# DESIGN OF A MEAT PROCESSING WASTEWATER ANAEROBIC DIGESTER

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## ABSTRACT

Wastewater treatment processes are dynamic due to the many parameter's variety, such as in fluid concentration and streams composition for different polluted and industrial discharged waters. Due to these wide values discrepancy, they can't be precisely controlled, and so, it is preferable to use mathematical models and simulations that are essential to describe, predict, and control the occurring processes in the industrial wastewater system. This study presents a model that describes the design procedure of an anaerobic digester performing activated sludge treatment for carbon removal, nitrification and denitrification reactions. This simple mathematical approach of the first order, has been successfully used to describe the biodegradation of organic matter comprises in wastewater derived from the meat processing industry in Albania. In this study, was carried out a detailed pre-treatment analysis using the specific coagulation process adding $FeCl_3$ agent, followed by the activated sludge treatment.
The influent enters the digester with a BOD value of 2200 mg /l $O_2$, but this rate is reduced during primary treatment before the influent passes through the biological treatment unit of the design considered plant. The permitted value of BOD should not be greater than 50 mg/l of $O_2$ in the out coming treated water. Digester simulation model was useful and was used to design the activated sludge process entirely.

**Keywords:** Slaughter wastewater, biodegradation, reactor design, COD, $BOD_5$

## INTRODUCTION

Industrialization and urbanization have caused a significant increase in the level of polluting the waters. Environmental protection agencies, along with several non-governmental organizations have set stricter rules on environmental protection. This has made the necessity of water treatment in line with the quality standards, which recently become a major burden for industries. In the food industry, water is a key component. Waters discharging from the meat processing industry are distinguished for high BOD and COD content, high levels of solids or suspended solids including fats, nutrients such as nitrogen, phosphorus and therefore require proper attention before disposal. Wastewaters from the meat industry generally does not contain toxic chemicals. However has been high concentrations of organic dissolved components, accompained by unpleasant aroma causing smelling difficulties. Due to the deposition of these pollutants they cause concern for living population in the industrial areas.

The main purpose of our study was selecting the proper biological method of contaminated slaughter wastewater treatment, along with meat processing. We intended to follow the suitable procedure which is based on the reduction of organic materials used by special microorganisms finded in activated sludge, resulting in lower improved BOD values. Before

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biological treatment with activated sludge was performed, the samples were subjected to physical treatment (filtration) and then to the coagulant ($FeCl_3$).

Pre-treatment was done to destabilize the particles present in polluted water, reduce the suspended and colloidal mass associated with their sedimentation by reducing the turbidity and organic matter responsible for high values of BOD and COD. Coagulant treatment is done based on optimum coagulants, pH and retention time. Since the purpose of our study is to design anaerobic digester for the treatment of wastewater from these industries, the samples were subjected to activated sludge treatment with the aim of reducing pollution parameters. Activated sludge was taken from the secondary decanter in Durres water treatment plant. The samples after treatment with activsted sludge were also treated with activated carbon to remove the color and odor.

## MATERIAL AND METHODS

To realize this study, samples were taken from the effluent line of the meat processing industry in Tirana, at the discharge pipe of the sausage production plant.

The main objectives of the study were as follows:

1. Determination of physical-chemical indicators such as pH, nitrate, nitrite, ammonia, phosphate, total phosphorus, $BOD_5$, COD, suspended solid (SS), soluble solids (TDS) [11,12], and
2. Design of an anaerobic digester for the treatment of wastewater discharged from the meat processing industry [2,5,6].

The methods used for physico-chemical analysis were done according to S SH ISO. Process modeling[9] considered as useful was used to design the process with activated sludge. The mass balance for biodegradable COD is given by the equation [4, 9]:

$$r_s * V = q_s * X * V = Q_e(S_e - S)$$

Where: V – reactor volume, $Q_e$ – influent flow, $S_e$ –concentration of biodegradable influent, S – concentration of biodegradable influent in reactor.

Substrate consumption rate ($r_S$) can be converted to a substrate at a specific consumption rate ($q_S$) which increases by the concentration of active biomass (X).

