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Article

Environmental assessment of wastewater from food and beverage production in the Romanian urban water cycle

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Abstract
The food and beverage industries are considered essential sources of wastewater contaminated with pollutants discharged into the sewerage networks of cities. This study focused on monitoring the analytical parameters regulated in the environmental legislation in force in Romania for factories with various sectors of activity in the processing industry. The main objective is to understand the presence of conventional contaminants in the effluents from the food and alcoholic beverages industry and raise awareness of the effects of spillage in local networks. The study occurred over three years, between 2020 and 2022 when monthly wastewater samples from factories processing chocolate, meat, and alcohol were monitored. Values that exceed the maximum allowed limits were recorded for the meat processing factory due to the processed raw materials. The effluents resulting from the technological processes of meat processing significantly impact the aquatic environment.

Keywords: *wastewater monitoring, food and beverage industry, suspended solids, environmental impact*

INTRODUCTION

Urban wastewater represents a mixture of household wastewater with industrial wastewater and/or rainwater, a definition provided by the European Union (EU) within the framework of Directive 91/271/EEC [1]. The information regarding the use of water by industry and the wastewater discharged in the European Union is collected by Eurostat as statistical data. Among the most significant industrial sectors are mention mining industry, the processing industry (food products, textiles, paper and paper products, chemical, and petrochemical products), the production and distribution of energy, and construction [2].

The food and beverage industry in the EU represents the most important sector of activity that contributes to economic growth. However, the sector faces environmental problems, such as high-water consumption and wastewater production [3]. The factors that can have a significant effect on the quality of wastewater from the food industry are the size of the factories, the production capacity, the degree of pre-processing of certain ingredients, waste management, and the company's ability to modernize its treatment equipment and most importantly, the volume of water involved in specific technological processes [4, 5].

A series of quality indicators are used to assess the degree of impurity of wastewater, regardless of its origin. These indicators are grouped according to their nature and effect on water quality (physical, chemical, and biological parameters) [6]. Wastewater from the food industry is characterized by a series of physical-chemical parameters that influence the availability of their discharge into the urban water cycle. The concentration of organic pollutants (expressed by

biochemical oxygen demand – BOD [7,8], chemical oxygen demand – COD [8]) in wastewater from the food industry varies, depending on the branch from which they come and the technological process carried out. Another critical parameter involved in the quality of wastewater from the food industry is the high concentration of solid suspensions [7-9] (generally characterized by the presence of fats, oils, but also waste resulting from the processing of vegetable raw materials); it is necessary to be separated before the water enters the urban water cycle. At the same time, effluents from the food industry contain significant amounts of nutrients [10] (organic nitrogen or phosphorus) (e.g., effluents from the production of bakery products) [7], but also of heavy metals (copper, chromium, nickel, lead) [11].
Technological processes in the food and beverage industry are the primary sources of wastewater production. The most well-known is the processing of meat, milk, fish, vegetables, and fruits, but also the production of starch, gluten, sugar, or alcoholic/non-alcoholic beverages.
The sweets industry has its main products: candies, cakes, pies, rolls, and other desserts. Factories in this field process raw materials and products such as flour, butter, margarine, eggs, sugar, and flavors; most of the wastewater obtained from the manufacturing processes has a high content of BOD [7, 12] and suspended solids [7, 9, 12], and it is necessary to pre-treat the wastewater resulting from discharge into the city sewer network [13].
From the meat industry comes ham, sausages, salami, and pastrami. The technological manufacturing process requires fast processing of the raw materials. Most of the time, factories producing meat specialties have their slaughterhouses. The waste associated with slaughter shows inseminated amounts (beef 50%, sheep 50%, and pig 25%) [14]. The primary effluents come from washing machines, washing meat, sanitizing work spaces, and personnel. The waters from this industry are highly charged and contain many lipid compounds (fats, solid suspensions, blood, feces) and organic compounds derived from proteins) [7, 8, 14]. High values of pH parameters, chemical oxygen demand, biochemical oxygen demand, suspended solids, total nitrogen, and total phosphorus characterize them [14, 15].
Due to the diversity of products in the beverage industry, there is also a significant variation in the composition of wastewater (flow and loading). The volume of wastewater from the distilled drinks industry is lower than in other food processing sectors due to the low number of production processes. However, in the alcoholic beverages industry, due to the fermentation processes, an impressive volume of wastewater and waste is produced from grain granules and materials used in the fermentation process [15]. Generally, the wastewater from the alcoholic beverages industry is characterized by an average load of organic matter [15].
In the territory of Romania, the food industry is the second most important economic activity that generates inseminated quantities of wastewater loaded with pollutants, after the chemical and petrochemical industry, according to statistical data published in 2021. Moreover, the most significant volume of water distributed for the industry and construction sector, approximately 35 thousand m^3, was registered in the Arges - Vedea hydrographic basin, the activity area of most food and beverage factories [16].
The current case study explores the similarities and differences regarding the pollutant loading level of wastewater from three companies in the food and beverage industry activity sector, over three years, between 2020 and 2022. This study aims to understand the influence on the environment regarding the wastewater discharges of factories with different fields of activity. Moreover, by comparing the results recorded regarding the residual water footprint, it is possible to rank the products obtained from the food industry on the environmental profile, and the main impact factors will also be illustrated.

