EPA 440/1-75/066
Pretreatment Requirements
for Oil and Grease

TREATABILITY OF OIL AND GREASE DISCHARGED TO PUBLICLY OWNED TREATMENT WORKS

U.S. ENVIRONMENTAL PROTECTION AGENCY
APRIL 1975

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April 1975

Prepared for

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U.S. Environmental Protection Agency
Washington, D.C. 20460

TREATABILITY OF OIL AND GREASE DISCHARGED TO PUBLICLY OWNED TREATMENT WORKS

The Effluent Guidelines Division recommends that the following pretreatment requirements be established for existing point sources discharging into publicly owned treatment works for the listed categories of oil and grease:

animal and vegetable origin	no limitation
petroleum or mineral origin	100 mg/l

Introduction

The need for pretreatment of any industrial waste is related to the ability of a publicly owned treatment works to remove pollutant parameters in the waste. The Federal Water Pollution Control Act Amendments of 1972 (the Act) contains sections which required EPA to take specific actions regarding pretreatment of industrial waste introduced into municipal systems. The pretreatment sections of the Act were intended to prevent intoduction of pollutants into publicly owned treatment works which interfere with, pass through, or are otherwise incompatible with such works.

Oil and grease is a pollutant parameter which has been considered to interfere with the performance of publicly owned treatment works. Factors affecting the establishment of pretreatment requirements include the constituents and their biodegradability in a publicly owned treatment works.

Method of Analysis

Unlike some pollutant parameters, such as distinct chemical elements, oils and greases are defined by the method used for their determination. An absolute quantity of a specific substance is not measured. Rather, groups of substances with similar physical characteristics are determined quantitatively, based on their mutual solubility in the solvent used. The term oil and grease will include fatty acids, soaps, fats, waxes, petroleum products and any other material which is extracted by the solvent and which is not volatilized during evaporation of the solvent. Both hexane and freon (trichlorotrifluoroethane) are the recommended solvents (1, 2, 3). A method using activated alumina is available to separate polar (primarily hydrocarbon) and non-polar (fatty acids and esters) constituents of oil and grease (1). This method provides information on the proportion of oil and grease composed primarily of fatty matter from animal and vegetable sources and of hydrocarbons from mineral oil and petroleum sources.

Constituents

Oil and grease in waste waters or natural waters result from the introduction of animal and vegetable fats and oils and from petroleum products. Animal and vegetable fats and oils are present in significant concentrations in household sewage. They are also present in the waste waters from the refining of these materials for preparation of shortening, soap, and from other industries such as meat packing, slaughterhouse, leather tanning, and food processing operations.

Petroleum products in waste water result from losses of petroleum oils during refining or other processing in refineries and petrochemical plants. Oil also may be lost during cleanup of metal machining and metal working operations, from lubricating operations, and in the case of service stations some may be deliberately disposed of to the sewer system. Oil, though basically insoluble in water, may become emulsified or dispersed in waste waters through pumping and other agitation. Emulsified oils may also be discharged from certain industrial operations.

The majority of greases or oils in food or animal fat exist as glycerides. Glycerides may be hydrolyzed in waste water collection and treatment systems to yield glycerol and the alkalyzed salts of the fatty acid. These compounds constitute

the major faction of grease in normal domestic sewage. The principle constituents of these glycerides and soaps are the long-chain saturated fatty acids--lauric, myristic, palmitic, and stearic acids--and the long-chain unsaturated fatty acids--oleic and linoleic acids. Palmitic, stearic and oleic acids usually constitute over 80% of the fatty acids in most municipal waste waters. Vegetable oils discharged to sewerage systems will be absorbed onto other suspended material in sewage and are unlikely to be in liquid form entering waste water treatment facilities.

Oil and greases of petroleum origin consist primarily of long-chain, saturated hydrocarbons that are relatively non-reactive. These compounds can be degraded to various degrees especially if the microorganisms are acclimated to use the compounds as a substrate.

Removal by Waste Treatment Processes

Waste treatment processes are utilized, among other reasons to reduce the oxygen demand of waste waters prior to discharge. The total oxygen demand and the rate of the demand of a compound is related to the ability of microorganisms to metabolize the compound. Long chain, saturated, reduced organic compounds, such as hydrocarbons, generally are oxidized more slowly but require more oxygen per unit weight than short chain, unsaturated, oxidized compounds such as organic acids.

Grease in waste water can be in three forms a) free, b) attached to other solids, and c) semi-colloidal. Free grease can float and be skimmed from primary sedimentation tanks. Grease attached to other particles can settle with these particles or remain in suspension if the resultant specific gravity is not greatly different from that of water. Much of the grease attached to other solids and that in the semi-colloidal state is not removed in a primary sedimentation tank and flows to a secondary treatment unit, such as an activated sludge unit or a trickling filter. The microorganisms in the secondary biological treatment unit will metabolize the entering greases. The energy from such metabolism is used for both maintenance of organisms and for synthesis of additional organisms. It can be expected that biological waste treatment will not only decrease the quantity of grease in waste waters but will also change the relative proportion of grease components as the easily metabolized greases are removed, the less easily metabolized greases remain, and microbial oil and grease extractable compounds are synthesized. Such material forms a significant fraction of microorganisms.

