KAPITEL 5 / *CHAPTER 5* [5]
INFLUENCE OF FATS WASTEWATER ON THE OPERATION OF THE SEWAGE SYSTEM

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Introduction

The food production industry (enterprises for meat processing, bakeries, confectioneries, dairies, etc.), public catering establishments, etc. are characterized by wastewater with a significant fat content – FOG (fat, oil and grease). A general overview and classification of fats belonging to the internal drainage system is shown in Figure 1.

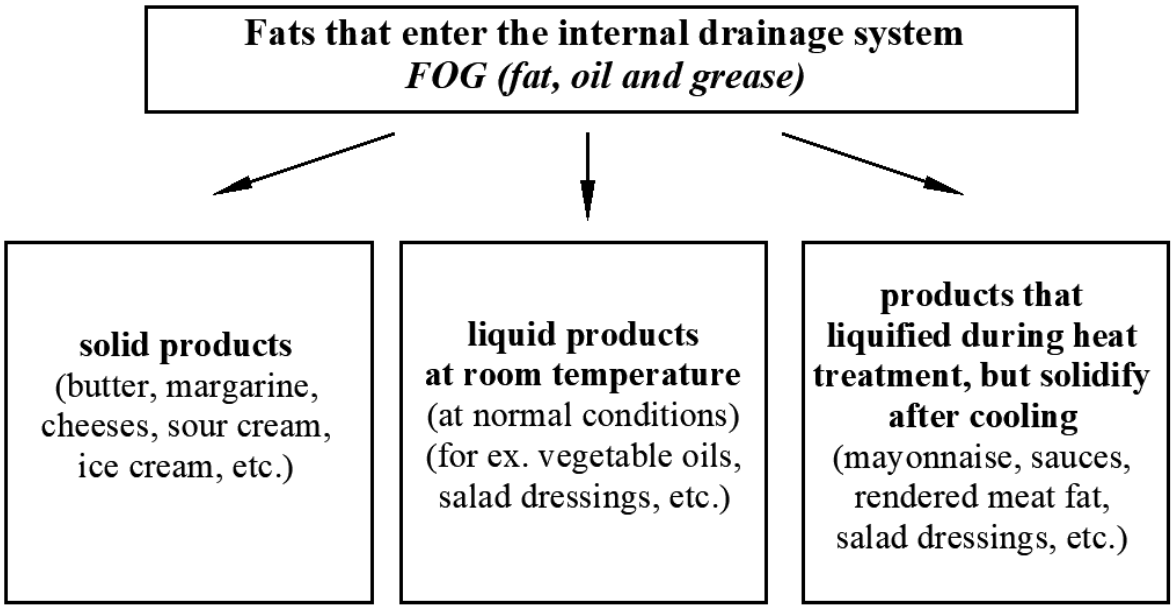

Figure 1 - Classification of fats present in the internal drainage system

The concentration of FOG in wastewater depends on many factors, including the trends for high-oil diets, the dietary preferences of the population in particular region, the use of food waste shredders, etc. The most unfavorable for the drainage system is wastewater from public catering establishments, in which the concentration of fats and oils varies in a wide range, for example, 42...1405 mg/dm^3 or even reaches the value of 6500 mg/dm^3 [1, 2]. The average value according to latest investigations is 1650 mg/dm^3. During 2015, about 50 kg of FOG was generated per person in developing countries [3].

Table 1 shows the average chemical composition of wastewater from meat and seafood processing enterprises compared to typical municipal sewage [4]. The

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analysis of Table 1 shows that the values of wastewater quality indicators of different enterprises differ. This is explained by the difference in the applied food processing technologies. However, the similarity of these wastewaters is observed – a high value of chemical oxygen demand (COD) and biochemical oxygen demand (BOD_{total}), an increased content of suspended solids, total nitrogen, and FOG. Significant concentrations of FOG are observed in wastewater during fish processing, butchering and primary processing of meat, high and low-temperature processing, and frying.

Table 1 – Comparison of the chemical composition of wastewater

Indicator	Sewage			
	food industry	meat processing plant	restaurant business	municipally owned enterprise
COD, mgO_2/dm^3	8000...18700	9600...12900	1250...4500	210...740
BOD_{total}, mgO_2/dm^3	1000...72000	2500...8000	820...3000	150...350
Suspended solids, mg/dm^3	500...2000	790...3350	220...2700	120...450
Total Nitrogen, mg/dm^3	200...300	230...260	—	20...80
Total Phosphorus, mg/dm^3	—	30...50	—	6...23
FOG, mg/dm^3	250...5000	100...2000	140...4100	—

Wastewater which containing FOG causes malfunctions in both internal systems and external sewage networks. Such wastewater has a negative impact on sewage treatment facilities, in particular on the mass exchange of oxygen in aeration tanks, as well as on the processes of dehydration of sewage sludge due to adhesion on its surface.

