Bioaugmentation for Wastewater Systems

By Terry L. Joubert, microbiologist
T.L. Joubert and Associates, Inc.

The rendering industry has challenges in meeting wastewater compliance issues due to the complexity of the waste streams encountered. Wastewater generated from the industry is generally rich in protein and fat content, making wastewater treatment a greater than normal challenge when compared to domestic wastewater systems (i.e., municipalities). The complexity of the biological breakdown of proteins and fats is a cause for looking at technologies that will make the process more efficient and less difficult to maintain.

At each level of the degradation of proteins and fats, there are challenges in the treatment process. Fats break down initially to form fatty acids and glycerol (an alcohol), and proteins generate copious amounts of ammonia and hydrogen sulfide gas. These degradation by-products can cause major problems if not managed correctly. The implementation of bioaugmentation products can be extremely helpful in alleviating these problems and meeting compliance goals.

But what is bioaugmentation? Bioaugmentation is defined as the addition of bacteria, nutrients, and other growth factors to enhance the biodiversity and efficacy of wastewater or other pollution-degrading systems. The major types of bioaugmentation products generally fall into the following categories: (1) commercially prepared microbial and enzyme formulations (most common); (2) macronutrient- and micronutrient-based products consisting of nitrogen, phosphorus, sulfur, and trace minerals (metals, etc.); and (3) plant extract-based bio-stimulants mainly consisting of enzymes, vitamins, sugars, amino acids, and other growth factors (e.g., yucca, kelp).

These products are not all created equal. They must be tailored to meet the specific wastewater challenge being addressed and should not be designated as a cure-all in every situation. It is imperative that these types of products are applied with a good working knowledge of wastewater chemistry and biology to avoid misapplication. Analytical evaluations should be made appropriately to determine areas where treatment process deficiencies exist. Chemical treatment products to address issues such as pH and alkalinity control (caustic, acid, carbonates) generally enhance the above-mentioned products.

Application Areas in the Rendering Industry

Anaerobic digesters: Wastewater from the rendering industry is generally rich in fat and protein content and will generally be high in biochemical oxygen demand (BOD) or chemical oxygen demand (COD) levels. Because of this, the waste will be generally characterized as a “high strength” waste.

When operating correctly, anaerobic digesters operate in the absence of oxygen and produce methane gas as a useful by-product. However, at times, the process can have difficulty processing the waste, particularly the fat content. High levels of fatty acids can accumulate to inhibit the generation of methane gas. Bioaugmentation products can be added to accelerate the degradation of fats and the accumulation of these acids.

Another major concern is the generation of hydrogen sulfide, ammonia, and other odor-causing organic compounds (i.e., mercaptans, organic amines). These can also be addressed by accelerating the degradation of such compounds.

Aerobic systems: These systems operate in the presence of oxygen and can degrade wastewater to levels acceptable for discharge to natural bodies of water or to a receiving publicly owned treatment works, or POTW. Aside from the fat degradation challenges, protein and protein by-products degradation produces high levels of ammonia. As a result, ammonia removal is needed to meet compliance. In the presence of oxygen and the proper pH control, bacterial cultures are the main approach. Specifically, bacteria known as nitrifying bacteria are added to convert ammonia (NH₃/ NH₄⁺) to nitrates and nitrates (NO₂⁻ and NO₃⁻), respectively. Additional micronutrients and growth factors may be needed to enhance the process.

Aerobic systems receiving anaerobic wastes will generally
be deficient in some area. For example, the generation of hydrogen sulfide from the anaerobic systems will react with trace metals to form sulfide-based metal precipitates. As a result, these trace metals will not be available for other bacteria to complete the degradation process. Nitrifying bacteria can be quite susceptible to trace metal (mineral) deficiencies. Bioaugmentation products are typically added to aerated basins (activated sludge) or lagoons, sequence batch reactors, facultative holding or process water lagoons, and cooling ponds.

