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Wastewaters quality in the anaerobic stage of a treatment plant from a baker's yeast factory

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Abstract

The efficiency of a wastewater treatment plant located into a food industrial platform was assessed. Main wastewaters are collected from the baker's yeast factory. The wastewaters are purified through a process, which is running in two steps, namely anaerobic treatment and the aerobic biological stage.

The purpose of this work is to evaluate the wastewaters quality of the anaerobic stage from above-mentioned treatment plant. The assessment was performed based on standard parameters, such as materials in suspension, chemical oxygen demand, biological oxygen demand, temperature, pH, nitrogen content, phosphor compounds and sulphur ones. Meantime, the analysis results were compared with the initial data design of anaerobic treatment phase.

Overall, the results showed that anaerobic wastewater phase, as part of treatment plant from considered baker's yeast factory ensured partially the purge process in aim to frame within load limits of pollutants from industrial wastewater discharge into the local sewerage network. Determined values of the effluent parameters varied by a polynomial equation, being influenced by many factors. There are differences between operation modes of the anaerobic digestion in comparison with design data of the treatment equipment, reason for which effectiveness of the treatment ranges towards 70% instead of 100%.

Keywords: baker's yeast, wastewater, anaerobic treatment

1. Introduction

Generally speaking, wastewaters, which result from food industry, have contained high level of organic matter and these have represented an increased biological and chemical contamination risk. Different type of food industry plants produce industrial effluents of which quality is influenced by factors, such as: food industrial branch / type, applied technology, existing technical equipment for food processing.

Among the food plants, manufacturers of baker's yeasts have discharged wastewater resulting from the separation of yeast and other separation processes, such as centrifugation and rotary vacuum filtration; important quantities of wastewaters from cleaning operations have been discharged, too. All these wastewaters were distinguished in two groups, namely high strength process wastewater and low-medium strength process wastewater [1,2].

Wastewaters of the baker's yeasts industry contain dissolved organic substances, namely dextrins, organic acids, resins, gums, other types of sugars, trimethylglycine, coloured melanoidins and phenol substances, as well as insoluble organic substances or materials in suspension, high concentrations of total nitrogen, variable phosphorus content and sulphate. Most of contaminants in the wastewater come from raw materials, namely the molasses [2,3,4,5,6].

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In table 1 is introduced some values of pollution parameters assessed during characterization studies of baker's yeast industry wastewaters. Data from the literature show high variation from one indicator to another, probable depending on technical equipments put into operations.

Because of high amount of wastewater pollutants, which should discharge in sewerage network it is necessary a pre-treatment for clearing partially industrial effluents so treated waters comply with either standard conditions for directly wastewater discharge into the local sewerage networks and wastewater treatment plants (NTPA 002/2005) or standard load limits of pollutants from industrial wastewater discharge into the natural receptors (NTPA 001/2005) [7,8].

Nevertheless, regarding acceptable values of pollution indicators, the opinions are different from one country to other or related to a certain food industry. In fact, BAT values of yeasts production wastewaters may have deviations due to local conditions or dependent on area of work. A comparative description of yeasts production wastewater's quality before and after treatment is shown in table 2; although the rate of wastewater cleaning is over 90% for oxygen demand (COD and BOD), the purified wastewater do not comply with NTPA 002/2005, and NTPA 001/2005 are even more restrictively. Therefore, the critical limits were assessed according with above-mentioned factors; for instance, for COD the critical limit value is 800 mg/l, instead of 500 mg/l as is quoted in NTPA 002/2005.

In aim to remove part of wastewaters contaminants the different kinds of treatment plants were put in operation. In literature were expressed opinions according with which anaerobic treatment appears to be economically more attractive by compared with aerobic process for effluents discharged from a baker's yeasts factory [2]. In this case the treatment of high strength wastewaters allows simultaneous organic matter and sulphate removal, with low sludge production and low energy requirement.

Nevertheless, by usage of wastewater treatment into a single anaerobic stage the purified wastewaters are not able to comply with standard discharges requirements for baker's yeast industries. For these reason, the effluents of the anaerobic treatment process should be further treated by the other treatment technology in order to fulfil the NTPA 002/2005 requirements.

