharged as high strength organic, nutrient (nitrogen and phosphorus), fat and microbial contaminated effluent. Many of the processing plants are rural based and therefore require on-site treatment with discharge limits that are becoming tighter as community expectations increase for better treated wastewater discharges, especially into surface water.

The meat industry has to deal with a number of environmental challenges. Thisincludes responsible wastewater treatment and disposal to prevent land and waterpollution. A well designed and managed wastewater treatment system is essential to achieve regulatory requirements and help protect and maintain a sustainableenvironment.

By focusing on reducing water usage, optimize wastewater treatment and improved waste management, both disposal and treatment costs can be reduced.

Biological wastewater treatment is often associated with secondary wastewater treatment and intends to treat the dissolved and colloidal organics after primary treatment. The goal of all biological wastewater treatment systems is to coagulate and remove or reduce the nonsettling organic solids and the dissolved organic load from the effluents by using microbial communities to degrade the organic load. Biological wastewater treatment is generally a major part of secondary treatment design of wastewater and characterized by reduction of the oxygen demand of an influent wastewater to a given level of purification. The microorganisms responsible for reducing the organic matters and consequently the oxygen demand of incoming wastewater can be classified in aerobic and anaerobic.

Aerobic biological treatment dominates secondary wastewater treatment and is performed in the presence of oxygen by aerobic microorganisms. From a nutritional point of view, the majority of microorganisms in biological wastewater treatment systems use the organic matters in the wastewater as the energy source for growth and maintenance of microorganisms.

Anaerobic processes are also used in the secondary biological treatment of wastewater. Anaerobic processes, in addition to sludge digestion, are employed to treat high-strength wastewater, such as food-processing wastewater streams.

II. WASTEWATER CONSTITUENT

In the wastewater stream has inevitably some blood, fat, manure, meat and detergents. These wastes contribute to the key constituents, which are described below:

- Organics:comprising BOD, COD, TSS, oil and grease - are generally biodegradable. If the wastewater is not managed well its degradation by bacteria can cause odours.

- Nitrogen (in organic, ammonia and oxidised forms) and Phosphorous (typically in the form of organic P or phosphate) are essential nutrients forliving organisms. Abattoir effluent contains high levels of both. The degreeof treatment required depends on the final disposal route. River disposalrequires almost complete removal of both.
- pHis typically neutral and temperaturescan vary from cool to hot. High temperatures (greater than 38°C) can enable fats to liquefy and pass through rather than being removed by primary treatment
- Meat processing wastewater contains negligible amounts of either of these pollutants.

About 50% of the total phosphorus and sodium contaminants are generated from manure and paunch wastes, which come from stockyard washing, emptying of the animal stomachs and further processing of internal organs. Wastewater from these processes is often combined and referred to as the "green" stream, and is primary treated separately from the "red" stream. This "red" waste stream is generated mainly from water used to guarantee modern hygienic practice in the facility, and which becomes contaminated with blood and fats. Blood is the main source of nitrogen followed by urine and proteins from meat scraps. Blood recovery should be maximised and water entering blood containment areas should be avoided.

Rendering, often called the 'by-products department', and incorporating blood processing, is responsible for about 60% of COD and 20–40% of the sodium, phosphorus and nitrogen liberated to the wastewater. The major sources of nitrogen, phosphorus and sodium include the raw materials bin drainage and blood processing, whereas COD is primarily sourced from tallow refining. Smaller facilities may not operate a rendering plant. Waste streams from these operations may also be included in "red" streams.

III. WASTE MINIMISATION STRATEGIES

Minimising waste into the water stream will reduce the wastewater load to the treatment system. This source reduction will have a direct impact on the costs associated with water usage.

It is very important that storm water be divided from wastewater streams to the maximum extent possible in order to reduce volumes.

Effluent disposal objectives depend on the disposal route and the surrounding environment. For each disposal route, the effluent must meet the required regulatory disposal standard. These may vary from state to state and are dependent on local and state legislations. The correct effluent disposal criteria should be obtained from the relevant regulatory authority. The legislation of Albania (No. 177) is given in the Table 1:

TABLE 1
LEGISLATION FOR MEAT AND MEAT BY-PRODUCT WASTEWATERS DISCHARGES

Parameters	Normal values from the legislation
pH	6-9
Suspended Solid	50 mg/l
BOD_5	50 mg/l
COD	250 mg/l
Vegetable oil	10 mg/l
Nitrogen	10 mg/l
Phosphorus	5 mg/l

Effluent disposal via sewer is best suited to generally larger abattoirs located close to residents. Best practice wastewater treatment will generally consist of:

- Oil and grease removal,
- Suspended solids and BOD reduction,
- Nitrogen and phosphor reduction,
- Monitoring and reporting to the authority.