MATERIAL AND METHODS

All the factories included in this study, with a field of activity in the processing and producing food and beverages carry out their activity in the southeastern area of Romania. These have as their activity sector processing and marketing of chocolate, chocolate products, and pastry products; another factory is involved in the processing and marketing of meat products such as sausages,

salami, and other products similarly, and the last factory has its main activity the production of distilled alcoholic beverages. These will be anonymized as follows: Chocolate factory – F1, Meat products factory – F2, and Alcoholic beverage factory – F3.
Sampling and monitoring of the discharge of wastewater into the aquatic environment were done monthly in accordance with the requirements of the NTPA 002, norm regarding the treatment of urban wastewater, respectively, regarding the conditions for the evacuation of wastewater in the sewerage networks of the localities and directly in the treatment plants. The parameters for monitoring the quality of wastewater discharged into the sewage networks of the localities, together with the maximum values allowed for each parameter, are presented in Table 1 with the standardized test methods.

Table 1. Quality indicators of wastewater discharged into the sewage networks of localities

No.	Parameters	Unit	Reference values*	Standardized method
1	Temperature	°C	40	-
2	pH	pH units	6.5-8.5	SR EN ISO 10523-97
3	Suspended solids	mg/L	350	SR EN 6953:81
4	BOD_5	mgO_2/L	300	SR EN 1899-2:2002
5	COD	mgO_2/L	500	SR EN ISO 6060:96
6	Ammoniacal nitrogen	mg/L	30	SR ISO 7150-1:2001
7	Total phosphorus	mg/L	5	STAS 10064-75
8	Total cyanides	mg/L	1.0	SR ISO 6703/1-98-2/00
9	Sulphides and hydrogen sulphide	mg/L	1.0	SR ISO 10530-97
10	Sulphites	mg/L	2.0	STAS 7661-89
11	Sulphates	mg/L	600	STAS 8601-70
12	Water vapour-extractable phenols	mg/L	30	SR ISO 8165/1/00
13	Extractable substances	mg/L	30	SR 7587:1996
14	Synthetic detergents	mg/L	25	SR EN 903:2003
15	Lead	mg/L	0.5	SR ISO 8288:2001
16	Cadmium	mg/L	0.3	SR EN ISO 5961-2002
17	Total chromium	mg/L	1.5	SR EN 1233:2003
18	Hexavalent chromium	mg/L	0.2	SR EN 1233:2003
19	Copper	mg/L	0.2	SR ISO 8288:2001
20	Nickel	mg/L	1.0	SR ISO 8288:2001
21	Zinc	mg/L	1.0	SR ISO 8288:2001
22	Total manganese	mg/L	2.0	SR ISO 6333-96
23	Free residual chlorine	mg/L	0.5	SR EN ISO 7393-3:2002

* NPTA 002, Decision no. 352/2005, Official Monitor of Romania no. 398/11 May 2005.

RESULTS AND DISCUSSION

Following the current environmental legislation in Romania, the wastewater discharged from three factories in the food and beverage industry was monitored. The monitoring included analyzing the leading indicators that characterize the pollution level of wastewater discharged into urban sewage networks; these are pH, suspended solids, COD, BOD5, synthetic detergents, ammoniacal nitrogen, total phosphorus, total chromium, copper, lead, and zinc. With the results obtained from the analytical investigations in the period 2020-2022, a database was obtained that allowed the performance of studies to interpret the quality of the wastewater discharged by the economic agents and to detect possible exceedances of the maximum values allowed by the legislation in the field, for the tested parameters.

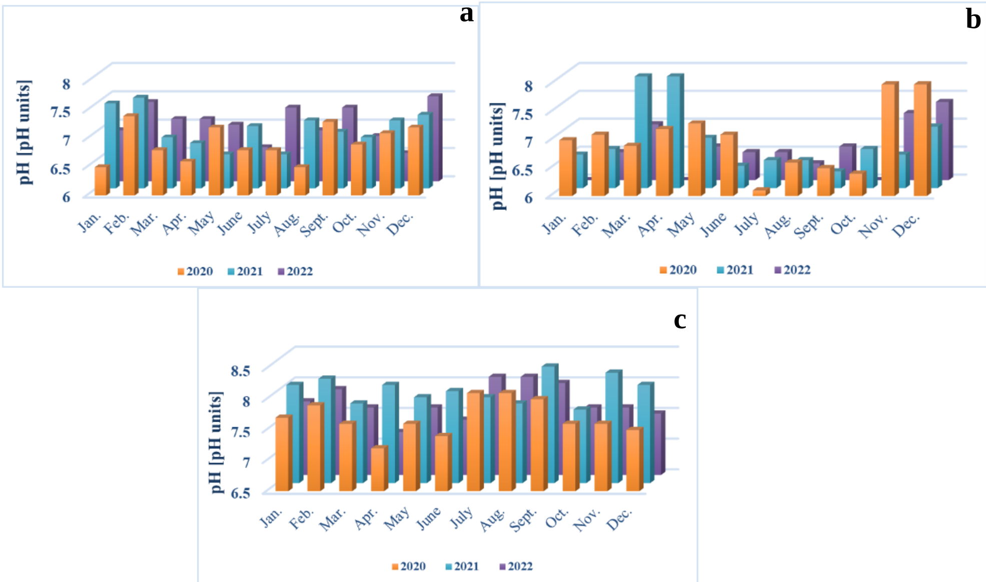

Fig. 1. pH variation between 2020 and 2022 in: (a) F1, (b) F2, and (c) F3

The pH parameter in wastewater samples is regulated in environmental legislation in the 6.5-8.5 pH unit range. Most of the determined values for the chocolate factory were 6.6-7.1 pH units. Thus, in 2020 the range of values fell between 6.5-7.4; in 2021, between 6.6-7.5 and in 2022, the pH values ranged between 6.5-7.5 units (Fig. 1a).