5.1. Mechanism of formation of fat deposits

In wastewater, FOG is present in unchanged and modified form, for example, after heat treatment or as a result of reaction with detergents. Fats in wastewater are in a non-emulsified state on the water surface and in the form of emulsions. All of

them, regardless of origin, are characterized by the ability to stick to the inner walls of pipelines and water treatment facilities. Other waste water impurities, in particular of organic origin, stick to fats and rot with the formation of an unpleasant smell. The accumulation of such impurities leads to a decrease in the throughput of sewage pipelines, up to their complete blockage. This causes emergency leaks of sewage, and therefore leads, in particular, to: flooding of territories, soil degradation, groundwater pollution, drinking water pollution by sewage, deterioration of the condition of premises on the first floors of buildings, etc. The share of accidents due to clogging of pipelines is in: USA – 40...50%, Great Britain – 50%, Australia – 21%, Malaysia – up to 70% of the total number of accidents [5–7].

The mechanism of the formation of fat deposits in sewage pipelines depends on many factors [8]. Schematically, the mechanism of the formation of fat deposits is shown in Figure 2.

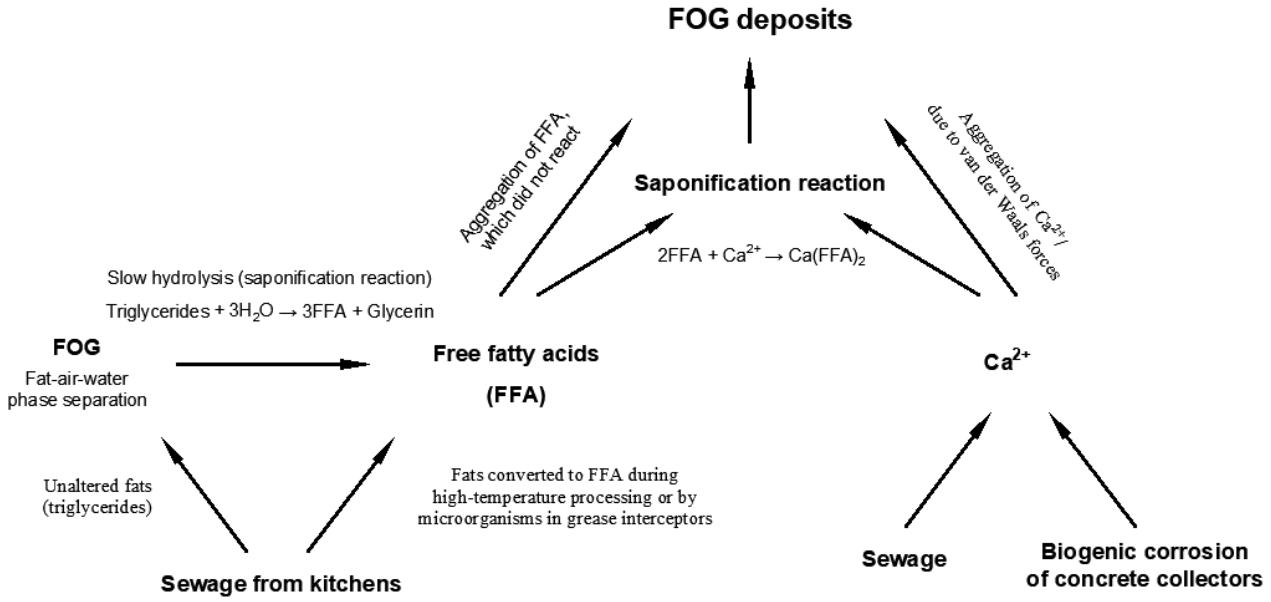

Figure 2 - The mechanism of formation of fat deposits in sewage pipelines

Fats enter into the sewage system in unchanged and modified forms. Fats are converted into free fatty acids during high-temperature processing or by microorganisms in grease interceptors. Unchanged fats (triglycerides) entering the sewage system are also hydrolyzed to free fatty acids (saponification reaction). In a neutral environment, this process proceeds slowly but is noticeably accelerated in the presence of bases. Such catalysts are KOH and NaOH, which are part of detergents. In turn, free fatty acids react with bases and form salts called soaps.