Different technologies and equipments were designed in aim to ensure a better removal of wastewaters' pollutants' with increment of contaminants' removal efficiencies between 52-100% during the anaerobic treatment of baker's yeast industry effluent. The feasibility of anaerobic treatment technology for baker's yeast industry wastewater in various conditions was investigated, too [9,10,11]. In this sense the objective of this paper is to introduce the results following the assessment of anaerobic treatment efficiency from a factory producing baker's yeasts in Romania.

2.Material and Method

The experimental study was performed at a plant-scale, facility being part of the baker's yeasts factory, which has had an amount of production of 220 tonnes monthly with a production cycle of 30 days per month. The wastewater treatment plant consists of equipments that process in two steps: the anaerobic treatment follows by the aerobic biological stage.

Sampling of wastewaters from above-mentioned baker's yeasts plant was performed according with standard [12] after an established program; the average daily samples were achieved by sampling from four to four hours throughout the day, that were taken at points of entry and exit of the each stage of the wastewater treatment plant.

The influents and effluents were analysed in laboratory and quality assessment was based on the following parameters: materials in suspension, chemical oxygen demand, biological oxygen demand, total nitrogen, nitrates and nitrites, ammonium – nitrogen, total phosphorus, sulphates, residue, temperature and pH. There were used standard methods of analysis for water samples quality determination, as is introduced in table 3. The diagnosis was done comparing the analysis results with the initial data design.

Table 1. Characterization of the effluent from the baker's yeast industry [2]

Parameter [1]	Unit	Reference				
		(Ersahin et al., in press)	**(Krapivina et al., 2007)**	**(Blonskaja et al., 2006)**	**(Altinbas et al., 2003)**	**(Gulmez et al., 1998)**
pH	mg/l	6.5	-	-	6.2	5.9
COD	mg/l	6090	14400-25700	25020	15848	17100
Magnesium	mg/l	-	-	-	30.7	-
Ferrous	mg/l	-	-	-	4.9	-
PO_4-P	mg/l	2.3	-	-	6.6	-
TSS	mg/l	583	-	-	835	-
VSS	mg/l	475	-	-	810	-
Alkalinity	mg $CaCO_3$/l	1475	-	-	2349	1675
Soluble COD	mg/l	4980	-	23420	15193	-
TKN	mg/l	274	-	-	1196	1185
NH_3-N	mg/l	132	-	-	206	250
TN*	mg/l	-	250-350	1470	-	-
TP	mg/l	3	17.3-48.2	100	20.1	21
Sulphate	mg/l	485	3500-5300	2940	-	-

*TN – total nitrogen

Table 3. Methods of analysis used for assessment of water samples quality

Nr.crt.	Quality indicators	Methods of analysis
1.	Materials in suspension (MS)	STAS 6953-81
2.	Chemical oxygen demand (COD-Cr)	SR ISO 6060 – 96
3.	Biological oxygen demand (BOD5)	SR EN 1899-2/2002
4.	Total nitrogen (TN)	SR ISO 10048/2001
5.	Ammonium – nitrogen (NH_3-N)	SR ISO 5664/2001
6.	Nitrates (NO_3^-)	SR ISO 7890-3/2000
7.	Nitrites (NO_2^-)	SR ISO 6777/2002
8.	Total phosphorus (TP)	SR EN ISO 6878/2005
9.	Sulphates (SO_4^{2-})	STAS 8601-70
10.	Sulfur/H_2S (S)	SR ISO 10530-1997
11.	Residue ®	STAS 9187/84
12.	pH	ISO 10523:2008

Table 4. Methods of analysis used for assessment of water samples quality

Nr.crt.	Quality indicators	Mean values	
		Effluent anaerobic phase	**Influent aerobic phase**
1.	pH	6.33	6.52
2.	Chemical oxygen demand, mg/l	2336	1728
3.	Biological oxygen demand, mg/l	763	721.50
4.	Ammonium – nitrogen, mg/l	75.06	132.80
5.	Total nitrogen, mg/l	126.65	295.64
6.	Phosphor total, mg/l	0.88	1.39
7.	Nitrates, mg/l	19.76	13.10
8.	Nitrites, mg/l	0.80	0.28

3. Results and discussions

Purge quality of wastewater plant into anaerobic phase from the bakers' yeasts factory was assessed. Experimental results for effluents in this stage registered on basis of laboratory analyses in comparison with design data of the wastewater plant are expressed in the figures 1 to 5. The pH of the wastewaters' samples decreased during the anaerobic treatment stage from an average of 7.73 towards the values of 6.3…6.4. The anaerobic fermentations were performed in mesophilic temperature conditions.

