TREATMENT OF WASTEWATER FROM SWINE AND POULTRY SLAUGHTERHOUSES

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Abstract: The meat processing industry produces large volumes of slaughterhouse wastewater (SWW). For this reason, water and wastewater treatment has become crucial for the continuing development of the society. The present study reveals the water pollution degree from poultry and the swine slaughterhouses from Bacau (Romania). The possibility of reducing the quantity of pollutants by the active sludge treatment method is also presented. The efficiency of this treatment processes was evaluated through the following parameters: biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), turbidity, both before and after the active sludge treatment.

Keywords: wastewater, pollution, slaughterhouse, pig, poultry

1. INTRODUCTION

Wastewater from the meat processing industry is formed at slaughterhouses, meat processing plants and cattle and poultry farms, and is an important source of surface water pollution. It represents a serious problem due to their high levels of organic matter which demands effective and high cost treatments.

According to statistical data from literature [1-3], the meat processing industry is one of the major consumers of freshwater among food and beverage processing facilities, which makes slaughterhouses a significant producer of wastewater effluents. Widely, a slaughterhouse plant that may consume between 2.5 and 40 m^3 of water per metric tons of meat produced [1]. This wastewater is considered with potentially highly detrimental effects for environment due to its complex composition of fats, proteins, and fibers from the slaughtering process. SWW is initially stained due to blood and stomach contents, bleeding due to blood presenting with difficulty in removal due to hemoglobin that is not completely removed by coagulation and which is resistant to biological treatment and is decomposed over time [4-6].

The direct discharge of the SWW effluents to a water body is impractical due to their high organic charge. According to the European Union legislation, slaughterhouses commonly discharge the SWW into the municipal sewer system after a preliminary onsite treatment. So, the treatment of wastewater from the meat processing industry has been one of the greatest concerns of the agro-industrial sector [7, 8].

An option to allow pre-treatment of wastewater in good conditions may be grouping the channels according to the water specificity as follows: waters containing predominantly suspended matter, waters containing fat and waters containing blood [4].

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Waste water resulting from the slaughter of pigs has a high fat content and coarse matter, so they are separated before biological treatment with active sludge. For subsequent purification, various physico-chemical, chemical and biological treatment methods can be applied [9-13].

This paper presents the study of the water pollution degree from poultry and the swine slaughterhouses as well as the possibility of reducing the quantity of pollutants by the activated-sludge treatment method [9, 11].

2. EXPERIMENTAL SETUP

The wastewater was sampled from S.C. Agricola International S.A. Bacau (Romania) whose activities include the slaughter and processing of poultry which generates around 350 m^3 of wastewater per hour and from S.C. Nicbac Prod S.R.L. Nicolae Balcescu, Bacau (Romania) whose activities include the slaughter of swine.

In the literature, it is advisable to analyze water samples as soon as possible after sampling, because the loss of some gaseous substances can result as changes of temperature and pressure. Microbial activity can also contribute to changing the ammonium nitrate-nitrate balance, or may decrease the content of organic compounds that degrade rapidly for more than 4 hours.

Slaughterhouse wastewater is usually evaluated in terms of bulk parameters due to the specific amounts of SWW and pollutant loads related to the animals slaughtered and processed that vary among the meat processing industry, usually containing considerable amounts of total phosphorus (TP), total nitrogen (TN), chemical oxygen demand (COD), total suspended solids (TSS), and biochemical oxygen demand (BOD$_5$) [14].

The samples were collected into 1 L polyethylene bottles and were processed immediately or they were stored at 4 °C until analysis. Within the first 4 hours, we performed the following determinations: temperature, pH, dissolved oxygen (DO), turbidity, biochemical oxygen demand (BOD$_5$), chemical oxygen demand (COD), total suspended solids (TSS), fixed residue, NO_2^-, NO_3^-, SO_4^{2-}, Cl^-, Fe, and Cu contents. Biochemical oxygen demand (BOD$_5$) of wastewater from poultry and swine slaughterhouses was determined by the difference between the amount of oxygen presented in the sample initially and after five days of storage at standard conditions: temperature 20 °C and without of air and light.

The chemical oxygen demand (COD) test applied consisted in the ability of potassium permanganate to oxidize organic substances from water in acid condition, and excess permanganate is determined with oxalic acid. Another indicator is the sediment, which shows the amount of sedimentable suspensions for 2 hours due to gravitational force. To determine the sediment an Imhoff cone with 1000 mL capacity was used.