For a given temperature T, the value $q_S$ depends on the S concentration in the reactor and from the Monod kinetics that is used to describe this dependence:

$$q_{S,T} = q_{Smax,T} * \frac{S}{K_s + S}$$

Where $q_{S,T}$ is the specific consumption of substrate temperature at T and $q_{Smax,\ T}$ is the maximum specific rate of substrate consumption at the temperature T.

In the case of wastewater treatment by the food industry, sedimentation and sludge sedimentation capacities are generally low and may vary during the operation.

The defined value of the AS biomass concentration should not be too high and a safety factor should be applied for the surface design. A simple evaluation of this surface (A) is obtained using the following equation:

$$A = \frac{Q_e}{q_{Amax}}$$

where $q_{Amax}$ is the maximum flow rate. In slaughter are preferred the values 0.25 and 0.35 $m^3/h$.

In the case of wastewater treatment from the food industry[1][3], the unloaded COD is often quite high compared to the COD of urban wastewater.

## RESULTS

The measured parameters in the sample taken from the meat processing plant before and after treatment are shown in the table1.

**Table 1.**Results of the analysis performed taken before and after treatment

| Measured parameters | Value before treatment | Value after treatment with AS and $FeCl_3$ | Allowed value |
|---|---|---|---|
| **COD** | 3928 mg O/l | 928 mg O/l | 250 mg/l |
| **$BOD_5$** | 2200 mg O/l | 162 mg O/l | 50 mg/l |
| **$N\text{-}NO_2$** | 5.42 mg /l | 1.004 mg/l | |
| **$N\text{-}NH_4$** | 30.1 mg /l | 2.03 mg/l | |
| **$N\text{-}NO_3$** | 8.28 mg /l | 0.071 mg/l | |
| **$P\text{-}PO_4$** | 38.4mg /l | 3.76 mg/l | |
| **P- total** | 49.1 mg/l | 8.6 mg/l | 5 mg/l |
| **pH** | 7.25 | 7.53 | 6-9 |
| **SS** | 475 mg/l | 186 mg/l | 50 mg/l |

### Design of Anaerobic Digester

The first step in biological wastewater treatment is to determined the size of the anaerobic digester[2][5][6]. Below it is shown the design procedure and performance of an anaerobic process where the characteristics of untreated waste are:

Effluent volumetric flow rate =60 $m^3$/d

Concentration of $BOD_5$ = 2200 mg/l

Temperature=22.5$^0$C

Digester design assumptions:

a. Digester operates in 22.5$^0$C.

b. $\theta c$ = 14 d

c. Efficiency, Es = 0.80

d. Wastewater contain the nitrogen and phosphorus necessary for biological growth

e. Y = 0.07 kg VS / kg $BOD_5$ used and $k_d$ = 0,03 $d^{-1}$in 22.5$^0$C

### Determinations by Calculations:

1. **Daily loads of $BOD_5$:**

$$BOD_5 = \frac{2200\,\frac{mg}{l} * 60\,\frac{m^3}{d} * 1000\frac{l}{m^3}}{1000000\,mg/kg} = 132\,kgBOD_5/d$$

2. **Digester volume:**

$\theta = \theta_C = V/Q$

$\theta_C = 14d$

$$V = 60\frac{m^3}{d} * 14d = 840\,m^3$$

3. **Volumetric load:**

$$BOD_5 = \frac{132\,\frac{kg}{d}}{840m^3} = 0.157\,\frac{kg}{m^3\,d}$$

**4. Concentration of waste in effluents:**

$$Es = \frac{100(S_0 - S_1)}{S_0}$$

So: $S_1 = \frac{(100*2200)-(80*2200)}{100} = 440\frac{mg}{l}$

**5. Volatile solid particle production per day:**

$$A = \frac{Y * Q(S_0 - S_1)}{1 + (k_d * \theta_c)}$$

$$= \frac{\left(0.07\frac{kgVS}{kgBOD_5}\right) * \left(60\frac{m^3}{d}\right) * \left(1000\frac{m^3}{d}\right) * \left(2200\frac{m^3}{d} - 440\frac{mg}{L}\right) * \left(\frac{g}{1000mg}\right) * \left(\frac{kg}{1000g}\right)}{1 + (0.03d^{-1} * 14d)}$$

$$= 5206\frac{kg}{d}$$

**6. Volume (m$^3$) of methane production per day:**

$$C = 0.35 * \left((E * F) - 1.42A\right) = 0.35 * \left((0.8 * 132) - (1.42 * 5206)\right) = 34372.618\frac{m^3}{d}$$

