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Study of Chemical Indicators of Wastewater from the Brewing Industry

Cornelia Lungu[1*], Magdalena Ignat[1], Oana Emilia Constantin[1]

[1] *Dunarea de Jos University, 800008, Domnească Street, 47, Romania*

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Abstract

Waste water from breweries may contain a significant presence of organic materials from the raw materials used and a degree of acidity and alkalinity from the cleaning chemicals.

The objective of this study was to evaluate wastewater samples from the brewing industry in terms of the following indicators: suspended solids, biochemical oxygen demand, chemical oxygen demand, ammonia nitrogen, total nitrogen. Data were statistically analysed by ANOVA single-factor method. The results demonstrated that quality parameters analysed had values below the limit.

Keywords: brewing, wastewater, pollution

1. Introduction

Water management and waste disposal have become a significant cost factor and an important aspect in the running of a brewery operation [9]. Water consumption in a brewery is not only an economic parameter but also a tool to determine its process performance in comparison with other breweries [6].

Brewers are very concerned that the techniques they use are the best in terms of product quality and cost effectiveness.

During production, beer alternately goes through three chemical and biochemical reactions (mashing, boiling, fermentation and maturation) and three solid liquid separations (worth separation, worth clarification and rough beer clarification). Consequently, water consumption, wastewater and solid liquid separation constitute real economic opportunities for improvements in brewing [4, 10-12].

Water is a renewable natural source, vulnerable and limited, an essential element for life and society, a raw material for productive activities, an energy source and transport route, factor in maintaining the ecological balance [3].

Water and wastewater management constitutes a practical problem for the food and beverage industry including the brewing industry. In spite of significant improvement over the last 20 years, water consumption and disposal remain critical from an environmental and economic standpoint [4].

Water pollution affects the quality of life on a planetary scale. Water is the source of living organisms from all environments [8]. Its quality has increasingly begun to deteriorate further due to changes in physical, chemical and bacteriological. The global consumption of water, 69% is allocated to agriculture, industry 23% and only 8% in the household [2].

Corresponding author: *e-mail:* Cornelia.Lungu@ugal.ro

The beer industry resulting wastewater concentrates from different processes, and more diluted wastewater, consisting of the washings of the facilities, reservoirs, pipes and containers [7]. The concentrated wastewater are up to 0.5% of the total flow of water discharged and contains about 24% of organic load expressed in BOD5.

High content of degradable organic matter and the presence of microorganisms lead to a rapid start of fermentation processes associated with acidification and putrefaction [5, 13-15].

Taking into account all the above issues, the paper aimed to determine the chemical pollutant load of wastewater from the brewing industry.

2. Materials and Method

The analysed samples of wastewater were from a brewery plant in Galati, the evacuation of the station during the period January to December 2009. Samples were analysed immediately after collecting them.

For determinations were sampled instant. The samples collecting to comply with ISO 5667-2/1998 standard: Water quality. Sampling - Part 2: *Guidance on sampling techniques* [1]. Code samples analysed is shown in Table 1.

Table 1. Code wastewater samples

Code sample	Collection date
P1	January
P2	February
P3	March
P4	April
P5	May
P6	June
P7	July
P8	August
P9	September
P10	October
P11	November
P12	December

In experiments was used Lange Hach DR2800 Spectrophotometer Analysis Laboratory. In table 2 are presented quality indicators analysed and limits for wastewater discharge according to NTPA 001-2002 and standardized methods of analysis.

Statistical analysis was performed by one-way ANOVA method to determine if are significant differences between the physico-chemical characteristics of the wastewater samples from the brewing industry.

Table 2. Methods of analysis used in experiments

No.	Quality indicator values	Unit	Permissible limit values	Method of analysis
1	Suspended solids (MS)	mg/dm^3	35	SR ISO 6953-91
2	Biochemical oxygen demand (BOD 5)	mgO_2/dm^3	20	SR ISO 5815-91
3	Chemical oxygen demand (COD)	mgO_2/dm^3	125	SR ISO 6060-91
4	Ammoniacal nitrogen (NH_4)	mg/dm^3	2	SR ISO 8683-91
5	Total nitrogen (N)	mg/dm^3	10	SR ISO 7312-91

3. Results and Discussion

To determine the pollutant load of wastewater from the brewing industry were carried out research on the content of suspended solids, biochemical oxygen demand, chemical oxygen demand, ammonia nitrogen and total nitrogen. Variation of suspended solids is plotted in Fig. 1.