All greases are not metabolized at the same rate in microbial systems. Fatty acids, glycerides, and methyl esters are more readily oxidized than hydrocarbons. The less easily metabolized greases and the greases in microorganisms discharged in the

effluent represent the major part of the organic matter discharged from secondary treatment facilities.

Investigations of oil and greases in waste water and their removal in waste water treatment processes have shown that hydrocarbons, sterol esters, glycerides, fatty acids, compound lipids, and possibly sterols were found in the oil and grease extractable material from untreated waste water and activated sludge samples. Oil and grease extractables from influent waste water samples indicated that fatty acids were the predominant extractable components, followed by hydrocarbons, triglycerides, and compound lipids. In some samples, hydrocarbons and compound lipids were the predominant extractable components (4,5).

The general pattern of hexane soluble material in influent waste water was shown to change as the degree of treatment increased. Compounds more resistant to biological degradation remained in the waste water for a longer period of time. Whereas fatty acids were a predominant oil and grease component in the effluent from an activated sludge treatment facility (4, 5).

A waste water treatment plant receives a heterogenous group of organic compounds, the mix being a function of the commercial, manufacturing and domestic contribution of the community. Bacteria will adapt to degradation of each category of material,

i.e., proteins, carbohydrates, and greases, since these compounds are normally found in waste water. No problems concerning adaptability or acclimation would be expected until a specific compound suddenly appeared in abnormally high concentrations.

Analysis of oil and grease at waste water facilities is not as routine as it is for BOD, COD, or solids. Available information indicates the following total grease removals at activated sludge plants: 84% - Topeka, Kansas; 85.7% - Cleveland easterly plant; 94% - Madison, Wisconsin. The Cleveland data represents a yearly average with the average influent grease concentration being 80.3 mg/l and the average effluent concentrations being 11.5 mg/l (6).

The Topeka study was done to investigate grease removal patterns at a secondary treatment facility (7). Grease removal by primary treatment was 45%, by secondary treatment 74%, and by complete treatment 84%. The average BOD and suspended solids removal at this time was 85 and 82% respectively. Other results from the study showed that there was a reasonable correlation between the grease and the suspended solids concentrations in the effluent from treatment plant.

When the suspended solids concentration was low, the concentration of grease was also low. Grease in the effluent

from the activated sludge plant averaged 22 mg/l with hourly samples having concentrations that ranged from 7-68 mg/l.

A summary of one years data, 1968, at the three major Chicago sewage treatment plants indicated that the West Southwest, Calument, and North Side plants failed to meet an effluent oil and grease concentration of 15 mg/l 36, 34, and 3% of time respectively. During the same period, the three plants failed to meet a BOD effluent standard of 20 mg/l and a total suspended solids effluent standard of 25 mg/l 40 and 55%, 60 and 40%, and 20 and 14% of the time respectively. The data was based on daily 24 hour composite samples. The summary indicates that the oil and grease removals were on the same order Two research studies have provided additional insight into the removal of oil and grease by biological treatment processes.

One study investigated the effect that wastes from processing vegetable and animal fats and oils had on treatment systems involving biological degradation and sludge filtration (8). The results indicated that these wastes were readily degraded by the activated sludge process even at temperatures as low as 12.25°C, that they were readily degraded by anaerobic treatment with removal efficiencies of from 82 to 92 percent, and that the presence of the wastes, with one minor exception, had no adverse effect on oxygen transfer in the activated sludge process.

An EPA supported study determined the tolerance of biological treatment systems to various oily materials which included crankcase oil, crude oil, refinery waste, vegetable oil, benzene, and benzene derivateive (9). The study indicated that the failure of activated sludge systems due to oily materials is physical rather than biochemical. The oily compounds are absorbed in the sludge floc but are only slowly metabolized. The result of the oil accumulation is a lowering of floc density which results in a loss of sludge settling properties. An activated sludge system will perform satisfactorily with a continuous loading of oil and grease of 0.1 pounds per pound of mixed liquor suspended solids. For conventional plant operations, the influent to the biological system was suggested to contain less than 75 mg/l oil and grease and preferably less than 50 mg/l. None of the compounds studied interfered with the oxygen transfer in the system.

The above information indicates that different oil and grease components in waste water have different removal and biodegradation rates in waste treatment facilities. Hydrocarbons and complex greases associated with microbial cells are likely to be the main components in secondary treatment plant effluent. Fats and oils of vegetable and animal origin are more readily metabolized. Although data is not excessive, grease removal

efficiencies in primary facilities appear to be about 40-50% and in secondary treatment facilities about 80-90%.