COD-Cr concentrations of the purified wastewaters were lower than 4g/l after anaerobic digestion. As is described in figure 1, the chemical oxygen demand registered variations by a polynomial equation. There are at least three factors, which influenced COD-Cr. By comparing with the design data, the COD values for run 1 and 3 exceeded the expected figures from the equipment's project. In fact in run 1 the influent contained the largest quantity of chemical pollutants and this is related to other results. For the set of samples no. 1 the materials in suspension had the highest value, while higher quantities of phosphorus and nitrogen registered for the third set of samples, too.

The values indicated in figure 2 shows that BOD5 was higher for the third set. Although there is an important fluctuation of the biological oxygen demand for analysed samples, excepting run 3 the cleaning efficiency is appropriately with design data.

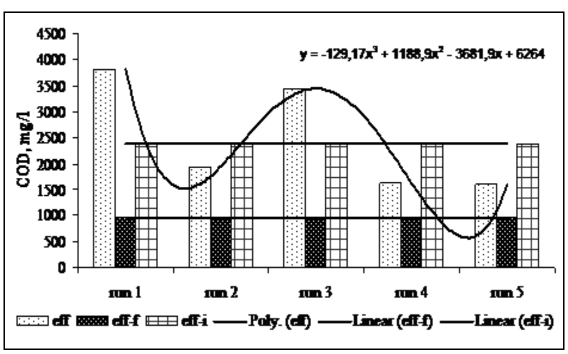

Figure 1. Chemical oxygen demand values for treated wastewaters into anaerobic stage

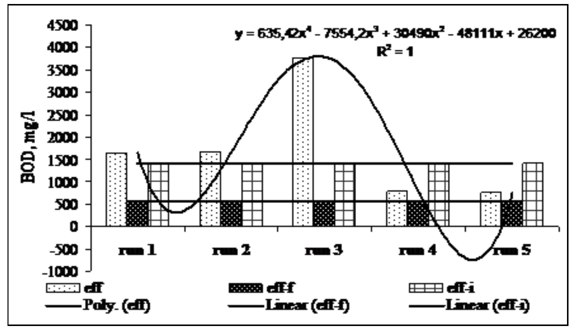

Figure 2. Biological oxygen demand values for treated wastewaters into anaerobic stage

Overall the oxygen demand concentrations of analysed samples were acceptable to be discharged into the sewerage system in terms of biodegradability of wastewater, but amounts registered during the experimental did not comply with optimum values of purified waters in the anaerobic treatment phase expected to be clean according with design data. Even the baker's yeasts wastewater normally contain high amounts of sulphates, through anaerobic digestion the sulphur values for purified wastewaters were less than 2 mg/l for each sample.

Nitrogen content varied in large for treated wastewaters into anaerobic stage (see figure 3). Total nitrogen of analysed samples ranged between 187 and 450 mg/l, more than double of the design data. While the purified wastewaters from run 4 and 5 recorded lower levels of both chemical and biological oxygen demands, the total amount of nitrogen in comparison is higher than other samples because of chemical pollutants accumulated or by slow degradation. Most part of nitrogen comes from ammonium, nitrates are less and the least nitrites.

Another important objective of the anaerobic process during baker's yeast wastewater digestion is the removal of organic materials in suspensions. As it is observed into figure 4, materials in suspension ranged by a polynomial equation with a general decreasing trend that proves a better effectiveness of cleaning treatment in terms of the suspensions' removal increasing. Because of many factors that influence this evolution is difficult to predict overall efficiency based on analysed data.