Total suspended solids (TSS) represent another important parameter used in defining the wastewater quality, which refers to all small particles suspended in water. Separation of the suspended matter by filtration was followed by bringing the residue to constant weight. Before analysis, the sample was vigorously shaken. Filtration was performed through filter paper for samples with a high content of suspended solids, and for samples with small content, through the crucible type G4 with asbestos layer. Centrifugation (Universal 320 R) was performed for samples that contain large amounts of colloidal materials.

Fixed residue indicates all the organic and inorganic substances dissolved in water and not volatile at 105 ° C.
The principle of the method consists in separating of the hydrosoluble substances by evaporating of the water followed by weighing of the resulting residue. A measured volume of unfiltered water was evaporated on a water bath (Brookefield TC 502). The residue was dried at 105 °C in a MEMMERT vacuum drying oven and was weighed. By comparison, the fixed residues on the two types of SWW were also analyzed. For this, the separation of organic and inorganic substances dissolved in water by evaporation at 105 °C, followed by their weighing has been performed.

Dissolved oxygen DO is important for the sanitary characterization of water; the higher is it, the higher is the level of water pollution and the danger to the consumers' health.

The method consists in calculating the difference between the amount of oxygen under saturation conditions and the amount of oxygen found in the water. Knowing the amount of oxygen dissolved in water and the amount of oxygen under saturation conditions using Winckler table was determined the oxygen deficiency (in %).

The content of suspensions, nitrates, nitrates, sulphates, phosphates, free chlorine, total chlorine, total iron, copper were accomplished using Hach DR / 2010 portable spectrophotometer. To achieve the above assays (exception of suspensions, phosphates and iron) 1:10 dilutions were required. For the determination of dissolved oxygen, temperature and pH, we used the oxygen sensor model DurOx 325. The turbidity of the waste water was conducted using the 2100P Portable Turbidimeter.

The active sludge treatment was chosen as method of reducing the pollutants content present in the wastewater. The purification principle consists in the development of bacterial flora originating from waste water and activated sludge, which in the presence of oxygen consumes organic pollutants. The active sludge is a complex colloidal system with a heterogeneous composition containing colloidal particles (d < 1μ), dispersed particles (d = 1-100 μm), aggregates, suspension material, etc., having a gelatinous appearance and with high water content. From microbiological point of view, the active sludge is a mixture of microorganisms that consume the biodegradable material contained in the wastewater. The active sludge used in the experimental part comes from the secondary decanter of the city purification station of Bacau Municipality. In order to highlight the reduction of pollution, the analyses were carried out on the waste water and the samples from the biological treatment process.

Laboratory biological treatment was carried out in a 2 L capacity vessel in which waste water was introduced and inoculated with active sludge at a rate of 1 g·L^{-1}. The sample was kept under magnetic agitation and aeration for 24 hours at 20 °C at atmospheric pressure. After purification, the same determinations as in the initial sample were made.

3. RESULTS AND DISCUSSION

As a result of the continuous stirring and aeration of the mixture of wastewater and active sludge for 24 hours, brown mud flasks are deposited on the bottom of the container after magnetic stirring ceases. The results obtained from the analyses are presented in Tables 1 and 2. The values of the physicochemical parameters and heavy metals determined in this study were compared with the maximum admissible values provided by the Romanian (NTPA 002/2005).

Table 1. Quality indicators for wastewater from pig's slaughterhouse.

Quality indicator	Unit	Waste water	Treated water	Efficiency [%]	Maximum admissible values according to NTPA 002/2005
BOD$_5$	mg·L^{-1}	575.6	350.5	40	300
COD-Mn	mg $KMnO_4$·L^{-1}	465.5	399.2	15	-
	mg O_2·L^{-1}	116.375	99.8	15	125
Total Suspensions	mg·L^{-1}	610.1	170.0	72	300
Sediment	mL·L^{-1}	7.5	15.0	-	-
Fixed residue	mg·L^{-1}	2100	1300	38	1200
O$_2$ dissolved	mg O_2·L^{-1}	1.7	2.2	-	6
Temperature	°C	10	21.9	-	40
pH	-	5.7	6.0	-	6.5-8.5
Nitrates (500 nm)	mg·L^{-1}	13.5	2.0	85	2
Nitrites (585 nm)	mg·L^{-1}	86.0	60.0	30	
Sulphates (450 nm)	mg·L^{-1}	63.0	55.0	13	600
Phosphates (890 nm)	mg·L^{-1}	5.9	2.0	66	
Free chlorine (530 nm)	mg·L^{-1}	0.4	0.01	90	0.5
Total chlorine (530 nm)	mg·L^{-1}	0.6	0.2	67	
Fe (510 nm)	mg·L^{-1}	0.31	0.07	77	
Cu (560 nm)	mg·L^{-1}	0.37	0.09	75	0.2
Turbidity	NTU	51.9	42.1	30	-
Deficit O$_2$	%	26.0	20.0	6	-

Table 2. Quality indicators for wastewater from poultry's slaughterhouse.