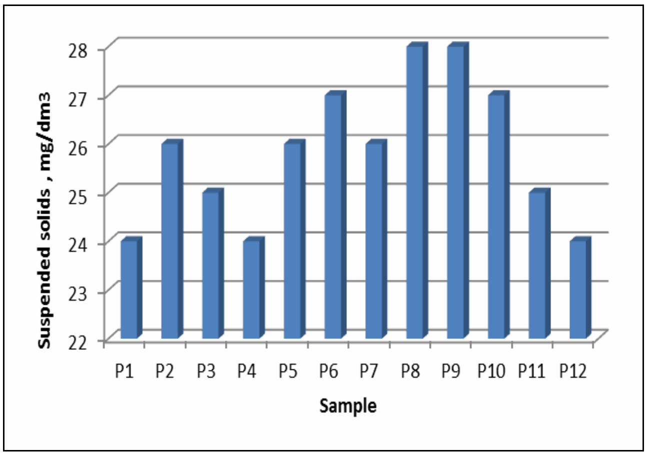

Figure 1. Variation of suspended solids in wastewater from the brewing industry

Fig. 1 shows that the results for this parameter remained relatively constant, with slight variations between 24 mg/dm^3 suspended solids in samples P1, P4, P12 and 28 mg/dm^3 suspended solids in samples P8 and P9.

The global analysis of the results it can be concluded that all the samples are within the limits imposed by ISO 6953-91, in terms of suspended solids content.

From the comparative analysis of suspended solids shown in Table 3 is statistically confirmed that among the 12 wastewater samples differ significantly, since F (144.4071)> Fcrt (2.417963).

This distribution allowed the acceptance of the alternative statistical hypothesis H1 (the values are influenced by the variable tested).

Table 3. Comparative analysis of materials in suspension

Source	Sum of Squares	df	Mean Square	F	P-value	Fcrt
Between groups	315.97	4	28.9925	144,4071	3.71	2.417963
Within groups	39.15	35	0.200769			
Total	355.12	39				

The amount of oxygen dissolved in water depends on water temperature, air pressure, the content of oxidizable substances and microorganisms.

Decrease the amount of oxygen in water leads to loss of freshness of its character by giving it a musty taste and making it non-potable.

Biochemical oxygen demand is the amount of oxygen consumed by microorganisms in a period of time to biochemical decomposition of organic substances contained in water. The standard time established was for 5 days at 20°C. In figure 2 is represented the variation of biochemical oxygen demand.

It can be noted from Fig. 2, that the results obtained for this parameter registered the minimum value of 14.1 mgO_2/dm^3 the sample P1 (minimum in winter, January), followed by 14.2 mgO_2/dm^3 value throughout the cold months in the sample P2 (February), P11 (November) and P12 (December). Maximum biochemical oxygen demand 16.2 mgO_2/dm^3 was recorded for sample P8 (maximum in summer). The overall analysis of the results can be concluded that all the samples are within the limits imposed by ISO 5815-91, in terms of biochemical oxygen demand.

A considerable decrease in dissolved oxygen with a grow biochemical oxygen requirements were present downstream of sewage discharges. Large amount of the organic matter presented in the bacteria that causes the point of discharge to grow and reproduce, consume dissolved oxygen. So initially there is a decrease in the amount of oxygen and biochemical oxygen dissolved increasing demand, so that in phase two, as the organic matrix is degraded in proportion to the amount of dissolved oxygen increases and decreases the BOD5.

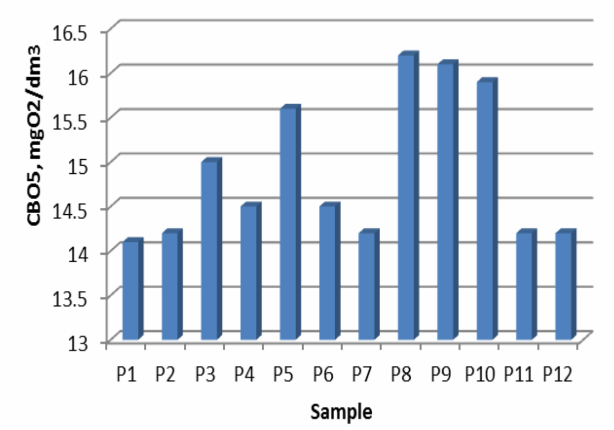

Figure 2. Variation of biochemical oxygen demand in the brewery wastewater

A comparative analysis of biochemical oxygen depicted in Table 4 is statistically confirmed that among the 12 sewage samples differ significantly, since F (17.40632)> Fcrt (2.101465).

This distribution enables acceptance of the alternative statistical hypothesis H1 (the values are influenced by variable frequency).

Table 4. Comparative analysis of chemical oxygen demand

Source	Sum of Squares	df	Mean Square	F	P-value	Fcrt
Between groups	178.75	4	80.9125	17,40632	5.29	2.101465
Within groups	66.25	35	4.120714			
Total	245.00	39				

Oxidizable substances in water or chemical oxygen demand (COD) are substances that can oxidize both cold and hot, the action of an oxidant.