For the meat products factory, the analysis results showed that the wastewater samples discharged from the technological processes had pH values exceeding the range of 6.5-8.5. In 2020, exceedances of the normed values were determined in July (6.1 pH units) and October (6.4 pH units). A relatively identical situation was reported in 2021 when two exceedances were reported in June (6.4 pH units) and September (6.3 pH units). In 2022, more overage values were recorded with lower pH values; January (5.3 pH units), April (5.9), August (6.3), and October (6.0) (Fig. 1b).

The pH parameter in the case of the beverage factory recorded values that fall within the maximum allowed by the legislation of 6.5-8.5 pH units. The variations of the values recorded in 2020 and 2022 were comparable. Thus, in 2020 the range of values fell between 7.1-8.2 pH units, and in 2022 between 7.2-8.1 pH units. In 2021, the measured range included values between 7.7 in October and 8.4, respectively, in September (Fig. 1c).

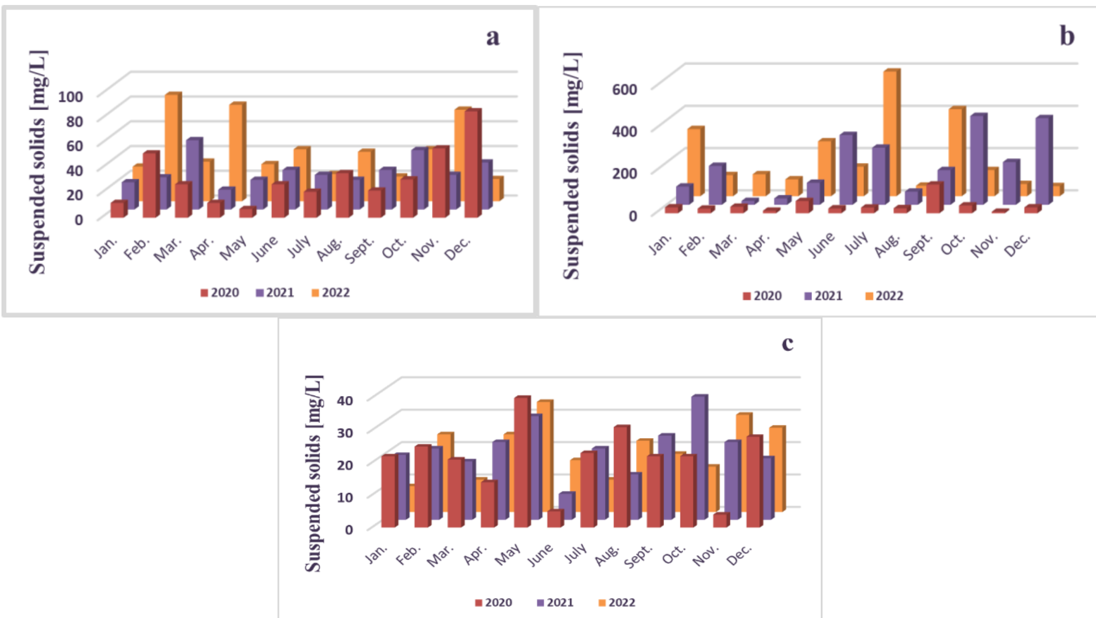

Fig. 2. Suspended solids variation between 2020 and 2022 in: (a) F1, (b) F2, and (c) F3

Another important parameter for identifying the pollution level of wastewater is represented by suspended solids with the maximum allowed value of 350 mg/L. For the chocolate factory, in the 2020-2022 monitoring interval, all the determined results fell within the standard value. In 2020, there were recorded concentration values in the range of 7mg/L - 56 mg/L with a maximum value of 86 mg/L in December, while in 2021, the determined values were between 16 mg/ L - 56 mg/L. More significant variations were registered in 2022 when the recorded values started from 18 mg/L in December and reached 42 mg/L in June, adding two maximum values of 78 mg/L in April and 86 mg/L in February (Fig. 2a).
Contrary to previous results, exceeding the maximum allowed concentrations for the meat products factory was recorded in 2021 and 2022. Thus, in 2020, values were recorded in a lower range of concentrations (7 mg/L - 58 mg/L, with a maximum in September of 136 mg/L). In the following years, the range of measured values was more comprehensive, with four exceedances of the standard value being recorded, namely 420 mg/L in October 2021 and 410 mg/L in December 2021, respectively 590 mg/L in July 2022, and 412 mg/ L in September 2022 (Fig. 2b).
The suspended solids parameter was also monitored regularly for the alcoholic beverage factory, and the determined results fell within typical values. The concentrations determined in 2021 and 2022 show values between 8 mg/L - 32 mg/L, respectively, between 8 mg/L - 34 mg/L. In 2020, there were recorded values of concentrations determined on a broader range of values, from 4 mg/L in November and reaching a maximum value of 42 mg/L in May (Fig. 2c).