In most concrete sewer collectors, biogenic corrosion is observed, as a result of which calcium is released from the pipe material. In addition, calcium is naturally present in wastewater. Therefore, in the presence of free fatty acids and calcium ions in wastewater, a rapid process of saponification with the formation of fatty acid salts is observed at the boundary of the fat–water or fat–concrete environments. Accumulation of fatty deposits in pipelines is caused not only by the process of saponification but also by the aggregation of released calcium, fatty acids, and other impurities of wastewater on the inner surface of the pipe. This, in turn, leads to the formation of solidified fatty deposits interspersed with other wastewater impurities. An increase in the calcium concentration was recorded in the fatty deposits on the pipe walls. Therefore, it can be assumed that water hardness affects the formation of such deposits [8].

5.2. Methods of removing fat deposits

Internal drainage systems are especially vulnerable to clogging with fatty deposits. In addition to incorrect operation of such systems, the causes of clogging are mistakes made during their design and installation. The most common mistakes are failure to observe the required slope of the pipeline, use of pipes of smaller diameter, and connection of sewer risers to outlets at an angle of 90° (the optimal connection angle is 135°). In addition, unskilled installers can ignore the arrangement in the system of revisions and cleanings.

Methods of removing fat deposits are shown in Figure 3.

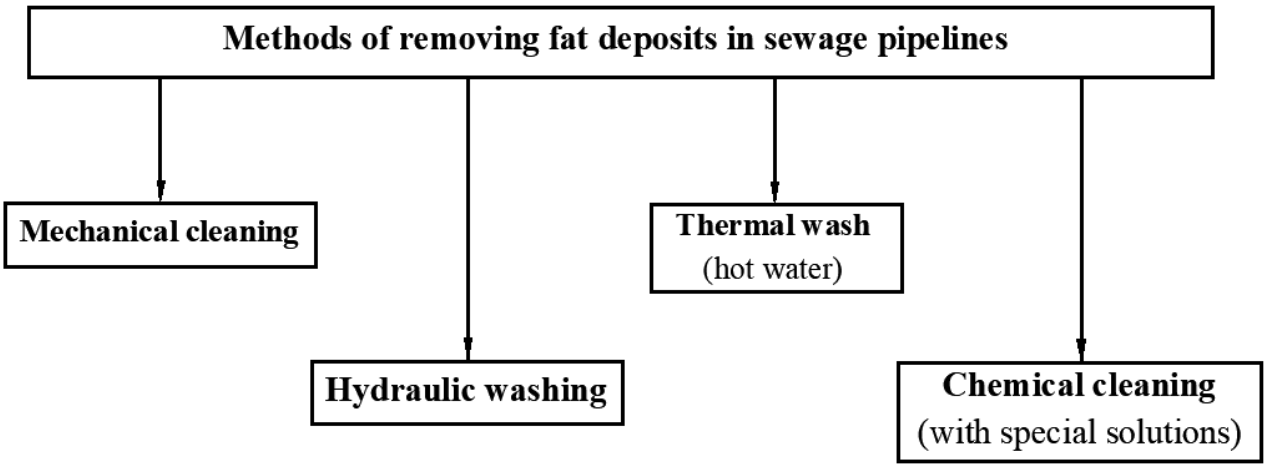

Figure 3 – Fat deposit removal methods in sewage pipelines

At the same time, it should be remembered: pipelines made of Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), and PVC are designed for permanent transportation of wastewater with a maximum temperature of 60°C and short-term (duration no more than 1 minute) with a temperature of up to 95°C. Pipelines made of PP are used for the removal of wastewater with a temperature not higher than 80°C. The temperature of short-term transportation of wastewater for PP, PVD, HDPE, and PVC pipes should not exceed 95°C.

At the same time, it is forbidden to use metal tools for the mechanical cleaning of plastic pipes. Clogging in plastic sewage pipelines is eliminated with the help of a polyethylene pipe with a diameter of up to 25 mm, or a hard rubber hose.

During the periodic cleaning of sewer pipes from fat, it is effective to use mixtures that contain enzymes – accelerators of biochemical processes. Such a biological degreaser prevents the formation of deposits of fat, emulsions, and soap in sewage pipelines. The powder preparation is a highly concentrated mixture of microorganisms and enzymes that control and accelerate the natural process of decomposition of organic waste water impurities in aerobic and anaerobic conditions.