**7. Total biogas production supposing 65% of methane:**

$$Total\ gase\ production = \frac{34372.618}{0.65} = 52880.95\frac{m^3}{d}$$

## DISCUSSION

*The benefits that will be realized by anaerobic treatment are:*

a. A reduction in the organic sludge content.
c. Destruction of pathogens.
d. Methane gas production
e. Reducing volume.

*In addition to methane production, the advantages for anaerobic treatment are:*

a. Stabilization of waste
b. Small amounts of organic waste produced.
c. No oxygen was needed.
d. Nutrient requirements were low

## CONCLUSIONS

From the physico-chemical analysis of the wastewaters discharged by the meat processing industry, one can conclude that all parameters impacting the quality were out of the allowed limits, in contradiction with the parameters set by the Albanian legislation on the pollution rate in the waters discharged by this industry. It is obligatory for these industries to apply wastewater treatment process.

- The rate of COD reduction with the activated sludge was 76.4%;
- The rate of BOD reduction with activated sludge was 92.6%;

- Phosphates are reduced to 82.5% by treatment of sample with activated sludge;
- Reduction of SS in was sample treated with the activated sludge 77.8%.

**REFERENCES**

**[1]** Water Treatment Handbook Volume 2-Ondeo Degremont. Water treatment handbook - 1991 sixth edition ISBN: 2950398413 (pp 1482-1489)

**[2]** Advanced Biological Treatment Processes For Industrial Wastewater Francisco J. Cervantes, Spyros G. Pavlostathis and Adrianus C. van Haandel Published by IWA Publishing London, UK 2006 ; ISBN-10: 1843391147; ISBN-13: 9781843391142. (pp 243-255)

**[3]** Waste Management For The Food Industries Ioannis Arvanitoyannis ISBN: 9780123736543, © Academic Press 2008 Published:16th November 2007. Springer

**[4]** Water Treatment Plant Design Fifth Edition by: The American Water Works Association (AWWA), The American Society of Civil Engineers (ASCE) 2012 The McGraw-Hill Companies, Inc. ISBN: 9780071745727

**[5]** Biological Treatment Processes, Volume 8 Handbook Of Environmental Engineering Edited by Lawrence K. Wang, PhD, PE, DEE; Norman C. Pereira, PhD; Yung-Tse Hung, PhD, PE, DEE; Nazih K. Shammas, PhD. ISBN 978-1-58829-163-9 e-ISBN 978-1-60327-156-1 DOI: 10.1007/978-1-60327-156-1; 2009 Humana Press, a part of Springer Science+Business Media, LLC (pp207-236; 266-270)

**[6]** Advanced Biological Treatment Processes, Volume 9 Wang, Lawrence K., Shammas**,** Nazih K., Hung**,** Yung-Tse ISBN 978-1-60327-170-7 Humana Press, a part of Springer Science+Business Media, LLC

**[7]** Eco-Efficiency Manual For Meat Processing Pagan, R. J. Renouf, M. A. Prasad, P. ISBN: 174036631X, 2002

**[8]** Handbook of Water and Wastewater Treatment Technologies

**[9]** Modelling Aspects of Wastewater Treatment Processes. ISBN 91-88934-00-4. ©1996 Ulf Jeppsson Printed in Sweden by Reprocentralen, Lund University

**[10]** Wastewater treatment in dairy industries — possibility of reuse Baisali Sarkar, P.P. Chakrabarti, A. Vijaykumar, Vijay Kale. Desalination 195 (2006) 141–152. Elsevier

**[11]** Procedura eksperimentale: Agjencia Kombëtare e Mjedisit dhe Pyjeve, Instituti i Shëndetit Publik

**[12]** Standard methods for the examination of water and wastewater 13th edition 1971 APHA. AWWA. WPCF