Quality indicator	Unit	Waste water	Treated water	Efficiency [%]	Maximum admissible values according to NTPA 002/2005
BOD$_5$	mg·L^{-1}	833.9	700.0	16	300
COD-Mn	mg KMnO$_4$·L^{-1}	498.4	423.4	15	-
	mg O$_2$·L^{-1}	124.6	105.85	15	125
Total Suspensions	mg·L^{-1}	600.0	150.0	75	300
Sediment	mL·L^{-1}	8.0	12.0	-	-
Fixed residue	mg·L^{-1}	2800	1400	50	1200
O$_2$ dissolved	mg O$_2$·L^{-1}	1.90	2.58	-	6
Temperature	°C	10	20	-	40
pH	-	7.1	7.6	-	6,5-8,5
Nitrates (500 nm)	mg·L^{-1}	58	40	18	2
Turbidity	NTU	50.8	48.0	3	-
Deficit O$_2$	%	25.1	22.3	4	-

It has been found that the sediment volume in the waste water deposited for 30 minutes varies as shown in the graphs from Figures 1 and 2.
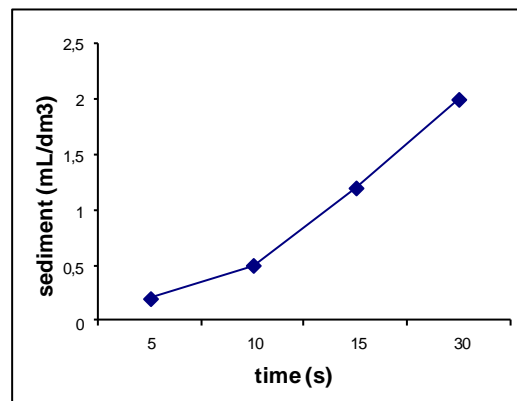

Fig.1.Variation of sediment volume deposited in time on water from poultry' slaughterhouse.

According to the values of qualitative indicators mentioned in Tables 1 and 2, there is a perceptible decrease of the pollutant content, which indicates that the process is viable. The results of the BOD$_5$ and COD-Mn analyses showed that the pollution degree is higher in the case of wastewater from the poultry abattoir than the wastewater from the slaughterhouse.
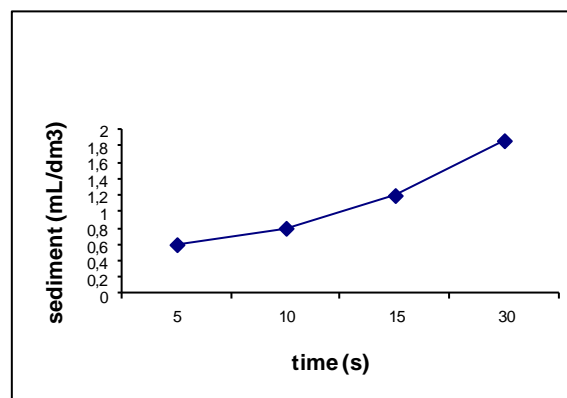

Fig.2. Variation of sediment volume deposited in time on water from pigs' slaughterhouse.

The amount of turbidity in the poultry slaughter water indicates higher blood content than solid suspensions. For porcine abattoir wastewater, a 30 % turbidity decrease is observed indicating a decrease in hemoglobin content and suspensions.

The degree of purification efficiency calculated for the two types of wastewater in terms of total suspension and fixed residue content is 50 % for poultry slaughter water and 40 % for swine sewage water. The water purification rate of the swine slaughterhouse calculated on BOD_5 is 40 %.

For the pH of the wastewater from the pig slaughterhouse there is an increase from 7.12 to 7.6, and in the case of the swine sewage water there is an increase from 5.7 to 6.

4. CONCLUSIONS

The biological treatment of the slaughterhouse wastewater with activated-sludge process presents some important advantages:
- cleaning process leading to an impregnable effluent;
- reduced smells emitted in technology;
- high efficiency for BOD_5 and for decanter suspensions;
- low investment cost.

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