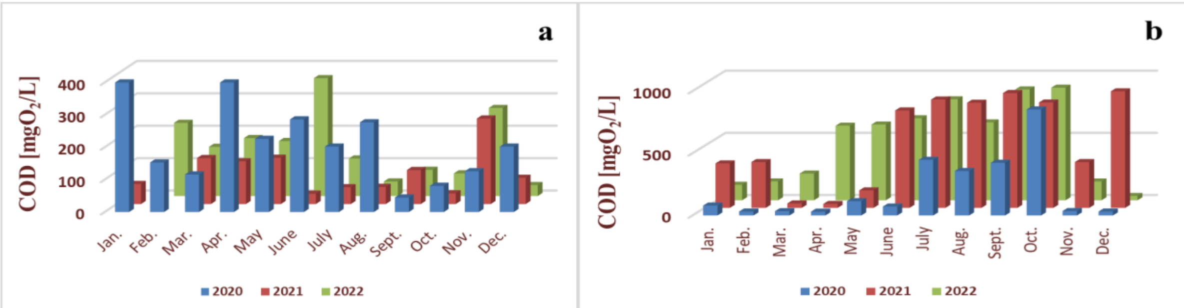

Fig. 3. COD variation between 2020 and 2022 in: (a) F1 and (b) F2

Regarding the COD parameter, it has a maximum allowed value of 500 mgO$_2$/L. Through the regular monitoring of the organic load in the tested wastewater, values below the permitted limit were recorded and correlated with the nature of the economic agent's production. This fact is confirmed by the values obtained, which are 100 mgO$_2$/L - 300 mgO$_2$/L in most of the analyzed samples from the chocolate factory. In 2020, the recorded results had values between 45.2 - 430 mgO$_2$/L. Lower values compared to 2020 were recorded in 2021, when the concentration range was between 32 mgO$_2$/L in June and 264 mgO$_2$/L in November. In 2022, the measured values were at most 200 mgO$_2$/L, with a minimum value of 34 mgO$_2$/L, in December and a maximum value of 364 mgO$_2$/L in June (Fig. 3a).
For the meat products factory, the evaluation shows a high level of organic load in the tested wastewater. If in 2020, the determined values fell within the range of 31 mgO$_2$/L - 448 mgO$_2$/L, with a single exceedance identified in October (853 mgO$_2$/L), the overage values were numerous in the following years of monitoring. Thus, in 2021, six samples exceeded the COD limit with values between 784 and 938 mgO$_2$/L. In 2022, for 7 of the 12 samples analyzed, exceedances were recorded up to a maximum value of 905 mgO$_2$/L, recorded in October. The increased values of this important indicator of the pollution level are due to the high organic load of the water resulting from the technological processes and the washing processes on the surfaces where the meat is processed (Fig. 3b).
According to the data recorded for the COD parameter, the evaluation carried out in the alcoholic beverage factory highlighted a shallow level of organic loading in the tested wastewater. This fact is confirmed by the obtained values, which, in most of the analyzed samples, are below the determination limit of the test method, which is 30 mgO$_2$/L.

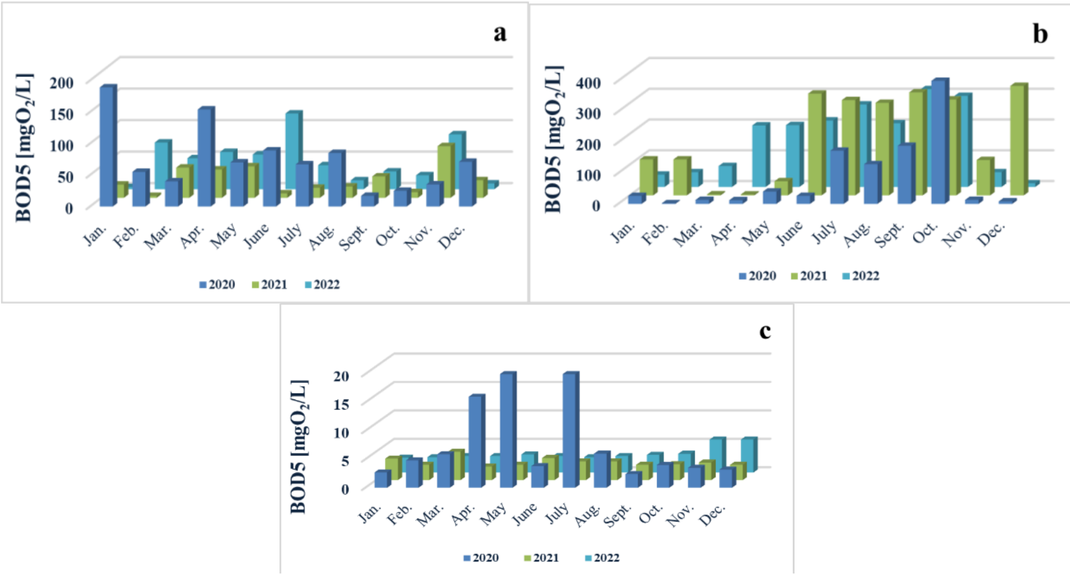

Fig. 4. BOD_5 variation between 2020 and 2022 in: (a) F1, (b) F2, and (c) F3

The values of BOD_5 show a maximum value allowed by the Romanian environmental legislation of 300 mgO_2/L. For the chocolate factory, the results of the monitoring of the BOD_5 parameter were correlated with those of the COD, being below the maximum allowed limit. Moreover, in the case of this parameter, there were variations in the determined values, these being between 17.2 mgO_2/L - 89 mgO_2/L, with a maximum of 189 mgO_2/L, in January 2020, between 3 mgO_2/L - 82 $mgO_2/$ L, in 2021 and between 3.3 - 74 mgO_2/L, with a maximum value of 120 mgO_2/L, in June 2022 (Fig. 4a).