Organic substances are oxidized to hot and inorganic to cold. Increasing the amount of organic substances in water is synonymous with water pollution by microorganisms that usually accompany those substances.

Fig. 3 is represented by the chemical oxygen demand change. It can be noted that all the samples are within the limits imposed by ISO 6060-91.

The lowest chemical consumption of oxygen was recorded in the sample P1 (87 mgO_2/dm3) and the highest value at P3 sample (99 mgO_2/dm^3).

Table 5. Comparative analysis of biochemical oxygen demand

Source	Sum of Squares	df	Mean Square	F	P-value	Fcrt
Between groups	395.65	4	92.9125	122,40632	5.29	2.414651
Within groups	161.725	35	5.100714			
Total	557.375	39				

Analysing the data in Table 5 is statistically confirmed that the chemical oxygen demand among the 12 sewage samples analyzed significant differences.

Applying this method allowed the acceptance of the alternative statistical hypothesis H1, as F (17.40632)> Fcrt (2.101465).

In terms of indicators of ammonia nitrogen and total nitrogen results in waste water samples analyzed are presented in Fig. 3 and Fig. 4.

In Fig. 3 the results for this parameter remained relatively constant, with slight variations between 1.2 mg/dm^3 ammonia nitrogen in samples P1 and P8 and 1.5 mg/dm^3 ammonia nitrogen in samples P6, P10 and P12. The samples are within the limits imposed by ISO 8683-91. In Fig. 4 indicates all the samples are within the limits imposed by ISO 7312-91. The lowest content was recorded for the sample P2 (7.8 mg/dm^3) and highest at P8 sample (9.5 mg/dm^3). Statistical analysis of ammonia nitrogen and total nitrogen content is presented in tables 6 and 7.

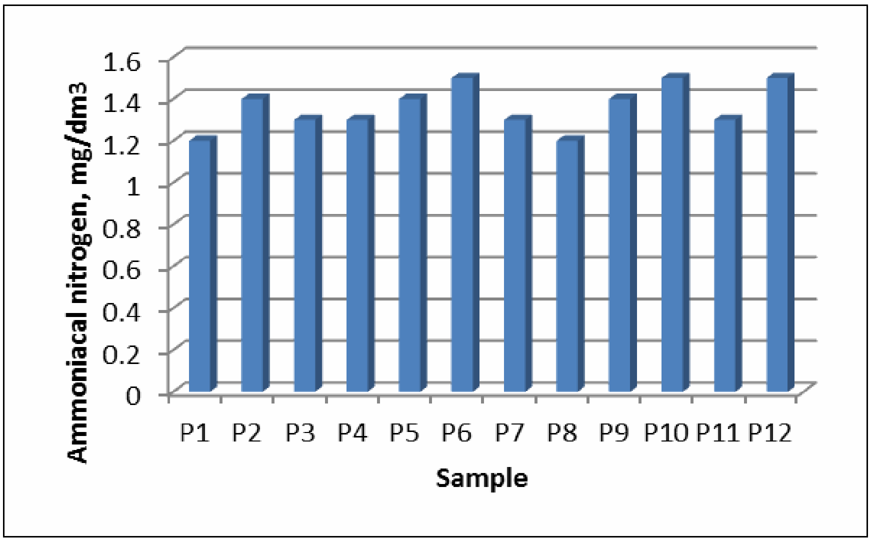

Figure 3. Changes in the ammoniacal nitrogen in the brewery wastewater

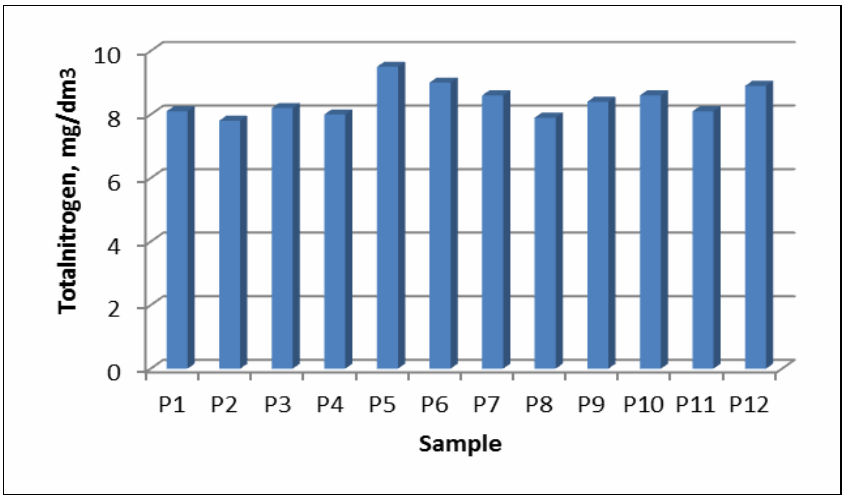

Figure 4. Changes in total nitrogen in wastewater from the brewing industry

Table 6. Comparative analysis of ammonia nitrogen content

Source	Sum of Squares	df	Mean Square	F	P-value	Fcrt
Between groups	1.05435	4	0.263588	2.3338	5.25	2.141466
Within groups	0.03796	35	0.001085			
Total	1.09231	39				