Miscellaneous systems: Bioaugmentation products are also versatile enough to handle non-traditional usage areas such as wash water systems, bio-filters, air scrubsers, and cooling water systems. Products containing bacteria, enzymes, and surfactants are generally prominent in these areas along with plant extracts with surfactant properties (e.g., yucca extract). Bioaugmentation products are beginning to play a greater role in odor management due to their ability to degrade completely in the environment.

Why Use Bioaugmentation Products?

Bioaugmentation products should be considered based on the benefits obtained. Below is a list of major benefits when products are properly applied.

- In the event of a plant startup or upset, a wastewater process can achieve a steady-state operation in days as opposed to weeks.
- Plants can meet discharge requirements more rapidly as opposed to waiting for indigenous (natural) microorganisms to kick in, particularly after a plant upset (e.g., heavy loading, spills).
- The possibility of reseeding a process with inhibitory organisms such as filamentous bacteria (e.g., Nocardia) is reduced.
- The ability to remove pass-through compounds such as hydrocarbons, surfactants, and solvents is enhanced. In some instances, certain bacteria can be grown specifically through a process called selective adaptation to remove certain compounds more efficiently than indigenous, naturally-occurring strains.
- Sludge is reduced through lower biomass produced per unit of BOD or COD removed from the process. Selective strains of microorganisms can produce less biomass than their indigenous counterparts can in nature. Sludge reduction is a great economic incentive in lowering disposal costs to lower overall plant operational costs.
- Foam is reduced through accelerated degradation of surfactants and fatty acids resulting from fat breakdown. Foam accumulations from certain unwanted filamentous bacteria (e.g., Nocardia spp., Microthrix parvicella) can also be decreased.
- Specifically addresses odor-causing compounds such as hydrogen sulfide, mercaptans (sulfur-bearing compounds), amines and ammonia from protein degradation, and fatty acids (rancidity from fats, oils, and grease degradation).
- Reduction of BOD, COD, and total suspended solids is improved, as is ammonia removal through greater nitrification.

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- A greater efficiency in aeration is experienced under aerobic treatments through an increase in oxygen transfer, thereby lowering utility costs.
- Overall biological nutrient removal processes to meet current and future goals is enhanced.

Legitimate Science Involved

Bioaugmentation products have been looked upon with disdain in some circles, but there are legitimate scientific principles involved in putting together effective products. Not all products are deemed “snake oil” or “weasel dust.” For example, at the heart of biological wastewater treatment processes is the ability for microorganisms to produce the necessary enzymes to break down wastes. Bacterial strains used in formulations can be characterized based on their ability to produce certain enzymes necessary to break down certain wastes.

In rendering, the breakdown of certain proteins and fats is essential. Enzyme classes such as proteases (for proteins) and lipases (for fats) are vitally necessary in wastewater treatment processes. Microorganisms with the ability to produce these enzymes at high levels are very beneficial to accelerating the overall wastewater treatment process. The sciences of microbiology and biochemistry afford us the know-how in producing these attributes in commercially available products. Figures 1-4 demonstrate the ability of a non-pathogenic microbe to degrade proteins, fats, oils, and greases encountered in the rendering industry and elsewhere.

Research results are manifested in wastewater systems. Any benefit obtained from bioaugmentation should show up with solid proof. Discharge parameters should be lowered as determined by laboratory tests and certain visual evidence such as improved clarity of the effluent.

Conclusion

Biological wastewater treatment is a process of using live organisms to produce a desired result. Although most systems have survived in the absence of implementing bioaugmentation products due to the action of indigenous organisms, the science of microbiology can certainly enhance most processes. Much of what is known in other fields such as biochemistry, medicine, and chemistry is slowly making its way into the environmental arena.

Good results will always require the proper attention and know-how when implementing bioaugmentation programs. As stated previously, not all products are created equal in their ability to solve problems encountered in wastewater systems. Misapplications occur when the wrong products are applied or when conditions for success are not properly established (e.g., dissolved oxygen, pH, time).

It is imperative that those who market these types of products be fully knowledgeable about the processes being treated. When scientific and application knowledge are combined, the probability for success is great.