In the case of the factory with meat products, the BOD_5 values showed variations below and above the maximum allowed limit. If in 2020, the values fell within the range of 2.24 mgO_2/L - 415 mgO_2/L, the value above the allowed limit being recorded in October, frequent exceedances were recorded in the following years. Thus, in 2021, 5 exceedances were recorded in July, August, September, October, and December with a maximum value of 356 mgO_2/L. In 2022, the trend was to increase the determined values between 12 mgO_2/L - 296 mgO_2/L, with only one exceeding the maximum allowed value in September (318 mgO_2/L) (Fig. 4b).

The BOD_5 values recorded in the beverage factory were below the maximum allowed limit of 300 mgO_2/L. The determined values were between 2.5 mgO_2/L – 25.6 mgO_2/L in 2020, 2.4 mgO_2/L - 3.9 mgO_2/L in 2021, and 2.6 mgO_2/L – 5.8 mgO_2/L in 2022. The determined concentrations indicated a low level of BOD_5 for wastewater discharged into the urban water network (Fig. 4c).

Anionic and non-ionic synthetic detergents have a maximum allowed concentration value of 25 mg/L. For anionic-active synthetic detergents, the values determined from the monitoring of the chocolate factory were below the value of the maximum limit allowed. The concentrations determined in the three years of monitoring were close in value, falling between a minimum value of 0.11 mg/L (2021 and 2022) and a maximum value of 0.95 mg/L in April 2020 (Fig. 5a).

For the meat products factory, the minimum concentration of anionic-active synthetic detergents was 0.11 mg/L, and the maximum was 2.33 mg/L in May 2022 (Fig. 5b). In the case of non-ionic synthetic detergents, the minimum concentrations were 0.15 mg/L and the maximum was 2.2 mg/L in May 2022 (Fig. 5c).

Relatively similar behavior was also observed in the case of the alcoholic beverages factory, where the values determined for anionic-active and non-ionic detergents in the years 2021 and 2022 were below the limit of determination of the test methods (0.1 mg/L, respectively 0.15 mg/L).

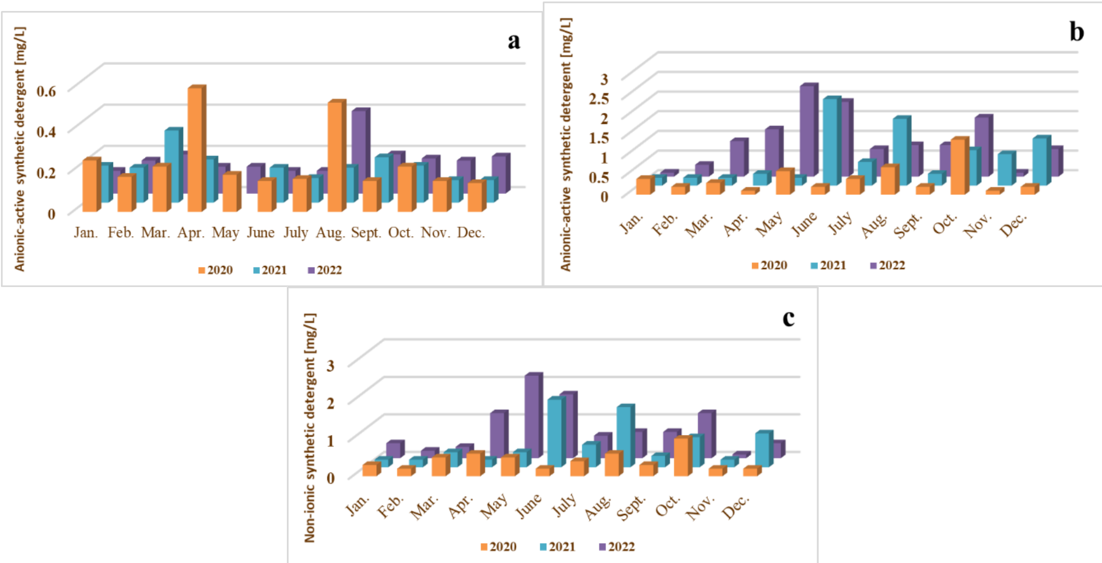

Fig. 5. Synthetic detergents variation between 2020 and 2022 in: (a) F1, (b) F2a, and (c) F2b

Among the metallic elements analyzed, Copper was the only one that recorded measurable values for the chocolate factory. The concentrations identified in the wastewater during the three years of monitoring were far below the maximum allowed value of 0.2 mg/L. The minimum value determined was 0.001 mg/L in 2022, and the maximum was 0.01 mg/L in 2020 and 2021. For the factory with meat products, the values recorded during the monitoring program were below the limit of quantification of the test method (Fig. 6a).

