Biodegradation of Fats, Oils, and Greases in Collection Systems

The Role of Bioaugmentation

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Background

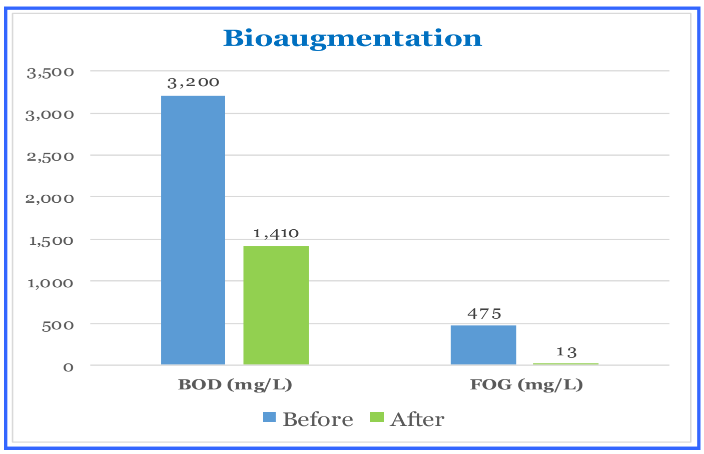
We don't typically think of the wastewater collection system as a biological process, but biological processes are in fact occurring in sewer lines and in related systems such as lift or pump stations. Fecal bacteria are the largest biological inputs into the system. Fecal bacteria are primarily facultative (surviving with or without oxygen sources) and obligate anaerobes (surviving only in the absence of oxygen sources). Microbes are also being contributed from everyday activities (bathing, laundry, food preparation and cleanup, floor mopping, etc.). These microbes may be aerobic (surviving only in the presence of molecular oxygen), facultative, or obligate anaerobes.

As wastewater and associated particulate matter is transported through the collection system to the wastewater treatment plant, microbes are causing biodegradation of the organic matter. The microbial community present consumes molecular oxygen and other oxygen sources (such as nitrate) to the point that most of the wastewater becomes anaerobic.

Microbial metabolism under these conditions results in:

- the reduction of the commonly present sulfate ion to hydrogen sulfide,
- the release of ammonia,
- the partial degradation of organic matter to volatile fatty acids and other odiferous by-products,
- and partial degradation of fats to fatty acids and mono- and di-glycerides.

This natural process results in several undesirable consequences: odor, a poisonous atmosphere, corrosion, and blockage of sewer pipes. Bioaugmentation can be used to increase the population of desirable microbes which degrade hydrogen sulfide, volatile fatty acids, and fats. Bioaugmentation can also reduce biochemical oxygen demand (BOD) within the collection system, which therefore reduces loading on the downstream wastewater treatment plant.



The chart on the right illustrates the reduction of FOG and BOD after microbial products were applied.

Bioaugmentation

In bioaugmentation, the microbial population naturally present in the collection system is augmented with a consortium of preselected, adapted microbes to push the activity of that indigenous population in a desirable direction. Bioaugmentation products are formulated to create a diverse biomass capable of operating in a wide range of conditions (pH, temperature, oxygen concentration, etc.) on a wide range of organic substances.

Most such products contain several different species and strains that work in concert to "mineralize" the complex organics present, breaking them down as far as possible. The ultimate breakdown product of this process is carbon dioxide. Each species or strain (like a family within a species) has different capabilities. Many different types of microbes are used with the objective of achieving the most rapid biodegradation of the widest range of organic contaminants under the conditions reasonably anticipated in a sewer collection system.

FOG Biodegradation

Enhanced fat biodegradation is a good example of the benefits of bioaugmentation. Fats consist of a glycerol molecule to which up to three fatty acid side chains are chemically attached via ester linkages. Natural extracellular enzymes such as lipases and esterases break the glycerol to fatty acid bonds. Individual enzymes may only act on fats with specific fatty acid chain lengths or may break only the bonds with carbons 1 and 3 of the glycerol leaving a partially degraded mono- or di-glyceride. The fatty acids released in this process are transported by the microbes inside their cell wall and biodegraded internally.

Enzymes may target fatty acids of a particular range of chain lengths and presence or absence of double bonds (unsaturation). Thus, a good bioaugmentation product for fat degradation must contain a variety of microbes and the enzymes they produce to metabolize the wide variety of fats occurring in wastewater[1].