Caustic soda is included in the composition of chemicals for cleaning pipes. In the means of different manufacturers, it can be in the form of a concentrated solution, granules, powder, or gel. This compound breaks down clogging from food residue, hair, and grease. The solution is poured into the drain hole of waste water receivers (kitchen sink, wash basin, bathtub, etc.) and left for the time specified in the instructions. After that, the pipes are washed with a stream of warm water.

For the guaranteed operation of the entire pipeline system, it is necessary to carry out its periodic prevention and cleaning. For sewage systems that are heavily used (for example, catering establishments, hotels, etc.), pipe cleaning should be carried out quarterly.

The harmful effect of fat-containing wastewater from public catering establishments is neutralized with the help of grease interceptors - devices for the mechanical purification of wastewater from non-emulsified fats. The use of such devices makes it possible to remove up to 80% of fat from wastewater. The classification of grease interceptors is shown in Figure 4.

Grease interceptors are installed as close as possible to sewage disposal sites, preferably in the open air and away from traffic.

For the treatment of industrial wastewater, grease interceptors should be designed at outlets outside the building – for food enterprises (restaurants) on semi-

finished products with a number of seats of 500 seats and more and for food companies (restaurants) on raw materials with a number of seats of 200 seats and more [9].

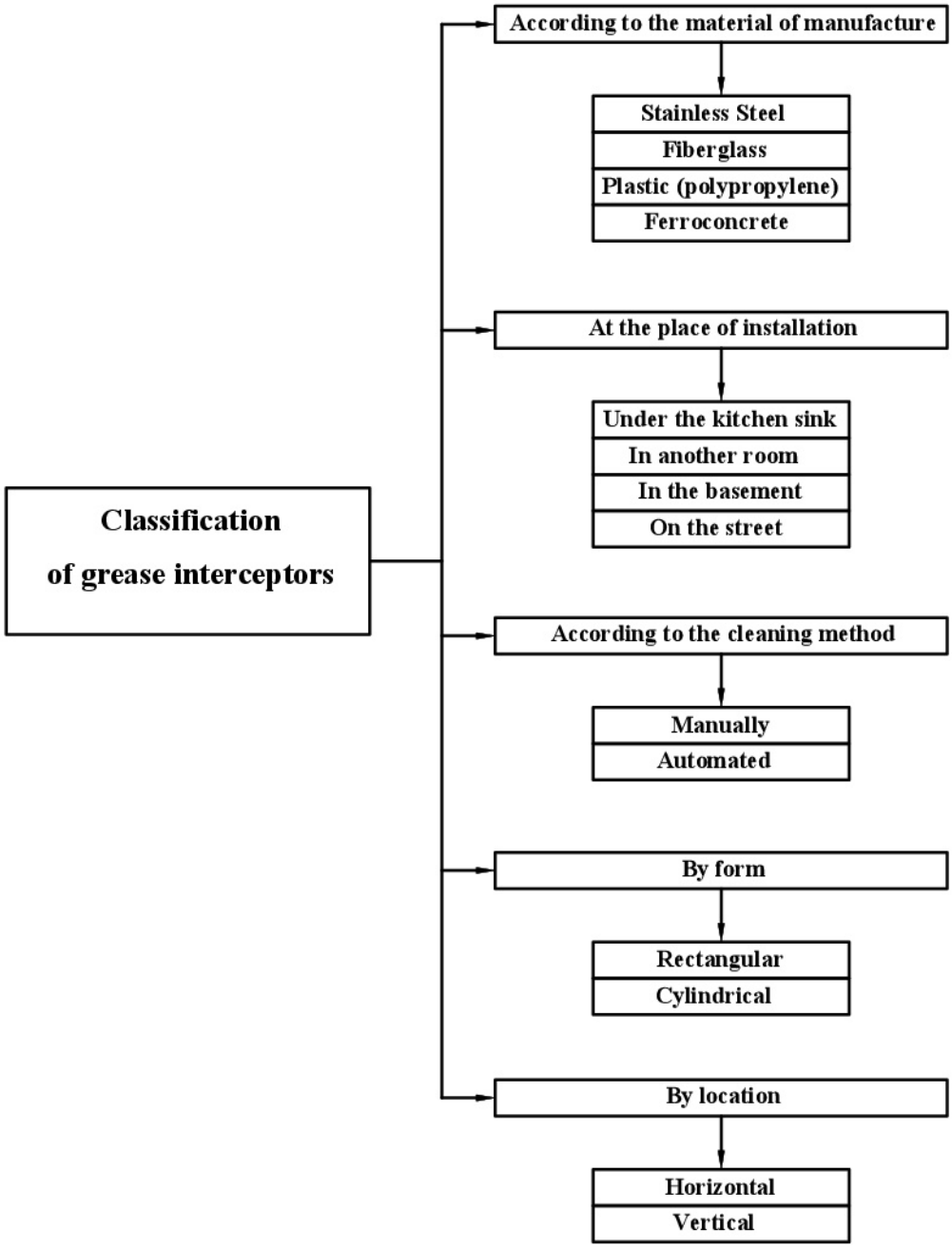

Figure 4 - Classification of grease interceptors

In public catering establishments with daily preparation of up to 500 portions of hot meals and in enterprises working on semi-finished products, compact hermetic grease interceptors with a complete technological cycle and automatic control of the building environment can be installed. Fat separators are installed as close to the

