White Paper

Microbial Odor Control in Sewage Transport and Treatment

Sources of Odor

Odors may be generated in any section of a sewage collection system or wastewater treatment plant. These odors may be a result of industrial discharges, reactions which take place between combinations of industrial and municipal wastes mixing in the system, or anaerobic bacterial metabolism. In the collection system, biodegradation of organic matter rapidly consumes all or most of the available oxygen. This causes anaerobic processes to take over. Odors escape from lift stations and maintenance access manholes as well as the headworks to the wastewater treatment plant. Often the most serious foul smells are those that develop in interceptor sewers and lift stations, as they are typically located in residential and/or commercial areas.

In a wastewater treatment plant, odors are generated in the primary clarifiers and scum pits, aeration basins, secondary clarifiers, sludge processing equipment, and sludge storage areas. Sludge found in drying beds, on vacuum filters, in storage tanks, or in sludge dryers is also a strong potential source of odor.

There are two main sources for odor in these systems;

- ✓ Volatile Fatty Acids
- ✓ Hydrogen Sulfide

Volatile Fatty Acids

Another source of odor problems is created by volatile fatty acids (VFA's). Anaerobic metabolism typically generates VFA's such as acetic, propionic, butyric and longer chain acids. These VFA's have a sharp or sour odor. Generally, these compounds must be present at higher concentrations than hydrogen sulfide to be offensive but they can be produced at significant concentrations and are typically a component of odors from anaerobic processes associated with septic sewage odor.

Production of Volatile Fatty Acids

Fatty acids are, as mentioned above, through anaerobic processes in the sewage. A fatty acid becomes volatile when the carbon chain length of the fatty acid is 6 carbons or less. Fatty acids are formed according to the equation below.

$$CH_3\text{-}(CH_2)_n\text{-}COOH + H_2O \longrightarrow CH_3\text{-}COOH + CH_3\text{-}CH_2\text{-}COOH + CH_3\text{-}(CH_2)_2\text{-}COOH$$

Although these compounds can be metabolic degradation products of a variety of compounds such as amino acids, sugars and lipids, they are formed in large amounts from the breakdown of fats. These compounds contribute to the sour odor of anaerobic polluted water.

Degradation of Fatty Acids

Fatty acids can be biodegraded to carbon dioxide and water under both aerobic and anaerobic conditions, eliminating the odor. Sulfur bacteria utilize fatty acids in addition to oxidizing sulfides.

Hydrogen Sulfide

Hydrogen sulfide (H_2S) is the most common cause of odor complaints – probably the source for more complaints than all other malodorous compounds combined. In addition to the rotten egg odor, H_2S causes:

- ✓ Serious corrosion problems costing many millions of Euro's each year
- ✓ Serious health and safety concerns
- ✓ Diminished effectiveness of any wastewater facility due to toxicity to the biomass that is necessary for biological treatment.

The formation of H_2S is initiated by sulfate reducing bacteria (SRB's) but environmental parameters like pH, temperature and sewage turbulence also play an important role in the process of H_2S formation.

Production of Hydrogen Sulfide

Under anaerobic conditions, various compounds or ions can be used by different groups of microbes as the electron acceptor. If neither oxygen nor nitrate (NO_3^-) is present, microbes that use sulfate (SO_4^{-2}) as an electron acceptor (sulfate reducing bacteria) predominate and these microbes generate sulfide.

$$C_6H_{12}O_6 + NO_3^- + H^+ \longrightarrow CO_2 + H_2O + N_2 + N_2O + \text{biomass (denitrifying bacteria)}$$

$$C_6H_{12}O_6 + SO_4^{-2} + H^+ \longrightarrow CO_2 + H_2O + HS^- + \text{biomass (sulfate reducing bacteria)}$$

(Note: equations are illustrative and not meant to show stoichiometry; H^+ on the left side indicates acid is consumed in the reaction while H^+ on the right indicates acid generation.)

Thus, as sulfate is normally present in wastewater, the sulfur cycle becomes a critical step in the breakdown of waste under anaerobic conditions. Sulfides are present in three forms: hydrogen sulfide (H_2S) at low pH, hydrosulfide ion (HS^-) at neutral pH and sulfide ion (S^{-2}) at high pH. The ionic forms stay dissolved in water while the neutral H_2S is easily volatilized.

$$H^+ + HS^- / S^{2-} \rightleftarrows H_2S \nearrow$$

Once volatilized it creates odor issues when it escapes to the atmosphere, health and safety issues for people working in confined spaces which are exposed to the H_2S gas and corrosion issues when the H_2S dissolves into water films present on metal and concrete surfaces.

Sulfur Oxidizing Bacteria

Corrosion of metal and concrete surfaces occurs when H_2S gas dissolves back into water films present on these surfaces. Again this is a process initiated by bacteria.

Sulfur oxidizing bacteria (SOB) reduce the dissolved hydrogen sulfide (H_2S) to elemental sulfur. Sulfur oxidation occurs when microbes convert hydrogen sulfide (H_2S) into elemental sulfur (S^0) by partial oxidation, or into sulfate (SO_4^{2-}).

