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05.01.01 – Muhandislik geometriyasi va kompyuter grafikasi. Audio va video texnologiyalari
05.01.02 – Tizimli tahlil, boshqaruv va axborotni qayta ishlash
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05.01.05 – Axborotlarni himoyalash usullari va tizimlari. Axborot xavfsizligi
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05.03.02 – Metrologiya va metrologiya ta'minoti
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08.00.06 – Ekonometrika va statistika
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08.00.09 – Jahon iqtisodiyoti
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08.00.15 – Tadbirkorlik va kichik biznes iqtisodiyoti
08.00.16 – Raqamli iqtisodiyot va xalqaro raqamli integratsiya
08.00.17 – Turizm va mehmonxona faoliyati

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INVESTIGATION OF THE EFFICIENCY OF FATS AND OILS REMOVAL FROM WASTEWATER GENERATED BY PUBLIC CATERING ENTERPRISES

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Abstract. This article presents a comprehensive analysis of the sources of wastewater generation in public catering enterprises and the mechanisms of their contamination. It is substantiated that high concentrations of fats and oils accumulate in wastewater as a result of kitchen processes, dishwashing, and sanitary–hygienic activities. Based on scientific literature, the negative impact of fatty substances on the operation of sewerage systems through processes such as emulsification, saponification, and mechanical mixing is analyzed. A review of the literature also summarizes the typical ranges of biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, and fat concentrations in wastewater generated by public catering facilities. The results of the study provide a scientific basis for the technological and environmental feasibility of using grease traps and contribute to ensuring the reliable and stable operation of sewerage systems.

Keywords: Public catering enterprises, wastewater, fats and oils, emulsification, saponification, BOD, COD, grease trap.

Annotatsiya. Ushbu maqolada umumiy ovqatlanish korxonalarida hosil bo'ladigan oqova suvlarning shakllanish manbalari hamda ularning ifloslanish mexanizmlari kompleks tahlil qilingan. Oshxona jarayonlari, idish-tovoq yuvish va sanitariya-gigiyena ishlari natijasida oqova suv tarkibida yog'-moy moddalarining yuqori konsentratsiyalarda to'planishi asoslab berilgan. Yog' moddalarning emulsifikatsiya, saponifikatsiya va mexanik aralashish jarayonlari orqali kanalizatsiya tizimlarining ishlashiga salbiy ta'sir ko'rsatishi ilmiy manbalar asosida tahlil qilingan. Adabiyotlar tahlili asosida oqova suvlarning kislorodga bo'lgan biokimyoviy ehtiyoj, kislorodga bo'lgan kimyoviy ehtiyoj, suspenziya moddalar hamda yog' moddalari konsentratsiyalarining tipik oraliq qiymatlari umumlashtirilgan. Tadqiqot natijalari yog' tutgichlardan foydalanishning texnologik va ekologik jihatdan maqsadga muvofiqligini asoslashga, shuningdek, kanalizatsiya tizimlarining ishonchli va barqaror ishlashini ta'minlashga xizmat qiladi.

Kalit so'zlar: Umumiy ovqatlanish korxonalari, oqova suvlar, yog' moddalari, emulsifikatsiya, saponifikatsiya, KBE, KKE, yog' tutgich.

Аннотация. В данной статье представлен комплексный анализ источников образования сточных вод на предприятиях общественного питания и механизмов их загрязнения. Обосновано, что в результате кухонных процессов, мытья посуды и санитарно-гигиенических работ в составе сточных вод накапливаются высокие концентрации жиров и масел. На основе научной литературы проанализировано отрицательное влияние жировых веществ на работу канализационных систем через такие процессы, как эмульгирование, омыление (сапонификация) и механическое перемешивание. В ходе анализа литературных источников также обобщены типичные диапазоны значений биохимической потребности в кислороде (БПК), химической потребности в кислороде (ХПК), взвешенных веществ и концентрации жиров в сточных водах, образующихся на предприятиях общественного питания. Результаты исследования служат научным обоснованием технологической и экологической целесообразности использования жироуловителей и способствуют обеспечению надежной и стабильной работы канализационных систем.

Ключевые слова: предприятия общественного питания, сточные воды, жиры и масла, эмульгирование, сапонификация, БПК, ХПК, жироуловитель.

INTRODUCTION

Currently, the processes of urbanization and the increasing number of public catering establishments are intensifying problems related to wastewater generation. In particular, the discharge of fats and oils into sewerage systems leads to pipe blockages, emergency situations, and environmental pollution. Therefore, studying the mechanisms of wastewater formation in public catering facilities is considered an important scientific and practical task. The purpose of this study is to analyze the sources and contamination mechanisms of wastewater generated in public catering enterprises and to assess the impact of fatty substances on sewerage systems.

