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PRELIMINARY STUDY OF THE EFFICIENCY OF ULTRAFILTRATION TREATMENT OF POULTRY SLAUGHTERHOUSE WASTEWATER

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Abstract

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Poultry slaughterhouses use relatively high amount of water with an average consumption of 26.5 L/bird during primary and secondary processing of live birds to meat. The used water contains proteins, fats, carbohydrates from meat, blood, skin and feather, resulting in much higher biological oxygen demand (BOD) and chemical oxygen demand (COD). A lot of attention has been focused on the development of unconventional methods for wastewater treatment. The possibility of using the ultrafiltration for poultry wastewater treatment was investigated. The results showed that the ultrafiltration could be an efficient purification method. Its application resulted in about 99 % and 98 % removal of fats and suspended substances. The efficiency of COD and BOD_5 removal exceeded 94 %.

Key words: poultry slaughterhouse wastewater, ultrafiltration, BOD_5, COD, total suspended solids, fat

Introduction

Traditionally, poultry slaughtering operation have been large users of potable water, and consequently, large generator of wastewater. Due to the regulation on minimum water usage at different stages in the process and set policies regarding the pathogen reduction requirements in the broiler meat, most poultry processor use an average from 18.9 to 37.8 L/bird. The poultry slaughtering wastewater contain proteins, fats, carbohydrates from meat, blood, skin, feathers. The water also polluted with a fair amount of grit and other inorganic matter. In addition, water that is used during slaughtering operations can accumulate contaminants, fecal materials and even pathogenic bacteria (Mijinyawa and Lawal, 2008; Ramesh et al., 2009) Prior to discharge from the plant, poultry processors are required to remove the majority of the soluble and particulate organic material in their wastewater in order to achieve compliance with environmental regulation (Bohdziewicz et al., 2003)

Proteins from carcass debris and blood ate the major pollutants besides fat in poultry processing wastewater. With an estimated 2-5 % of total carcasses protein lost in the effluent, wastewater contains predominantly 35 % of protein, resulting in much higher biological oxygen demand (BOD) and chemical oxygen demand (COD) than town sewage (Zhang et al., 1997). The composition of wastewater from the poultry slaughtering industry varies from one plant

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to another depending on the type of systems, the operation methods, and processing capacity. Depending on the degree of treatment required poultry processors have the option of utilizing one of the existing commercial wastewater treatment methods physical, chemical and/or biological. However, existing commercial treatment processes suffer from the following disadvantages: 1- only limited efforts have been made to reclaim nutrients (El Boushy and Van der Poel, 1994); 2- use of toxic compounds such as iron salts in the process makes the precipitated protein useless for biological applications (Whittemore, 1994); 3 potentially valuable constituents in wastewater are degraded during the secondary treatment to useless sludge, which in itself present a disposal problem (Barik et al., 1991).

For the last few years, a lot of attention has been focused on the development of unconventional methods for wastewater treatment, such as pressure driven membrane operations, namely ultrafiltration which helps remove colloids, suspended and macromolecular matter and reverse osmosis, which helps eliminate mineral substances and low-molecular organic compounds (Bohdziewicz et al., 2003; Lo et al., 1996; Nelson, 2006; Petkov et al., 2004; Ramesh et al., 2009). The ultrafiltration has an exceptional efficiency in removal of very small particles, including pathogen microbes and environmentally hazardous nutrients (Spasov and Dinkov, 2002). This practice can also reduce the need for chlorination and remove nitrogen and phosphorus nutrients. Wastewater treated from conventional treatment plant is commonly discharged to the environment, whereas membrane filtration technology can produce water clean enough for household use, crop irrigation and industrial processing (Ramesh et al., 2009).

Shih and Kozink (1980) conducted studies on ultrafiltration of poultry processing wastewater and found that 85 % of total solids and 95 % of COD in the wastewater were removed by the ultrafiltration system. The permeat was clear, transparent and slightly yellowish. The low reduction of ash (63%) was due to the fact that minerals and salts were not retained by ultrafiltration membranes. Significant reduction in total solids and COD of permeate of ultrafiltration wastewater was reported (Lo et al., 2005). Ultrafiltration treatment was capable of reducing the COD of PPW by about 59 %.

The aim of our article is to investigate the efficiency of the treatment of poultry slaughterhouse wastewater by using ultrafiltration.

Materials and Methods

Apparatus and Membranes

Ultrafiltration was carried out applying a laboratory installation with a plate and frame membrane module (Figure 1). The effective membrane area was 0.1 m^2. The membrane used in the pressure driven operations is a polymer membrane, type UF-25-PAN. The process was carried out at a pressure 4 Bar and flux 330 l/m^2h.

The wastewater was sampled from three Bulgarian poultry slaughterhouses is used. The samples were collected from the holding tank where the wastewater is sent before being discharge to the municipal sewage.

All samples were analyzed according to the following indices:

- 5-day duration Biological oxygen demand (BOD_5): BIS standards (National Standards of Bul-

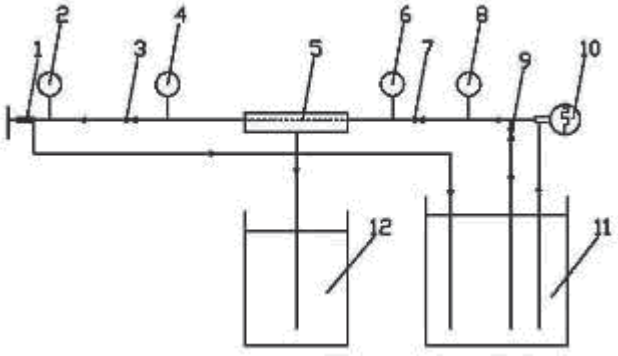

Fig. 1. Scheme of a laboratory installation: 1, 3, 7, 9 valve; 2 - anometer (0-50 bar); 4 - manometer (0-6 bar); 5 plate and frame membrane module; 6 - manometer (0-8 bar); 8 - manometer (0- 150 bar); 10- pump; 11- wastewater tank; 12 - permeat tank

garia): 17.1.4.07-78

- Chemical oxygen demand (COD) BIS standards 17.1.4.16-79

- Un-dissolved substances: BIS standards 17.1.4.04-80

- Fats: ISO: PIS 9377: 2001

The presented values were obtained on the basis of three repetitions of the experiments.

