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Physical and Chemical Composition of Wastewater and Properties of Fats and Oils

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ABSTRACT

Objective: *In this article, we studied in detail the physical and chemical composition of wastewater generated in public catering establishments and the main characteristics of fats, oils, and grease (FOG).* ***Method:*** *We analyzed the organic load of wastewater (BOD, COD, suspended solids, and FOG concentrations), as well as pH, temperature, and other parameters.* ***Results:*** *The types of fats originating from meat, dairy products, and plant sources, their chemical structure (saturated and unsaturated fatty acids), their emulsion state, and the difficulties in their treatment were also discussed.* ***Novelty:*** *In this article, we studied in detail the physical and chemical composition of wastewater generated in public catering establishments and the main characteristics of fats, oils, and grease (FOG).*

INTRODUCTION

Wastewater generated in catering establishments has a complex physicochemical composition and is characterized by a high level of organic pollution. The composition of this wastewater is dominated by organic substances, suspended particles, fats and oils, and detergent residues [1]. Fats, oils, and grease (FOG) are insoluble in water but exist in emulsified or suspended forms, which complicates the treatment process. Especially under the influence of hot water and chemical cleaning agents, oil droplets become finely dispersed and remain stable in the aquatic environment for a long time. As a result, they are not completely removed by conventional mechanical treatment methods and create a high load on sewer systems. The high concentration of organic matter in such wastewater accelerates biological degradation processes, which leads to oxygen depletion, unpleasant odors, and increased microbiological activity [2]. As a result of the interaction between suspended particles and fats and oils, large aggregates are formed, which adhere to the walls of pipes and, over time, reduce the capacity of sewer systems. At the same

time, the volume and composition of wastewater in catering establishments are uneven throughout the day, which complicates the operating режим of treatment facilities[3]. During food preparation and dishwashing periods, the concentration of fats, oils, and detergents increases sharply, negatively affecting the stable performance of treatment systems [4].

Physicochemical parameters of wastewater

The composition of wastewater depends on the type of enterprise activity and has the following average values:

1. BOD (Biochemical Oxygen Demand): 1000–5000 mg/L (up to 3170 mg/L in some studies) [5].
2. COD (Chemical Oxygen Demand): 2000–10,000 mg/L (maximum 9948 mg/L).
3. FOG (Fats, Oils, and Grease): 100–1640 mg/L.
4. TSS (Total Suspended Solids): 500–2000 mg/L [6].
5. pH: 5–6 (acidic due to anaerobic processes).
6. Temperature: 25–35°C.

The presented indicators clearly demonstrate that wastewater generated in catering establishments is highly polluted. High values of BOD and COD indicate a large proportion of biodegradable as well as hardly oxidizable organic substances in the wastewater. This situation significantly increases the oxygen demand in treatment facilities and reduces the efficiency of biological treatment processes [7]. The wide range of FOG (fats, oils, and grease) concentrations directly depends on the type of enterprise activity, food preparation technology, and washing processes. Fats and oils exist in wastewater as a floating layer, emulsified droplets, or in suspended form, and they have a tendency to form deposits in pipes and treatment equipment [8]. In particular, as a result of the interaction between FOG (fats, oils, and grease) and suspended solids, stable fat–organic aggregates are formed, which increases the risk of clogging in sewer systems. The high concentration of suspended solids (TSS) is explained by the presence of food residues, starch, fibrous materials, and solidified fat particles entering the wastewater [9]. If these particles are not sufficiently removed during the mechanical treatment stage, they negatively affect subsequent treatment processes and lead to an increase in sludge and sediment formation. The shift of wastewater pH toward the acidic range (5–6) is mainly associated with fat hydrolysis, the formation of organic acids, and anaerobic degradation processes. This condition accelerates corrosion processes in metal pipes and creates an unfavorable environment for certain biological treatment processes [10]. A temperature range of 25–35°C, in turn, contributes to keeping fats in a liquid state and intensifies the emulsification process. The composition of wastewater from catering establishments is complex not only in quantitative terms but also in qualitative aspects, and it requires special approaches for effective management.

RESEARCH METHOD

This study was carried out using an integrated analytical and experimental approach to evaluate the physicochemical composition of wastewater generated in public catering establishments and to assess the behavior of fats, oils, and grease (FOG) under typical operating conditions.

Wastewater samples were collected from selected catering facilities during peak and non-peak operating hours to account for daily fluctuations in pollutant load. Composite sampling was applied to obtain representative samples reflecting variations in food preparation and dishwashing activities. The collected samples were preserved and transported to the laboratory under controlled conditions to prevent changes in physicochemical characteristics prior to analysis.

Laboratory analyses were conducted in accordance with internationally recognized standard methods for water and wastewater examination. Key parameters, including BOD, COD, TSS, FOG concentration, pH, and temperature, were determined using standard analytical procedures. Gravimetric methods were used for suspended solids and oil–grease determination, while titrimetric and instrumental techniques were applied for oxygen demand measurements.