Based on the research objectives and the relevance of the problem, the following tasks were defined:

– to identify the sources of wastewater generation in public catering enterprises;

– to analyze the mechanisms of emulsification, saponification, and mechanical mixing of fatty substances;

– to evaluate the physicochemical characteristics of wastewater (BOD, COD, FOG, TSS) based on literature data;

– to provide a scientific justification for the necessity of using grease traps.

Wastewater generated in public catering facilities (such as restaurants, cafeterias, barbecue restaurants, and other service establishments) has a significant environmental impact on a global scale. Analyses conducted in different countries show that the physicochemical parameters of such wastewater are considerably higher than those of typical municipal wastewater, which creates an additional load on sewerage systems.

LITERATURE REVIEW

International studies have reported that wastewater samples collected from public catering establishments exhibit extremely high oxidation indices [1]. In particular, the chemical oxygen demand (COD) in such wastewater has been recorded at levels reaching up to 9,948 mg/L, while the biochemical oxygen demand (BOD) may increase to approximately 3,170 mg/L, which is significantly higher than the values typically observed in conventional municipal wastewater [2-3].

In addition, the concentration of fats, oils, and grease (FOG) is also relatively high. In several studies, FOG concentrations in wastewater from food service facilities have been reported to reach up to 1,640 mg/L. These elevated levels are mainly associated with cooking processes, dishwashing activities, and the discharge of food residues into drainage systems. Such international statistical data clearly demonstrate that wastewater generated by public catering enterprises is characterized by a high physicochemical load, which can negatively affect the operation of sewerage systems [4]. High concentrations of organic matter and fatty substances contribute to the formation of blockages, deposits, and operational failures within sewer pipelines. Therefore, many researchers emphasize the importance of implementing effective technological solutions and preliminary wastewater treatment methods in public catering facilities. In particular, the installation of grease traps and other pre-treatment systems is considered one of the most efficient approaches for reducing the concentration of fats and oils before wastewater enters the municipal sewer network [5-9]. The application of such technologies not only improves the reliability of sewerage infrastructure but also reduces the environmental impact of wastewater discharges.

RESEARCH METHODOLOGY

The object of this study was wastewater generated in public catering enterprises located in the city of Tashkent. The research employed methods of systematic analysis, comparison, and generalization to examine the characteristics and sources of wastewater contamination in such facilities. In assessing the main pollution mechanisms of wastewater, particular attention was given to the theoretical analysis of processes such as mechanical mixing, emulsification, saponification, and hydrolysis. These processes play a significant role in the formation and stabilization of fats, oils, and grease (FOG) in wastewater produced during cooking, dishwashing, and other sanitary activities in food service establishments. The operating principle of grease traps and their role in protecting sewerage systems from the adverse effects of fatty substances were evaluated based on existing regulatory documents and relevant scientific literature. Special emphasis was placed on the technological and environmental importance of grease traps in preventing pipe blockages and improving the reliability of urban sewerage systems. The physicochemical characteristics of wastewater were evaluated in accordance with the requirements of current standards for water quality assessment. In particular, the study considered the provisions of GOST 31861 and GOST 31957, as well as other relevant GOST and O‘zDSt regulatory standards related to the determination of suspended solids and fats, oils, and grease concentrations in wastewater. These standards provided the methodological basis for assessing the main indicators of wastewater quality and pollution levels in public catering facilities.

Analysis and Results. The results of the conducted research indicate that the largest proportion of wastewater (approximately 50–60%) generated in public catering enterprises originates from kitchen activities. During food preparation processes, both animal-based products (such as meat and dairy products) and plant-based substances (vegetable oils and fats) enter the wastewater stream. During frying, boiling, and cooking processes, fatty substances remain in a liquid state at high temperatures and can easily enter the drainage system. However, when the temperature decreases, these substances solidify and form deposits inside sewer pipes, contributing to blockages and operational problems.

During the dishwashing process (either manually or using dishwashers), the combined effects of detergents and hot water cause fat particles to transform into fine emulsions. Dishwashing machines further break down fat particles, with approximately 40–50% of the particles having sizes smaller than 45 micrometers. As a result, these particles cannot be completely separated by conventional grease traps, leading to the formation and accumulation of grease deposits in sewer systems [5].

In addition, floor and equipment cleaning activities contribute to wastewater pollution. During these processes, food residues, fats, and detergents mix with water, thereby increasing the organic load of the wastewater. Sanitary activities (such as toilet use and washing) account for the remaining portion of water consumption in such facilities. The distribution of wastewater sources in public catering enterprises is presented in Table 1.

