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ASSESSMENT OF THE INITIAL POLLUTION LEVEL AND MAIN POLLUTING COMPONENTS OF BREWERY WASTEWATER

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Abstract. The paper evaluates the initial pollution level of brewery wastewater and identifies the main pollutant components formed during beer production. Special attention is given to chemical oxygen demand (COD), biochemical oxygen demand (BOD), suspended solids, turbidity, and dry residue. The untreated wastewater showed COD of 3200 mg/L, BOD of 1800 mg/L, and suspended solids of 950 mg/L. The BOD/COD ratio was 0.56, indicating a substantial biodegradable organic fraction. The main pollution sources included wort and malt residues, yeast biomass, proteins, sugars, alcohols, organic acids, filtration materials, detergents, and disinfectants. Grouping pollution sources by production stage demonstrates the variability of brewery wastewater composition and the importance of initial characterization for selecting an appropriate treatment strategy.

Keywords: brewery, wastewater, COD, BOD, suspended solids, yeast biomass, wort, organic pollution, turbidity, dry residue.

Introduction

Brewing is one of the water-intensive branches of the food industry, and water is used at nearly all stages of the technological process. Raw material preparation, malt grinding and mash preparation, wort boiling, fermentation, filtration, container washing, and the sanitary treatment of pipelines and technological equipment generate considerable volumes of wastewater. The composition of this wastewater may vary substantially depending on the production regime and is generally characterized by a high organic load [1, 2].

Brewery wastewater contains dissolved, colloidal, and dispersed organic substances. Wort and malt particles, yeast cells, sugars, proteins, polyphenols, alcohols, and organic acids are among the main organic pollutants. In addition, alkaline and acidic agents used during sanitary washing affect wastewater pH and mineral composition [2, 6].

It is important to properly assess the initial composition of wastewater before selecting a treatment scheme. COD represents the total oxidizable organic load, whereas BOD reflects the biodegradable fraction of organic matter. Suspended solids indicate the total amount of mechanical

and dispersed particles, turbidity characterizes the fine and colloidal phase, and dry residue reflects dissolved mineral and organic components [1].

Previous studies by the authors investigated reagent treatment of industrial wastewater and the flocculation properties of modified polyacrylamide [4, 5]. Results obtained for the integrated treatment of brewery wastewater also showed that this type of wastewater is characterized by high COD, BOD, and suspended-solids concentrations [3]. However, the present article focuses not on treatment efficiency but on the initial pollution level and the technological origin of the pollutant components.



Figure 1. Main sources of wastewater generation in brewery production.

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Aim and Objectives

The aim of the study was to assess the initial pollution level of wastewater generated during beer production, identify the main pollutant components, and analyze their relationship with production stages.

To achieve this aim, the following objectives were defined: to characterize the main physicochemical indicators of the wastewater; to assess the initial values of COD, BOD, and suspended solids; to calculate the BOD/COD ratio; to group pollutant components according to their sources; and to analyze the influence of production stages on wastewater composition.

Materials and Methods

The object of the study was the general wastewater flow of a brewery enterprise. This stream included wastewater generated during fermentation, filtration, technological equipment washing, container rinsing, and sanitary cleaning of production lines.

COD, BOD, suspended solids, turbidity, and dry residue were selected as the main controlled indicators. COD and BOD were used to assess the organic load; suspended solids were used to

characterize the mechanical and dispersed phase; turbidity was used to evaluate colloidal and finely dispersed particles; and dry residue was used to characterize the total amount of dissolved substances [1].

For an analytical assessment of biodegradability, the BOD/COD ratio was calculated. According to the study data, this ratio was 1800/3200 = 0.56. This calculation was used not to evaluate treatment efficiency, but to characterize the fraction of biologically oxidizable organic matter in the untreated wastewater.

Results and Discussion

The initial analysis of brewery wastewater showed a high organic load. COD was 3200 mg/L, BOD was 1800 mg/L, and suspended solids were 950 mg/L. These values indicate the presence of substantial amounts of wort, malt, yeast biomass, sugars, proteins, and other organic components in brewery wastewater [2, 3, 7].

Table 1. Main initial indicators of brewery wastewater

No.	Indicator	Initial value	Technological interpretation
1	COD, mg/L	3200	Indicates a high total organic load
2	BOD, mg/L	1800	Characterizes the fraction of biodegradable organic matter
3	Suspended solids, mg/L	950	High content of yeast, malt, and filtration particles
4	BOD/COD	0.56	A significant fraction of organic matter is biodegradable
5	Turbidity	Qualitatively high	Effect of colloidal and finely dispersed particles
6	Dry residue	Determined by dissolved components	Contribution of salts, detergents, and dissolved organic matter