In addition to quantitative analysis, the chemical structure and origin of fats were evaluated through literature-based classification and comparative assessment of saturated and unsaturated fatty acids. The behavior of FOG in wastewater—such as emulsification, hydrolysis, and solidification—was analyzed by linking laboratory findings with physicochemical principles and operational observations from grease trap systems.

The obtained data were processed using comparative and descriptive analysis to identify relationships between wastewater parameters and treatment challenges. This methodological framework ensured both scientific reliability and practical relevance for improving wastewater management strategies in catering establishments.

RESULTS AND DISCUSSION

Fats and oils originate from animal (meat and dairy products) and plant sources, and they differ significantly in their chemical structure and physical properties. Fats obtained from meat and dairy products are mainly rich in saturated fatty acids, such as palmitic and stearic acids, and have a relatively solid structure [11]. These fats solidify rapidly at low temperatures and tend to undergo saponification by reacting with calcium and magnesium ions in the wastewater environment. As a result, the risk of forming solid fat layers and deposits in sewer pipes increases. Vegetable oils are mainly characterized by the predominance of unsaturated fatty acids, such as oleic and linoleic acids. They are more liquid and can be transported over long distances together with wastewater. However, under the influence of hot water, detergents, and an enzymatic environment, vegetable oils undergo hydrolysis and form free fatty acids. This process disrupts the pH

balance of wastewater and, under anaerobic conditions, leads to the formation of unpleasant-smelling compounds [12].

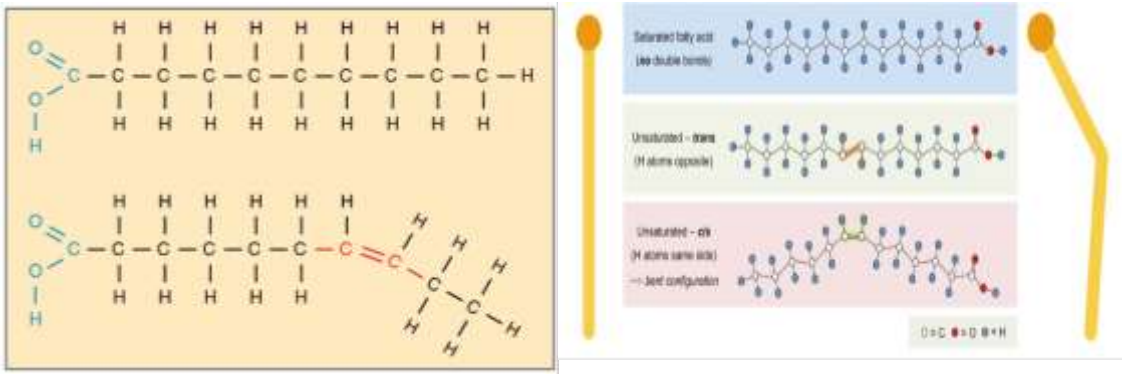

Figure 1. Structural Differences Between Saturated, Trans, and Cis Fatty Acids

In practice, the simultaneous discharge of these two types of fats and oils into wastewater in catering establishments leads to the formation of complex emulsified mixtures [13]. Such mixtures are difficult to separate in grease traps and reduce the efficiency of treatment systems. Therefore, considering the origin and chemical properties of fats and oils is of great importance in wastewater management and in selecting effective technological solutions [14]. Wastewater generated in catering establishments is characterized by a high level of organic pollution, as well as a large amount of fats and oils and suspended particles. Research results show that the physicochemical composition of such wastewater is complex, and high values of BOD, COD, FOG, and TSS impose a significant load on treatment facilities. In particular, the presence of fats and oils in emulsified and suspended forms makes their effective separation by mechanical methods difficult and increases the risk of sedimentation and clogging in sewer systems [15].

CONCLUSION

Fundamental Finding : It was found that the origin and chemical structure of fats and oils are among the main factors determining their behavior in wastewater. The richness of fats derived from meat and dairy products in saturated fatty acids leads to their rapid solidification and the formation of strong deposits on the walls of pipes, whereas the high content of unsaturated fatty acids in vegetable oils causes them to form stable emulsions that persist for a long time in the aquatic environment. The coexistence of these two types of fats and oils further complicates the wastewater treatment process. At the same time, it was found that the pH and temperature of wastewater directly affect the degree of fat emulsification and biological degradation processes. **Implication :** The uneven variation of wastewater composition throughout the day requires flexible and integrated approaches to ensure the stable operation of treatment facilities. The research results indicate the necessity of effective use of grease traps in catering establishments, the implementation of preliminary treatment stages, and the improvement of wastewater

management systems. **Limitation :** The obtained scientific conclusions have important theoretical and practical significance for the development of wastewater treatment technologies and for reducing negative environmental impacts. **Future Research :** — (No explicit statement related to future research is provided in the given text.)

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