Table 1. The content of fats and oils in wastewater from public catering establishments

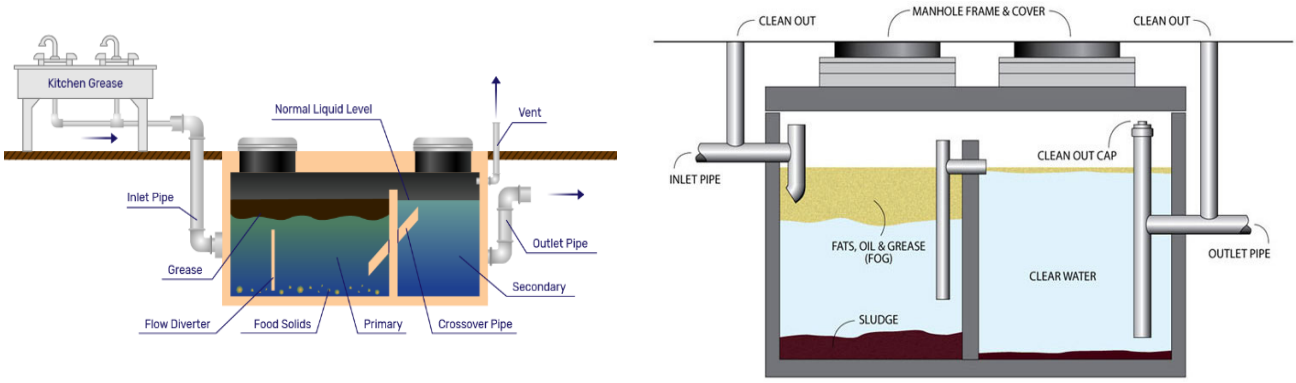
The type of the feeding point	FOG concentration, mg/l	Description
the small cafes and choyxona	150 – 400	is formed as a result of the preparation of light meals and wash utensils Basically
the average of the restaurants	300 – 800	Roasting, the cooking process the effects and the container of the washing machine large
fast-food in the kitchen and on the frityur	600 – 1500	Roasting used a lot of oils, oil of the downloads at the top,
large kitchen (kant, the production of the kitchen)	400 – 1200	large size of Meals, intensive washing process
as noted in the international literature, the maximum value	is 100 – 1640	tracked in the research of some extreme cases

The presence of high concentrations of fats, oils, and grease (FOG) in wastewater generated from public catering establishments leads to increased hydraulic resistance in sewerage networks, narrowing of pipe cross-sections, and a decrease in operational reliability.

Picture 1. The effect of oil and oil waste on pipes

In this regard, utilizing local mechanical treatment units, specifically grease traps, before discharging wastewater from such facilities into the centralized sewerage system is a technologically and sanitarily justified solution. Grease traps are mechanical treatment devices designed to separate fats, oils, and grease from wastewater; their operation is primarily based on the density difference between liquid phases and the process of gravitational separation [6-7]. Since the density of oils and fats is lower than that of water, oil droplets rise to the upper layer under stabilized hydraulic flow conditions, while relatively heavy mechanical particles form a sediment at the bottom of the unit. Consequently, relatively clarified water is discharged from the middle layer of the separation zone [10-11].

Scheme of operation of oil holders. The effluent is fed into the device with reduced flow rate in the inlet chamber; in the separation zone, the grease-grease accumulates in the upper part as a Floating layer, while mechanical impurities are collected in the bottom in the form of sediment; using special hydraulic barriers, relatively purified water is directed to the outlet pipe and transmitted to the next sewer network. The fat layers and sediments accumulated inside the device are periodically removed in accordance with the established (pic. 2).



Picture 2. Working pallets of oil holders

In the design of oil holders, their geometric dimensions and technological indicators were determined on the basis of wastewater consumption, concentration of pollutants and hydraulic conditions of the separation process. As the main calculation parameter, the calculation consumption of running water passing through the device was adopted:

$$Q = \sum_{i=1}^{n} q_i \quad (1)$$

here:

Q— total wastewater consumption (m^3/s or l/s); q_i — water consumption of individual sources (washing baths, dishwashers, etc.). For the effective separation of oil drops, the effluent is required to be in a relatively calm state within the device for a certain period of time. This stagnation (or hydraulic capture) time t in practice is usually taken at intervals of 15-30 minutes. On this basis, the minimum working volume of the oil holder was determined by the following expression:

$$V = Q \cdot t \quad (2)$$

V — working volume of oil holder (m³); Q — effluent consumption (m³/s); t — hydraulic capture time (s).