Results and Discussion

As shown in Figure 2, a typical poultry processing operation includes at least six operations in which water is used, contaminated and then discharged. Some of the operations used water has direct contact with the birds (scalding, de-feathering, washing, eviscerating, chilling) and all of component materials of chicken flesh and blood will be found in the generated wastewater.

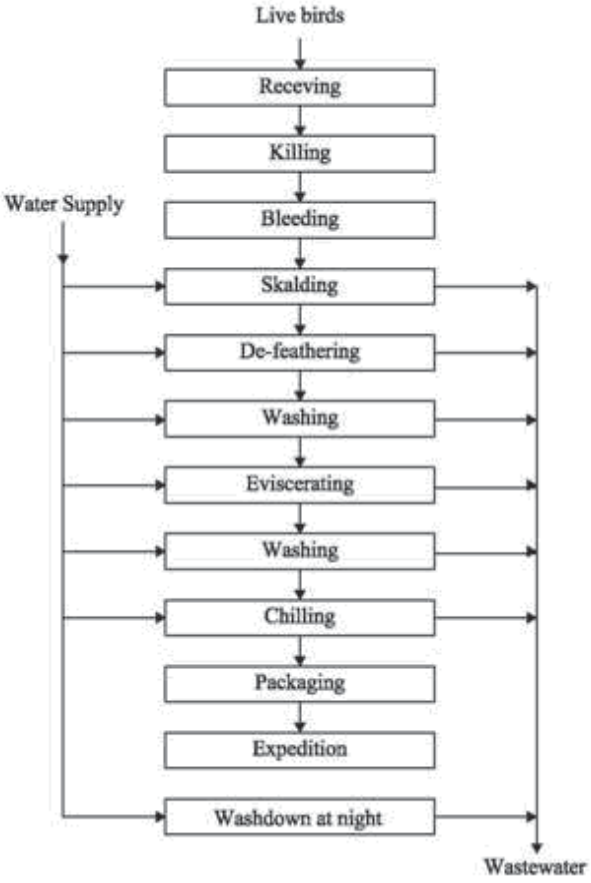

Fig. 2. Scheme of a poultry slaughtering operation

The raw wastewater taken from the poultry slaughterhouses was characterized by considerable pollutants. The characteristic of wastewater together with a permissible standard for dairy effluent are presented in Table 1.

Most of the materials in the wastewater are organic in nature. The results in Table 1 reveal that the fat content is relatively high. Poultry fat is known to be relative soft and more soluble, especially in hot water than other animal fats and forms colloidal suspension or emulsion. A second major component in poultry slaughtering wastewater is blood that results in high BOD_5 Blood contains red blood cells forming a stable suspension in water. The wastewater with above content was subjected to an ultrafiltration treatment which aimed to remove suspended and macromolecular matter. In this process wastewater passes through the membrane and contaminants are removed by various mechanisms mainly depending on the pore sizes. Table 2 shows the results related to the influence of ultrafiltration on the levels of pollution indices included in the experiment. The efficiency of the methods expressed in retention of each of the contaminants is also indicated.

The results in Table 2 reveal that after the ultrafiltration treatment of poultry slaughterhouse wastewater different degrees of a decrease in particular pollution indices (i.e. BOD5, COD, TSS, and Fat) were found. The highest retention coefficient, respectively above 99 % and 98 % were obtained for TSS and

Table 1
Pollution concentration in raw wastewater

№	Indices	Raw wastewater, mg/dm^3	Permissible standard, mg/dm^3
1	BOD5	1900 - 2200	50
2	COD	3610 - 4180	250
3	Total Suspended Solids (TSS)	2280 - 2446	50
4	Fat	289 – 389	5

Table 2
Pollution indices of wastewater after treatment by ultrafiltration

№	Indices	Raw wastewater, mg/dm^3	Wastewater after ultrafiltration process	
			Concentration, mg/dm^3	Retention, R %
1	BOD_5	1900	40	97.89
		2178	48	97.80
		2200	48	97.82
2	COD	3610	198	94.52
		4140	220	94.69
		4180	220	94.74
3	Total Suspended Solids (TSS)	2360	22	99.07
		2446	22	99.11
		2280	20	99.12
4	Fat	289	3	98.96
		380	4	98.95
		389	4	98.97

Fat. The retention coefficients of BOD_5 and COD were above 97 % and 94 %, respectively. The values of all ecological indices are below the limit standards. The results give us a reason to believe that the ultrafiltration process could ensure the efficiency required for environmentally friendly poultry slaughterhouse wastewater treatment. As the effectiveness of the processes depends on membrane performance the retention coefficient could be increased if other membranes would be investigated.

Conclusion

The investigations proved that the pressure driven membrane operation could be successfully applied to the treatment of the wastewater from poultry slaughterhouses. From an environmental and economic point of view, ultrafiltration could be an efficient alternative treatment method compared to conventional wastewater treatments. The main strength of membrane technology is that it works without the addition of chemicals, with a relatively low energy use and easy well-arranged conduction process.

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