places of fat formation in a separate heated room under the conditions of ventilation, cold and hot water supply, organization of fire extinguishing, etc. In apartments, private houses, and cottages, it is possible to install compact grease interceptors under the sink [10].

5.3. FOG disposal methods

Therefore, difficulties arise during the operation of the drainage system caused by fat-containing wastewater. Given this, a promising direction of scientific research is the identification of effective methods of FOG disposal, and most importantly, the possibility of their reuse in order to replace high-quality energy raw materials of fossil origin. Below is a brief description of the advantages and disadvantages of methods of disposal and reuse of FOG (Figure 5) [4, 11, 12].

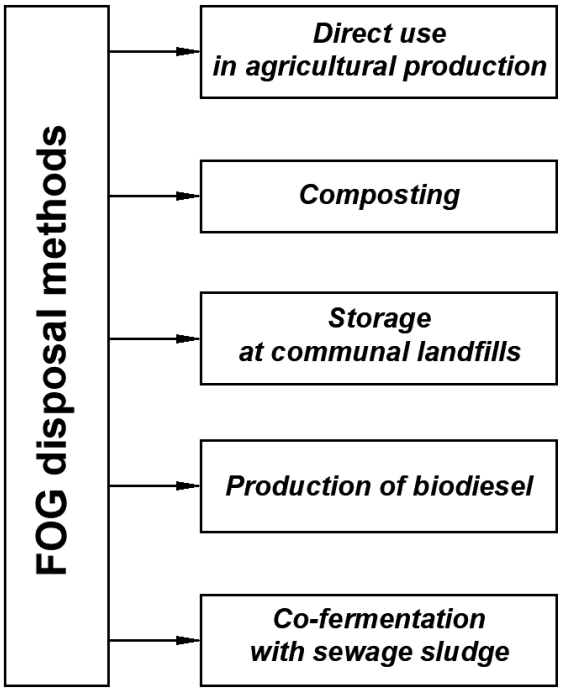

Figure 5 - FOG disposal methods

Direct use in agricultural production. One of the cheapest disposal options. At the same time, the content of organic carbon in the soil increases, and processes of nitrogen leaching, etc. are inhibited. However, a high-fat content can cause the formation of films around soil particles, which will prevent water from reaching the root systems of plants.

Composting. The final product of composting can be used directly in agriculture.

However, there is currently a lack of experimental studies on this use of FOG.

Storage at communal landfills. The method is considered less favorable from an environmental and economic point of view due to the difficulty of using the methane produced during the decomposition of FOG.

Production of biodiesel. In particular, using waste vegetable oil is an important tool for solving acute problems caused by the energy crisis and environmental pollution. In the world, this method is considered cost-effective due to the availability and low costs of purchasing raw materials. In addition, it is possible to save money on the processes of wastewater treatment and waste disposal. However, the chemical composition of waste from food industry enterprises, sewage sludge, and waste from grease interceptors is different. This, in turn, complicates the creation of unified technology and equipment for the production of biodiesel from FOG.

Co-fermentation with sewage sludge. The most promising method. It has been proven that co-fermentation of FOG from food industry enterprises with sewage sludge in methane tanks increases biogas yield by 30% or more. This makes it possible to meet half of the water treatment plant's need for electricity. Adding up to 4% of waste from grease interceptors to sewage sludge increases biogas yield by 65%. However, with an increase in the proportion of such waste in the mixture, the amount of biogas produced decreases. The main problems of co-fermentation are related to the adjustment of FOG volumes and their chemical composition.

The successful implementation of methods of disposal and reuse of FOG involves the creation of an extensive network of their collection at the places of generation.

Conclusions

The presented research characterizes fatty wastewater, describes the mechanism of the formation of fatty deposits in sewage pipelines, and provides methods for their removal from pipelines. The advantages and disadvantages of promising areas of scientific research on the disposal and reuse of FOG are indicated.