Grease removal efficiency correlates with BOD and suspended solids removal efficiency. Grease concentrations in an activated sludge effluent appears to correlate with high suspended solids in the effluent. This indicates that one mechanism to minimize oil and grease discharged to surface waters is to provide for better suspended solids removal from the effluent. Because vegetable and animal fats and oils can be metabolized by micro-organisms, they will be removed in secondary biological treatment facilities and their effect will be observed in the BOD test. Control of excess grease in an effluent, especially that from vegetable and animal sources, should be accomplished by implementation of BOD and suspended solids effluent standards at the secondary treatment plant. Additional constraints by a pretreatment limitation on these compounds would be redundant. A pretreatment limitation on the less biodegradable compounds, such as those of petroleum or mineral origin, may be advisable.

Currently Acceptable Concentrations

Specific limitations on oil and grease discharges to municipal treatment plants were published in 1949 when the Federation of Sewage Works Associations first presented its Manual of Practice

on Municipal Sewer Ordinances. The recommended maximum concentration of oils and greases in the manual was 100 mg/l. In the intervening years there has been considerable disagreement on such a rigid limitation. The concern has been with the non-specificity of the oil and grease components that may interfere with the performance of a publicly owned treatment works. As noted earlier, numerous investigations have more clearly identified the problem components. The most recent manual of practice (10) suggests the following limitations on oil and grease discharged to municipal treatment systems:

> "Waste water containing more than 25 milligrams per liter of petroleum oil, nonbiodegradable cutting oils, or product of mineral origin"

> "Waste water from industrial plants containing floatable oils, fats, or grease."

The manual notes that oils and grease of mineral origin (primarily nonpolar substances) are essentially non-biodegradable either in aerobic or anaerobic processes and that animal and vegetable oils and greases (polar substances) are readily degradable in these processes. It further notes that "if oils and greases are biodegradable and in a physical state that does not cause clogging or undue maintenance problems in the waste

water facilities, the discharge of these substances can be accepted in a wastewater treatment system." Many municipal sewer ordinances have been based on the material in the editions of the above Manual of Practice and include a statement to the effect that waste water discharges having oil and grease concentrations in excess of 100 mg/l are prohibited. Examples can be found in the sewer ordinances of the metropolitan St. Louis Sewer District (11) and of Jefferson County, Alabama (12).

Oils and greases are a normal constituent of municipal waste waters and information on the concentrations currently in the untreated waste water of municipalities should provide an idea of the concentration currently being accepted, and thus by inference, able to be handled by municipal treatment plants. Information in the Manual of Practice (10) indicated that oil and grease concentrations of 16 to 105 mg/l were found in waste water free of industrial wastes.

Summary and Conclusions

1. Available information indicates that oil and grease of animal and vegetable origin can be metabolized by microorganisms in secondary waste treatment facilities and would be reduced in concentration along with other organics. The oils and grease in the effluent from secondary treatment plants is related to the

suspended solids content of the effluent. Low concentrations of oil and grease in the effluent can be obtained by achieving low suspended solids concentration thus, oils and grease of animal and vegetable origin are not expected to pass through or interefer with a publicly owned treatment works. Pretreatment requirements for these compounds are not needed.

2. In the event that excessive quantities of oils and grease are discharged to a publicly owned treatment works such that they do cause obstruction to the flow in sewers or interfere with the operation of such works, or are in such slugs that they upset the treatment processes and result in a loss efficiency, such discharges are subject to the general prohibitions of section 128.131 of the General Pretreatment Regulation (40 CFR 128) published on July 19, 1973. No other pretreatment requirements are needed to control such discharges.

3. Oils and grease of mineral or petroleum origin are less biodegradable in secondary treatment plants. One of the above studies has noted that the influent ot biological treatment systems should contain less than 75 mg/l and preferably less than 50 mg/l oil and grease. Varying degree of dilution occur in an municipal sewer system due to household and commercial contributions. A dilution of a least two occurs, thus a limit of

100 mg/l on the discharge of oils and grease of petroleum or mineral origin is realistic.

This concentration is greater than that currently recommended in the Manual of Practice (10), however the available information justifies a number higher than that noted in the Manual of Practice. Because of the dilution the does occur in sewers as industrial and other waste waters are mixed, it is expected that the concentration of petroleum or mineral oils in the influent to the publicly owned treatment works will be less than 50 mg/l and thus will not interfere with the performance of such works.

These requirements do not preclude a municipality or other agency from establishing more stringent pretreatment requirements where it can be shown that they are needed for the protection of the publicly owned treatment works. Thus the recommended requirements for oils and grease of petroleum or mineral origin are not contradictory to the recommendations in the Manual of Practice.

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