Fats are only sparingly soluble in water and tend to congeal on the water surface or on solid surfaces. Accordingly, enzymes involved in fat degradation are only able to degrade the fat at the water interface. This provides limited access and tends to slow the biodegradation process. When microbes are in the presence of fats, they synthesize and secrete natural biological surface active agents to increase the surface area of the fat to speed up the degradation.

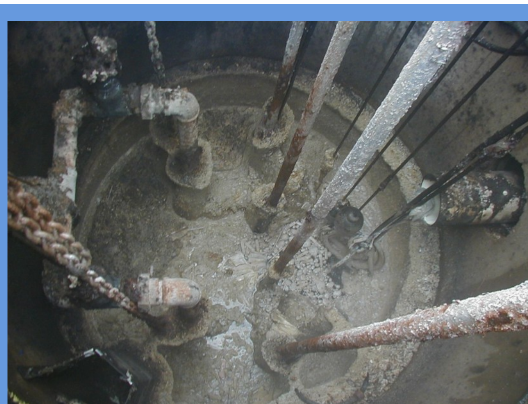
Average Fatty Acid Composition of Some Common Fats and Oils (%)*[2]

	Lauric	Myristic	Palmitic	Stearic	Oleic	Linoleic	Linolenic
Fats							
butter (cow)	3	11	27	12	29	2	1
tallow	-	3	24	19	43	3	1
lard	-	2	26	14	44	10	-
Oils							
canola oil	-	-	4	2	62	22	10
coconut oil†	47	18	9	3	6	2	-
corn oil	-	-	11	2	28	58	1
olive oil	-	-	13	3	71	10	1
peanut oil	-	-	11	2	48	32	-
soybean oil	-	-	11	4	24	54	7

*Totals less than 100% indicate the presence of fatty acids with fewer than 12 carbon atoms or more than 18 carbon atoms.

†Coconut oil is highly saturated. It contains an unusually high percentage of the low-melting C_8, C_{10}, and C_{12} saturated fatty acids.

The photos on the right show "Before" and "After" using microbial products for FOG biodegradation.



Product Formulations

Bioaugmentation products are formulated to create a diverse biomass capable of operating in a wide range of conditions (pH, temperature, oxygen concentration, etc.) on a wide range of organic substances.

Fatty acids at neutral or basic pH act as soaps and can increase solubility of fats, but in the presence of calcium and other metal ions precipitate and often form the deposits in sewers that cause clogging[3]. Thus, it is necessary that the degradation process substantially reduces the concentration of fatty acids as well as the parent fats. A good bioaugmentation product for fat degradation must contain a variety of microbes and the enzymes they produce to metabolize the wide variety of fats occurring in wastewater.

It is important to note that products which only solubilize fats (e.g., solvents and surfactants present in cleaning products) allow redeposition of the fats downstream when the active ingredients are diluted. This can cause blockages and excessive loading downstream to the wastewater treatment plant. Enzymes that only hydrolyze the fats to release long chain fatty acids rely on the bacteria already present to finish the degradation and this is often incomplete. It is therefore important to choose products that contain a large count and diverse variety of microbes.

Product Application Technology

Various technologies are used to dose the microbes into the system to maximize their ability to grow and attach to solid surfaces when conditions are favorable.

Cartridge dispensing systems dose a highly concentrated liquid microbial suspension regularly (e.g. every 7 or 14 minutes) to ensure that microbes are being added when the water flow is not too high, too hot, or too concentrated in disinfectant. Timer controlled dosing pumps can deliver liquid products at night when activity is low to ensure the microbes have time to grow before the next workday.

Slow-release solid products release microbes, nutrients, and other growth promoters continuously as they dissolve. These products can be placed in grease traps, lift/pump stations and collection systems and require little maintenance other than replacement after 30-60 days.

Dry products typically have the highest microbial count and longest shelf-life. These can be added directly to lift/pump stations and wastewater treatment plants where the hydraulic retention time is at least several hours to ensure that the microbes have time to germinate from spores, grow, and attach to surfaces before they are washed out. If applied to areas with short retention times, they should be pre-hydrated by stirring or aerating the product in water for 2-4 hours. Dry products can be applied manually or with an automated dry product feeder.

[1] A. M. Brooksbank et al. 2007. Degradation and Modification of Fats, Oils, and Grease by Commercial Microbial Supplements. World Journal of Microbiology and Biotechnology 23:977-985.
[2] David W. Ball, John W. Hill and Rhonda J. Scott. The Basics of General, Organic and Biological Chemistry, v.1.0
[3] K.M. Keener et al. 2008. Properties Influencing Fat, Oil, and Grease, Deposit Formation. Water Environment Research 80:2241-46.

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