IV. MATERIAL AND METHODS

The raw wastewater was collected from meat and meat by product industry in Tirana, Albania.
For the pretreatment studies was used inorganic coagulant like ferric chloride. Ferric chloride was taken from "National Environmental Agency" in Albania. Activated sludge was taken from the impiant of wastewater treatment in Durres. The first sampe of activated slugde was taken from oxygenation area and the second from the second settler.

Wastewater sample collected from meat industry was filtered and the filtered water samples were then subjected to coagulant and AS treatment.

a. Optimization of the coagulant and activated sludge dosages:

The dosages were varied from 100 to 1000 mg/L. The addition of coagulant was followed by stirring for 5 min on magnetic stirrer and settling for 120 min and the same for theactivated sludge.

b. Optimization of pH for an individual coagulant:

pHs selected were 4.0, 6.5 and 9.0. pH of the wastewater was maintained with the help of 1:1 HCl and 0.1N NaOH, whenever required.

c. Optimization of settling time after coagulation:

The settling time intervals were varied between 30–120 min to get the best possible results.

The laboratory procedures are: Dissolved oxygen according to S SH EN 25714-2003, COD according to ISO15705-2002, BOD_5 according to ISO 7393-1, ISO 6107, P-PO_4 (with ascorbic acid), N-NH_4 according to ISO 7150:1984.

Coagulation–flocculation is one of the most important physicochemical treatment steps in industrial wastewater treatment to reduce the suspended and colloidal materials responsible for turbidity of the wastewater and also for the reduction of organic matters which contributes to the high level of BOD and COD content of the wastewater. In Table 3,[(1)],[(2)]are index for the treatment with AS respectively [(1)]for the AS from the oxygenation area and[(2)]AS in the second settler.

TABLE 2
RESULTS BEFORE TREATMENT OF WASTE WATER DISCHARGE

Parameters	Values
pH	7.25
Temperature	22.5 ^oC
TDS	1825 mg/l
Konductivity	3650 µs/cm
N-NH_4	30.1 mg /l
COD	3928 mg O/l
BOD_5	2200 mg O/l
N-NO_2	5.42 mg /l
N-NO_3	8.28 mg /l
P-PO_4	38.4 mg /l
P-tot	49.1 mg /l
SS	475 mg/l
Oil & Grease	775 mg/l
Alcalinity	18.9 milimol/l

TABLE 3
RESULTS AFTER TREATMENT WITH COAGULANT AND ACTIVATET SLUDGE OF WASTE WATER DISCHARGE

Parameters	Before treatment values	After treatment values	Normal values
TDS	1825 mg O/l	650 mg/l[(1)]	-
TDS		645 mg/l[(2)]	-
COD	3928 mg O/l	1252 mg O/l[(1)]	250
COD		928 mg O/l[(2)]	250
BOD_5	2200 mg O/l	162 mg O/l[(2)]	50
$N\text{-}NO_2$	5.42 mg O/l	1.012 mg/l[(1)]	-
$N\text{-}NO_2$		1.004 mg/l[(2)]	-
$N\text{-}NO_3$	8.28 mg /l	0.071 mg/l[(2)]	-
$N\text{-}NH_4$	30.1 mg /l	2.03 mg/l[(2)]	-
$P\text{-}PO_4$	38.4 mg O/l	3.76 mg/l[(1)]	-
$P\text{-}PO_4$		8.27 mg/l[(2)]	-
P-tot	49.1	8.6 mg /l[(2)]	5
SS	475 mg/l	213 mg/l[(1)]	50
SS		186 mg/l[(2)]	50
pH	7.25	7.53[(2)]	6-9

V. CONCLUSION

From the analysis of the physical-chemical indicators in the polluted waters discharged by the meat processing industry, all the parameters set were at a very high rate, in contradiction with the parameters set by the Albanian legislation on the Pollution Rate in the waters discharged by this industry. Treatment with the active sludge obtained from the secondary decanter resulted in a higher reduction of all the parameters.

The percentage reduction of the parameters from the treatment with AS from second settler are: TDS 64.66%; SS 60.84%; COD 76.37%; BOD_5 92.64%; $N\text{-}NO_2$ 81.48%; $N\text{-}NO_3$ 99.14%, $N\text{-}NH_4$ 93.21%; $P\text{-}PO_4$ 90.21% and P-Tot 82.48%.

To prevent pollution, industries should stop immediately discharge wastewater in high values and to use methods or treatment that increase the efficiency of the removal of the organic matter in wastewater.

From this study we recommend that the meat industries should remove the solid mass (fat) to avoid the difficulty of the filtration process and treating wastewater with coagulant and active sludge to realize the reduction of parameters.

Design an anaerobic treatment process for wastewater treatment in slaughterhouses, as a high rate of COD reduction at a lower cost than aerobic systems is achieved and gas-generating methane-rich gas can be used as fuel.

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