Table 7. Comparative analysis of total nitrogen content

Source	Sum of Squares	df	Mean Square	F	P-value	Fcrt
Between groups	6.235	4	1.60875	12.8125	2.13	3.641465
Within groups	1.396	35	0.039886			
Total	7.631	39				

Analysing the data in Table 6 and 7 is statistically confirmed that between the content of ammoniacal nitrogen that between all the 12 sewage samples analyzed were significant differences, because F> Fcrt. This distribution enables acceptance of the alternative statistical hypothesis H1.

4. Conclusion

To determine the quality of wastewater from the brewing industry were taken into account the results of chemical analysis conducted in January 2009 - December 2009, aiming at a general or specific set of indicators;

The parameters that give us information on the system oxygen demand (COD and BOD5) were within the acceptable limits throughout the period analysed.

Biochemical oxygen demand was lower during the winter and higher in summer.

Analysing nutrient group parameters, i.e., ammonia nitrogen and total nitrogen were found that present low levels of concentration, well below the allowable limit;

The indicators analysed showed that the wastewater coming from the water brewing industry is one that can be used for agricultural, fishery and industrial activities.

The statistical method one-way ANOVA confirmed that the parameters analysed statistically presents significant differences from the 12 samples studied wastewater.

References

1. *** NTPA 001/2002, Normativ privind stabilirea limitelor de încărcare cu poluanti a apelor uzate industrial si orăsenesti la evacuarea in receptori naturali;
2. Calin. G, Botez, M., Apele reziduale si mediul înconjurător, *Economia* **2004**, *1*, 5-9;
3. Găstescu, P., Zăvoianu, I., Resursele de apa din Romania – stare, calitate şi management, *Terra,* **2000,** XXX (L), 2;
4. Fillaudeau, L., Blanpain-Avet, P., Daufin, G., Water, wastewater and waste management in brewing industries, *Journal of Cleaner Production* **2006**, 14, 463-471, doi:10.1016/j.jclepro.2005.01.002
5. Pant, D., Adholeya, A., Biological approaches for treatment of distillery wastewater: A review, *Bioresource Technology* **2007**, *98*(12), 2321–2334, doi:10.1016/j.biortech.2006.09.027
6. Perry, M., De Villiers, G., Modelling the consumption of water and their utilities. *Brauwelt International* **2003**, *5*(3), 286-390
7. Serban, P., Politica europeană in domeniul apei – bază pentru dezvoltarea durabilă a gospodăririi apelor din Romania, *Hidrotehnica* **2003**, *48*(3), Bucuresti;
8. Traistă, E., Madear, G., *Igiena mediului – Igiena aerului si a apei*, Editura Universitas, 2000, Petrosani;
9. Unterstein, K., Energy and water go to make beer, *Brauwelt International*, **2000,** *18*(5), 368-370
10. Musee N., Nanowastes and the environment: Potential new waste management paradigm, *Environment International*, **2011,** *37*(1), 112-128, doi:10.1016/j.envint.2010.08.005
11. Ioannis S. Arvanitoyannis, Aikaterini Kassaveti, Demetrios Ladas, 6 - Food Waste Treatment Methodologies**,** *Waste Management for the Food Industries*, **2008**, 345-410, ISBN: 978-0-12-373654-3 doi:10.1016/B978-012373654-3.50009-2

12. Hideki Harada, Shigeki Uemura, Ann-Cheng Chen, Jayabalasingham Jayadevan, Anaerobic treatment of a recalcitrant distillery wastewater by a thermophilic UASB reactor, *Bioresource Technology*, **1996**, *55*(3), 215-221, doi:10.1016/0960-8524(96)00003-X
13. Burak Demirel, Orhan Yenigun, Turgut T. Onay, Anaerobic treatment of dairy wastewaters: A review, *Process Biochemistry*, **2005**, *40*(8), 2583-2595, doi:10.1016/j.procbio.2004.12.015
14. Meric S., Fatta Kassinos D., Water Treatment, Municipal, *Encyclopedia of Microbiology (Third Edition)*, **2009**, 587-599, doi:10.1016/B978-012373944-5.00164-4
15. Pell M., Wörman A., Biological Wastewater Treatment Systems, *Encyclopedia of Ecology,* **2008**, 426-441, doi:10.1016/B978-008045405-4.00317-7 |