In the case of the beverage factory, the concentrations identified for the copper parameter in the wastewater were below the maximum allowed value of 0.2 mg/L. The minimum value determined was 0.0006 mg/L in May 2022 and the maximum of 0.001 mg/L in November 2020 (Fig. 6b).

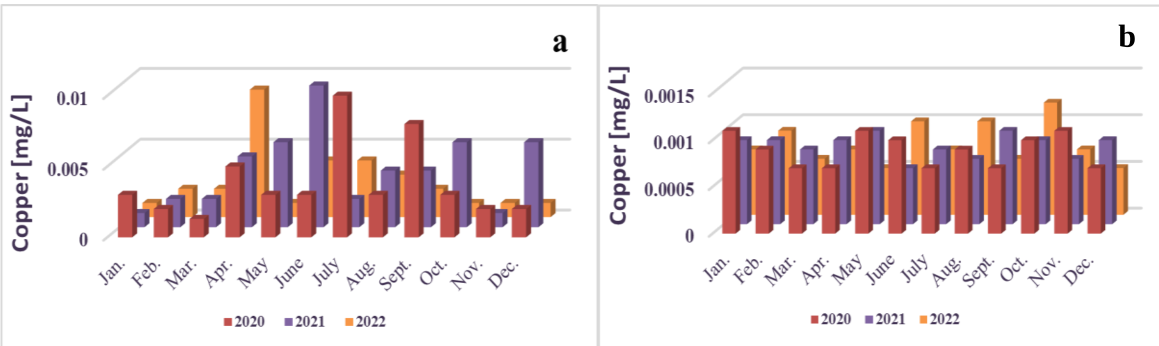

Fig. 6. Copper variation between 2020 and 2022 in: (a) F1 and (b) F3

Zinc is the only metal element that presented detectable values in the analyzed samples from the meat products factory but without overage the maximum limit allowed by law, namely 1 mg/L. The minimum and the maximum concentrations detected were 0.01 mg/L and 0.18 mg/L in 2020 (Fig. 7a).

In the wastewater samples from the alcoholic beverage factory, the element zinc was detected in most of the analyzed samples at concentrations starting from 0.022 mg/L and up to the concentration of 0.12 mg/L, recorded in October 2020. In 2022, in six of the samples analyzed, the determined values were below the quantification limit of the test method (Fig. 7b).

Lead was identified only in the samples from the beverage factory, in all tested samples, but at much lower concentrations than the maximum allowed limit of 0.5 mg/L. The lowest determined value was 0.001 mg/L (April 2021), and the highest was 0.002 mg/L (January 2020) (Fig. 7c).

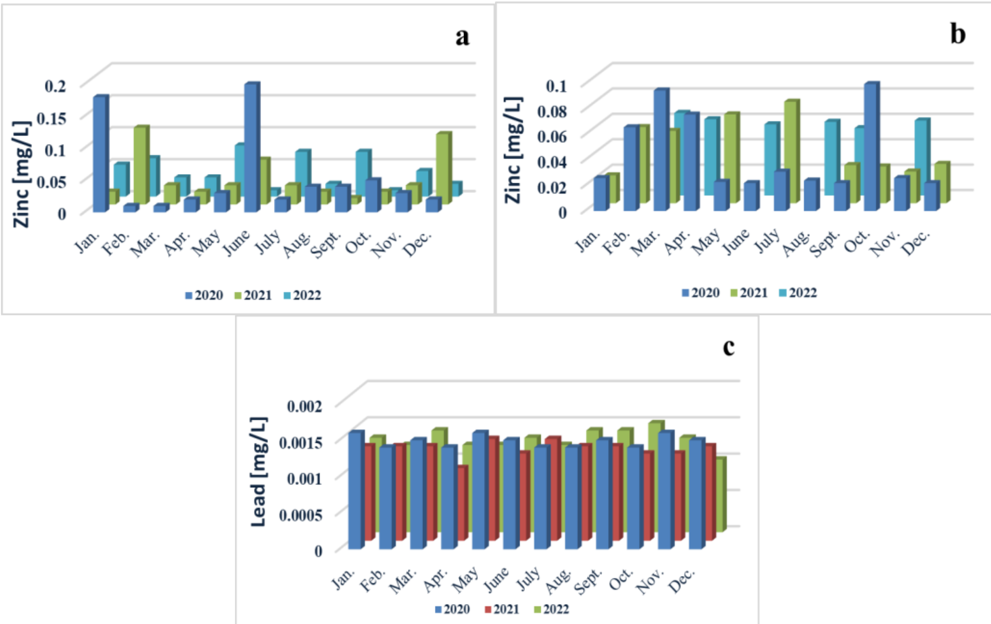

Fig. 7. Zinc and Lead variation between 2020 and 2022 in: (a) F2, (b) F3a, and (c) F3b

Ammoniacal nitrogen was identified only in the wastewater samples from the meat products factory. The parameter is standardized at 30 mg/L; the values obtained were exceeded in 2021 and 2022. Thus, in 2020 the determined values fell within the concentration range between 0.03 mg/L - 4.23 mg/l, while in 2021, the recorded concentrations reached the maximum in June at 76.5 mg/L. Furthermore, in 2022, the maximum allowed limit for wastewater was exceeded, namely 67.5 mg/L, in October (Fig. 8a).
Total phosphorus is another parameter quantified in the samples analyzed from the meat products factory. During the monitoring period, exceedances of the maximum allowed concentration value of 5 mg/l were recorded. The determined values fell into close concentration ranges (0.24 – 4.32 mg/L in 2020; 0.1 – 4.58 mg/L in 2021; respectively 0.5- 4.46 mg/L in 2022). In 2021, an exceedance of the maximum allowed value was recorded in July (7.02 mg/L), and in 2022, exceedances were recorded in May (5.78 mg/L), July (5.32 mg/L) and in September (6.44 mg/L) (Fig. 8b).
In addition, the results obtained for the total chromium parameter were below the maximum allowed value of 1.5 mg/L. The concentrations detected with values between 0.002 mg/L, in July and 0.0025 mg/L, in October 2022 could only be quantified for the samples from the alcoholic beverage factory (Fig. 8c).