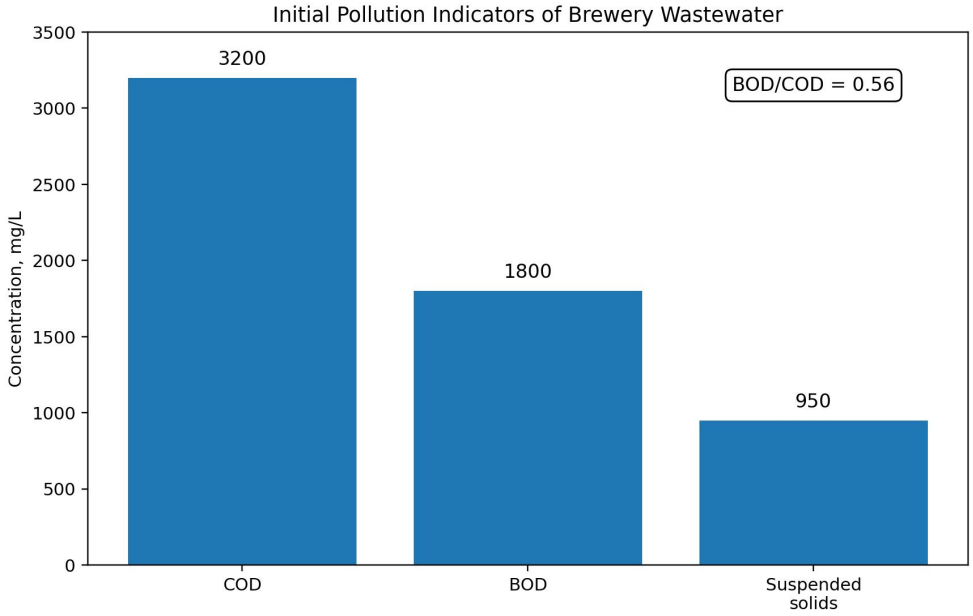


Figure 3. Initial pollution indicators of brewery wastewater.

The BOD/COD ratio of 0.56 indicates that brewery wastewater contains a relatively high proportion of biodegradable organic matter. This can be explained by the nature of compounds such as wort, sugars, alcohols, organic acids, and yeast biomass. At the same time, the overall organic load cannot be assessed using a single indicator because wastewater composition changes throughout the production cycle.

A suspended-solids concentration of 950 mg/L indicates a high level of dispersed-phase pollution. Such particles mainly consist of yeast cells, malt and grain residues, protein-polyphenol complexes, and filtration materials. They increase water turbidity and may contribute to sludge formation during subsequent treatment stages.

Pollution sources differ among the technological stages of beer production. For example, the fermentation stage contributes a larger share of yeast biomass, alcohols, and organic acids, whereas the filtration stage is dominated by protein-polyphenol complexes and filtration materials. Container and equipment washing increases pollution associated with cleaning agents, dissolved salts, and pH fluctuations.

Table 2. Main pollutant components by production stage

Production stage	Main pollutants	Expected effect	Primary control indicator
Wort preparation and boiling	Wort, sugars, proteins, malt particles	Increase in COD and suspended solids	COD, suspended solids
Fermentation	Yeast biomass, alcohols, organic acids	Increase in BOD and COD	BOD, COD
Filtration	Yeast, protein-polyphenol complexes, filtration materials	Increase in turbidity and suspended solids	Suspended solids, turbidity
Container rinsing	Beer residues, rinse water	Dilution and periodic variation of organic load	COD, BOD

Sanitary equipment washing	Alkaline/acidic cleaning agents, salts	Changes in pH and dry residue	pH, dry residue

The grouping presented in Table 2 shows that wastewater pollution is not formed by a single source but by the combined influence of several technological operations. Therefore, a single wastewater sample may not fully represent all production regimes. In practical monitoring, sampling should be organized at different times within the production cycle.

The obtained results are consistent with literature data. Brewery wastewater is generally characterized by a high organic load, suspended particles, and nutrient components [2, 7, 8]. From this perspective, a comprehensive assessment of the initial composition is a key stage in selecting subsequent reagent, biological, or combined treatment methods.

The practical significance of this study lies in the possibility of distinguishing pollutant components according to their technological sources, which allows the appropriate selection of control points, assessment of the need for wastewater equalization, and identification of priority indicators in the treatment scheme.

Conclusion

1. Brewery wastewater in its initial state is characterized by high organic and dispersed pollution: COD was 3200 mg/L, BOD was 1800 mg/L, and suspended solids were 950 mg/L.

2. The BOD/COD ratio was 0.56, indicating a significant fraction of biodegradable organic matter in the wastewater.

3. The main pollutants are wort and malt residues, yeast biomass, sugars, proteins, alcohols, organic acids, filtration materials, detergents, and disinfectants.

4. Fermentation, filtration, container rinsing, and sanitary washing affect wastewater composition differently; therefore, the composition varies over time.

5. Comprehensive assessment of the initial pollution level using COD, BOD, suspended solids, turbidity, dry residue, and pH is necessary for selecting subsequent treatment technology.

6. Grouping pollution sources by production stage enables targeted environmental monitoring and technological control at the enterprise.

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