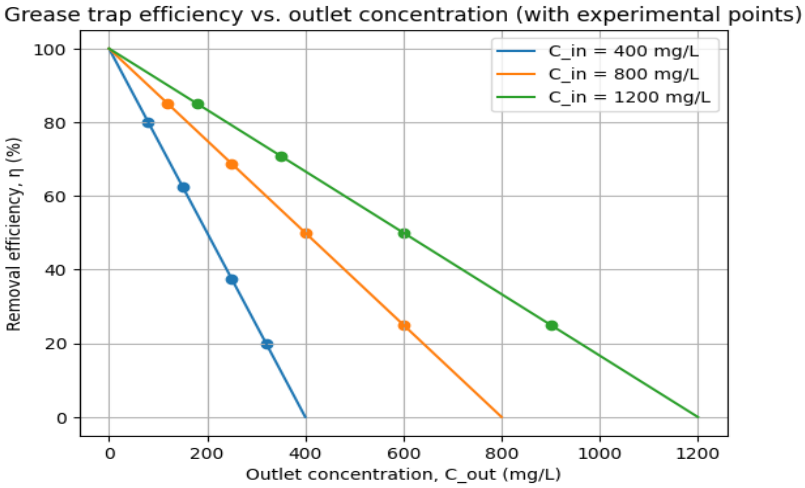
This relationship serves to reduce the flow rate in the device and provide the necessary conditions for the float of oil drops. In practice, the constructive volume of the device is assumed large from the calculated value with a certain reserve coefficient, which makes it possible to take into account the change in the load during the operation process.

The performance of the oil holder, i.e. the oil-to-oil retention rate, was assessed by comparing the concentrations in the input and output current. The cleaning efficiency was determined by the following formula:

$$\eta = \frac{C_{in} - C_{out}}{C_{in}} \times 100\% \qquad (3)$$

here: C_{in} — concentration of fatty-fatty substances in the entrance to the oil holder (mg/L), C_{out} — concentration of fatty-fatty substances at the exit from the oil holder (mg/L), η — cleaning efficiency, %.

This indicator is the main criterion in assessing the technological efficiency of the oil holder. Practical observations show that in ordinary gravitational oil holders, the value of η is usually in the range of 60-85%, while in devices equipped with lamellar or coalescent elements, this indicator can reach 80-95% (pic.3).



Picture 3. Oil holder efficiency

The cleaning efficiency of the graphic oil holder shows the dependence of η on the output concentration C_{out} for different input concentrations (Cin=400; 800 and 1200 mg/L). In accordance with the numerical links, there is a linear reduction of η with an increase in Cout, which is consistent with the expression (3). The position of the sample experimental points presented in the graph close to the theoretical curves confirms that the process is satisfactorily characterized by the accepted model. The results showed that oil holders could provide efficiency of around 60-90% at input concentrations in the 400-1200 mg/L range, and that their use in pre-treatment of effluent in catering establishments was technologically sound.

In this study, the sources of formation and mechanisms of pollution of wastewater generated from catering enterprises were analyzed, substantiating on the basis of scientific literature and analytical data that the high concentration of fatty-oil substances (fodder) in their composition has a serious negative effect on the reliable operation of sewage systems. Within the framework of the study, it was substantiated that the principle of operation of oil holders is based on the process of gravitational separation, that in their design it is possible to determine the working volume based on wastewater consumption and hydraulic capture time, and that cleaning efficiency (3) can be assessed by expression. The analysis of graphs and sample experimental points built on computational linkages showed that oil holders can operate at input concentrations in the 400-1200 mg/L range with an efficiency of 60-90% and above, depending on the constructive solution.

Conclusion and Recommendations. In this study, the sources of formation and pollution mechanisms of wastewater generated from public catering establishments were analyzed. Based on scientific literature and analytical data, it was substantiated that the high concentration of fats and oils (FOG – fats, oils and grease) in such wastewater can significantly negatively affect the reliable operation of sewerage systems. Within the framework of the research, it was determined that the operating principle of grease traps is based on the process of gravitational separation. It was also established that during the design of grease traps, the required working volume can be determined on the basis of wastewater flow rate and hydraulic retention time, while the

treatment efficiency can be evaluated using expression (3). The analysis of graphs constructed on the basis of calculated relationships and representative experimental data showed that grease traps can operate with an efficiency of 60–90% or higher at influent concentrations in the range of 400–1200 mg/L, depending on their structural configuration. The obtained results indicate that the installation of grease traps in public catering facilities can significantly reduce the load on centralized sewerage networks, prevent pipeline clogging and improve the overall operational reliability of wastewater systems. Therefore, it is recommended to introduce mandatory installation of appropriately sized grease traps at the outlets of catering facilities, along with the optimization of their hydraulic design parameters and regular maintenance schedules to ensure stable and efficient operation.

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