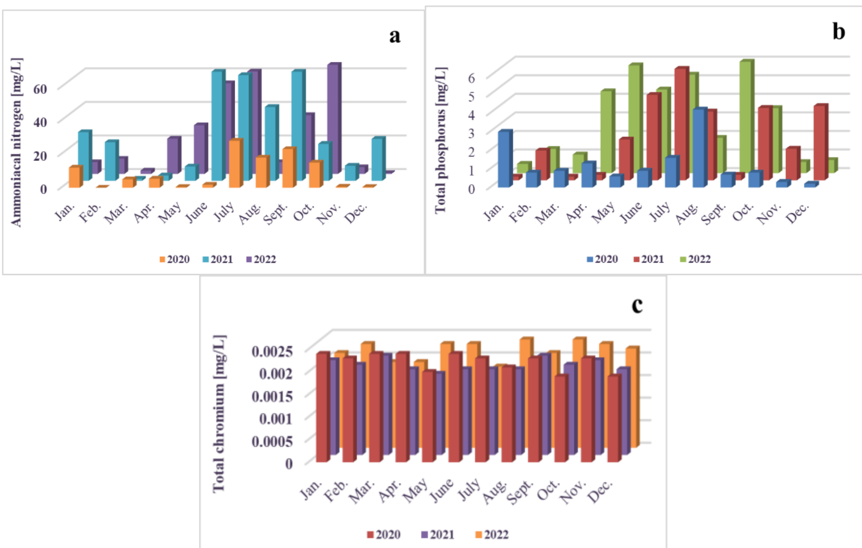

Fig. 8. Ammoniacal nitrogen, total phosphorus and total chromium variation between 2020 and 2022 in: (a) F2a, (b) F2b, and (c) F3

Summarizing the data collected in the monitoring program carried out between 2020-2022 in all the factories, the parameters stipulated in the environmental legislation were recorded. However, two of the factories participating in the study had parameter values that characterize the resulting wastewater, located below the maximum limits allowed according to Table 1, namely the chocolate factory and the alcoholic beverage factory. For the wastewater samples from the factory with meat products, exceedances were recorded for several analyzed parameters.

The wastewater from the chocolate factory and the alcoholic beverage factory is characterized by values of quality indicators that fall within limits imposed by the environmental regulations in force. The results obtained below the maximum allowed limits are due to a rigorously maintained technological discipline, strict hygiene for cleaning the machines and the production spaces, and the possible installation of pre-treatment stations for wastewater [17], which leads to a decrease in the values of their quality indicators.

In contrast, the results obtained from the factory's physical-chemical characterization of the wastewater discharged into the sewage network with meat products illustrated several exceedances of the parameters pH, suspended solids, COD, BOD_5, ammonia, and total phosphorus. These excesses mainly result from the meat processing stages and secondary operations (dosing, chopping, processing), which generate wastewater loaded with pollutants, liquid, and solid wastes that are difficult to remove. Moreover, these exceedances can occur due to the poor hygiene of the spaces and work equipment and the faulty management or lack of pre-treatment of the wastewater before discharge into the urban sewage system [15,17].

Sources of pollution loading and effects on the aquatic environment

In the food industry, there are many sub-sectors of activity; therefore, diversity in the raw materials (fruits, vegetables, meat, fish, and dairy) implicitly on the resulting food products, the technical production processes, and operations [18]. However, most factories in the food and beverage sector face many common environmental problems. Among the most important is the excessive consumption of water in manufacturing processes and the washing of work equipment; as a result, impressive amounts of wastewater are formed that will be discharged into the sewerage network. Another characteristic that affects the environment is the use of chemical products in processing procedures, cleaning and sanitizing work equipment, and qualified personnel, leading to solid and liquid waste generation [19]. All these aspects lead to an increase in the level of pollutants in the wastewater discharged by the factories, such as BOD, COD, solid suspensions, nutrients (nitrogen, phosphorus), synthetic detergents, and free residual chlorine. Pollutants discharged through the wastewater in the sewage networks adversely affect the entire aquatic system [20].

The exceedances recorded for each conventional pollutant in this study have an unfavorable environmental potential. Studies show that exceeding the biochemical oxygen demand (BOD5) in wastewater reduces dissolved oxygen concentration, leading to increased mortality among aquatic organisms and fish [21]. Low or high values of the pH level and nutrients contribute to the increase in mortality among aquatic organisms, to the eutrophication of waters, and to the deterioration of aquatic ecosystems [21]. In addition, an increased level of suspended solids reduces the penetration of light into the fish habitat. It limits the growth of aquatic vegetation, alters the aquatic environment through sedimentation, leads to the depletion of the oxygen level, and clogs the fish's gills [20-21].