Degradation of Hydrogen Sulfide (and other Reduced Sulfur Compounds)

The oxidation of H_2S under highly aerobic conditions, e.g. in the biofilm above the waterline in sewers, generates corrosive sulfuric acid.

$$HS^- + O_2 \longrightarrow SO_4^{-2} + H^+$$

The sulfuric acid dissolves the cement binder of concrete thus weakening the structure which starts to crumble. Heavy rainfall events which create a lot of flow, hence sheer inside the sewer will flush away the crumbled concrete particles. Similar, traditional sewer maintenance by hydro jetting can cause serious damage to the sewer pipe.

Furthermore the sulfuric acid can drip back into the sewage and again be used by SRB's to produce H_2S.

In contrast, the sulfur bacteria which oxidize sulfide to elemental sulfur without the generation of acid do not form a problem.

$$H_2S + CO_2 \longrightarrow S^0 + CH_2O \text{ (organic cellular components)}$$

Elemental sulfur is not used by SRB's, so the cycle is disrupted. This is a principal method used for microbial control of hydrogen sulfide in sewer systems and treatment plants.

Specialized microbes reduce sulfides under anaerobic or anoxic conditions to elemental sulfur, which is occluded by the cells thus suppressing odors.

These microbes can produce a variety of end products such as sulfur, sulfite and polythionates that are not available to sulfate reducers for formation of more hydrogen sulfide. These end-products are typically formed by the microbes under limited oxygen concentrations and do not require as much oxygen as does the full oxidation of sulfide to sulfate.

MICROCAT-ANL Odor Control Bioformula

MicroCat®-ANL Odor Control Bioformula is a blend of strict and facultative anaerobic microbes selected for their ability to oxidize sulfides to elemental sulfur (collectively referred to as sulfur bacteria). Because it is a blend of several species and strains, some components of the blend can function when oxygen is present, some can use alternate electron acceptors such as nitrate, others only function in the absence of oxygen, and some are photosynthetic. Fatty acids are also metabolized by the strains in MicroCat -ANL.

MicroCat-ANL is a liquid blend of preselected, adapted microorganisms for use under microaerophilic, anoxic or anaerobic conditions. It is formulated for use in sludge, compost, contaminated soils and wastewaters to suppress hydrogen sulfide odors and enhance biodegradation and contaminant removal where oxygen is of limited availability. MicroCat-ANL is particularly well suited to applications in sewer lines, primary treatment systems, sludge processing and handling systems, and anaerobic or facultative lagoons. Such systems are commonly found in dairy, meatpacking, food processing and municipal sewage transport and waste treatment.

Applications

MicroCat®-ANL is often used in primary clarifiers, ponds and lagoons, open tanks, and secondary clarifiers to control odor. Recommended maintenance dosage ranges from 1-30 ppm depending on sulfide concentration and biochemical oxygen demand (BOD). Dosage is normally higher initially until a population is established, then reduced to the maintenance dosage.

MicroCat®-ANL is also used in collection systems (lift stations and sewer lines) and sludge storage and processing operations to reduce sulfide levels and odors. It replaces nitrate based chemicals for odor and corrosion control in the collection system and chlorine and masking agents in sludge processing. Downstream wastewater treatment plants have reported reduced oxygen demand and improved settling.

MicroCat®-ANL can be used by composting facilities to reduce odor from compost piles. ANL targets H_2S and volatile fatty acids but will have minimal effect on released ammonia. ANL is especially effective when added to leachate and runoff from composting operations and when sprayed onto the surface of compost piles.

We recommend dilution of ANL (1 L ANL plus 4 L water) and application at 0,4 L/m^2 for surface odor control. If treating leachate or runoff in a holding pond, only 1,5 ml to 5 ml per m^3 of pond water are required.

The following conditions are recommended:

- ✓ pH: must be between 6.0 - 9.0.
- ✓ eH: must not be below - 350 millivolts
- ✓ Temperature: must not exceed 42° C.
- ✓ H_2S: must not exceed 80 ppm dissolved when ANL is introduced.
- ✓ Toxic conditions - which adversely affect the naturally present biomass

Some Example Applications

Industry	Maintenance Dosage	Results
Dairy/Cheese	40 ppm of flow/day	Eliminated H2S odors , Reduced effluent BOD_5, Reduced pond aeration costs.
Rendering	40 ppm of flow/day	Eliminated odor complaints. Reduced aerator costs. BOD/TSS permit standards met
Meat Packing	10 ppm of flow/day	Dramatically reduced H_2S odors
Municipal	6 ppm of flow/day	Dramatically reduced odor calls. Pond H_2S levels <.05 ppm. Reduced surface solids accumulation
Municipal/Food Processing	7 ppm of flow/day	Drastically reduced H_2S levels. BOD removal increased up to 90%
Municipal	1.25 ppm of flow/day	Dissolved H_2S reduced from 5 to <1ppm
Municipal	2 ppm of flow/day	Reduced trickling filter odors
Pulp and Paper	2 ppm of flow/day	Primary clarifier odor eliminated. Belt press room H_2S levels reduced from 50 ppm to <2 ppm
Soy Bean Refining	11 ppm of flow/day	Odor complaints eliminated. Effluent COD/TSS improved.