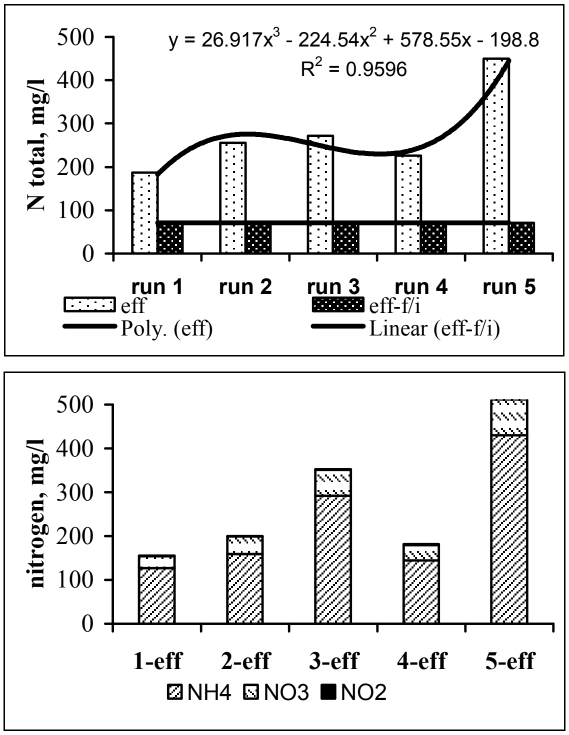

Figure 3. Nitrogen values for treated wastewaters into anaerobic stage

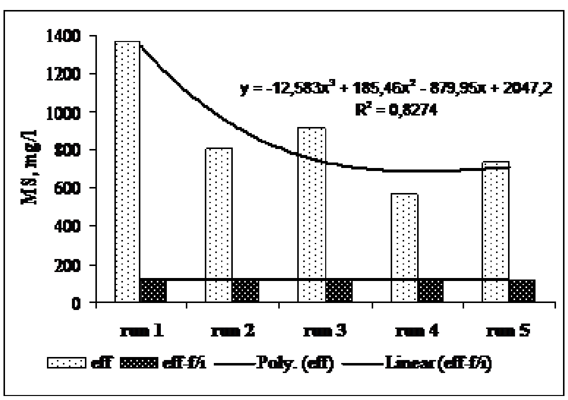

Figure 4. Values of materials in suspension for treated wastewaters into anaerobic stage

Also the phosphorus content registered high fluctuations depending on initial loads and mineralization of phosphorous compounds during the anaerobic treatment (see figure 5).

Beside fluctuation of the influents' quality from a sampling moment to another in relation with technological features of baker's yeasts production, there are other factors, which affected the experimental. Among them, flow rate was not constant within a certain domain because sometimes the same treatment plant was overloaded with additional amounts of wastewaters from other secondary technological processes of the factory than the basic ones. On the other hand, there was observed a process variation into wastewater treatment plant in sense that differences amongst experimental data were registered for the effluent of anaerobic stage and influent of aerobic phase. As is shown in table 4, there is a variation for many parameters between the anaerobic output and the aerobic input for wastewaters. This disturbed the operating mode at aerobic stage treatment, too [13].

4. Conclusions

The wastewaters quality in terms of effluents obtained after anaerobic digestion as part of a treatment plant from a baker's yeast factory was examined. Diagnosis was also performed by comparison the existing operational mode with technological design data of the anaerobic treatment stage.

The variation of standard pollutants was investigated, and it seems that many of them ranged significantly by polynomial equations depending at least on three factors of influence. Taking into account the factors, of which generally depend on the efficiency of anaerobic treatment processes, in this case the main variables are: the presence of nutrients, the nature and concentration of organic impurities, as well as the functional parameters of the purging equipment.

Overall, for the considered baker's yeast factory, the anaerobic fermentations ensured partially wastewater treatment in aim to frame within load limits of pollutants from industrial wastewater discharge into the local sewerage network. Differences between operation modes of the anaerobic digestion in comparison with design data were observed, with consequences on the treatment plant's efficiency. Excepting the organic loading of the influents, flow rates varied with overcharging of the installation. The analysis of the experimental data has showed that the anaerobic treatment step worked effectively in terms of organic substances as follows: the efficiency of 72% expressed in CCO-Cr and efficiency of 71% for BOD5; also 70.7% of ammonia nitrogen and approx. 60% of total nitrogen were removed. Finally, the purification effectiveness of the anaerobic treatment ranges towards 70%, less than 100%, but even in this case this phase provided proper treatment in order to contribute to overall wastewaters cleaning for discharging in municipal sewerage network.

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