Regarding the potential sources of origin of the primary pollutants, it is considered that they result from the use of chemical substances in several processes in the food industry. The main significant chemical substances, and the technological processes in which they are used, are presented in Table 2. According to the data included in the monitoring study, it can be said that factories with a sector of activity in the production of chocolate and chocolate products, as well as those with a sector in the production of distilled alcoholic beverages, are safer for the aquatic environment in terms of wastewater discharges into the sewage network urban, than factories with a profile of processing meat products.

Table 2. Chemical substances used in the production of food and beverages [21]

Technological process	Chemical substances
Water disinfection	Chlorine and chlorine derivatives
Detergents and cleaning products	Chlorine, nitric acid, phosphoric acid
Food ingredients	Phosphoric acid, metals (zinc, copper, manganese)
Wastewater treatment	Ammonia, nitric and sulfuric acid vapours
Refrigerants	Ammonia, Freon 113
Packaging manufacturing and printing	Various coating solvents (toluene, xylene), metals (manganese, nickel, chrome) and metallic pigments (copper, chrome, zinc, lead)
Catalysts	Nickel and nickel compounds
Extraction solvents	Phosphoric acid, dichloromethane
Reactants	Ammonia, chlorine and derivatives

CONCLUSIONS

The purpose of this study was to present an overview of the food and beverage processing industry, to raise awareness of the environmental effects of wastewater discharge into urban sewers, and to assess the potential sources leading to high concentrations of pollutants. For this reason, a monitoring study of wastewater discharged was conducted to record the parameters that characterize the pollutant load for three factories in the food and alcoholic beverage industry.

The recorded results showed that all the factories included in the study (chocolate factory, alcoholic beverage factory, and meat product factory) presented values of conventional pollutants from the Romanian environmental legislation. The chocolate factory and the alcoholic beverage factory recorded parameter values below the maximum limit allowed by law, which confirms the idea that the discharge of wastewater from these sectors of activity is safe for the aquatic environment. Regarding the parameters recorded for the meat products factory samples, they recorded several exceedances of pH, suspended solids, COD, BOD5, ammonia, and total phosphorus.

The consequence of these excesses having adverse effects on the aquatic environment, among others, is the reduced concentration of dissolved oxygen, which induces mortality in fish and aquatic organisms.

REFERENCES

[1] EUROSTAT. Statistics Explained. Urban wastewater, www.ec.europa.eu. [18.06.2023].
[2] EUROSTAT. Statistics Explained. Water use in industry, www.ec.europa.eu. [18.06.2023].
[3] CASANI, S., ROUHANY, M., KNØCHEL, S., Water Res., 39, no. 6, 2005, p. 1134.
[4] FAO (2020), The State of Food and Agriculture 2020. Overcoming water challenges in agriculture. https://www.fao.org/state-of-food-agriculture/en [18.06.2023].
[5] SIEGRIST, M., Trends Food Sci. Technol., 19, no. 11, 2008, p. 603.
[6] SCHMIDT, C. J., FARQUHAR, J. D., CLEMENTS, E. V., Wastewater characterization for the specialty food industry, National Environmental Research Center, Office of Research and Development, US Environmental Protection Agency, U.S., 1974, p. 15-41.
[7] BARBERA, M., GURNARI, G., Wastewater treatment and reuse in the food industry, Springer International Publishing, Scotland, 2017, p. 1-16.
[8] GARG, S., CHAUDHRY, S., Int. Adv. Res. J. Sci. Eng. Technol., 4, no. 6, 2017, p. 153.
[9] SERVAIS, C., JONES, R., ROBERTS, I., J. Food Eng., 51, no. 3, 2002, p. 201.
[10] ONET, C., An. Univ. Oradea, 15, 2010, p. 709.
[11] LIM, A. P., ARIS, A. Z., Rev. Environ. Sci. Biotechnol., 13, no. 2, 2014, p. 163.
[12] QASIM, W., MANE, A. V., Water Resour. Ind., 4, 2013, p. 1.
[13] MORAR, F., RUS, D., LUNG, B. I., Proc. Technol., 22, 2016, p. 486.
[14] MITTAL, G. S., Food Rev. Int., 20, no. 3, 2004, p. 229.
[15] VALTA, K., KOSANOVIC, T., MALAMIS, D., MOUSTAKAS, K., LOIZIDOU, M., Desalin. Water Treat., 53, no. 12, 2015, p. 3335.

[16] INSSE. Distributia apei si evacuarea apelor uzate, in anul 2021. www.insse.ro. [18.06.2023]
[17] DASKALOPOULOS, E., BADR, O., PROBERT, S. D., Appl. Energy, 54, no. 4, 1997, p. 209.
[18] GIROTTO, F., ALIBARDI, L., COSSU, R., Waste Manage., 45, 2015, p. 32.
[19] COROMINAS, L., BYRNE, D. M., GUEST, J. S., HOSPIDO, A., ROUX, P., SHAW, A., SHORT, M. D., Water Res., 184, 2020, p.1.
[20] AKPOR, O. B., MUCHIE, B., Afr. J. Biotechnol., 10, no. 3, 2011, p. 2379.
[21] Anthesis Provision. A Review of Wastewater Management & Best Practices for Dischargers in the Food Processing Sector, https://provisioncoalition.com/. [20.06.2023]

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