

Thioguard® in Sanitary Treatment Plants and Collection Systems

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Thioguard, is an alkaline magnesium hydroxide slurry, $Mg(OH)_2$, that is beginning to be recognized as having many advantages over the more common alkali sources, such as caustic soda and hydrated lime. Technical grade magnesium hydroxide suspensions are akin to the more familiar pharmaceutical grade "milk of magnesia" used to alleviate acid indigestion, and are therefore a safe non-hazardous product that will not cause chemical burns.

Magnesium hydroxide has found great use in treating industrial metal laden acidic wastewater, where, compared with caustic soda or lime, remove metals at lower pH, produce less sludge volume, and a filtercake that de-waters more readily. However, it is also beginning to be used in the municipal arena. When comparing the physical and chemical properties of magnesium hydroxide with conventional alkalis, hydrated lime and caustic soda (see Table 1) several advantages are noted.

The first is that fewer pounds of magnesium hydroxide are required to neutralize the same amount of acid, 37% more for caustic soda and 27% more for hydrated lime. Another unique characteristic is the maximum pH obtainable during an overdosing situation. Excessive additions of caustic soda and hydrated lime will result in the pH of the waste stream reaching 14 and 12.5 respectively.

However, the pH of a magnesium hydroxide slurry is 10.5, and when used to neutralize acidic waste, will only obtain a pH of about 9.0, even when overdosed. This upper pH limit happens to coincide with the upper limit under the Clean Water Act, 1976.

Magnesium hydroxide is supplied as an easily pumpable "latex paint like" aqueous suspension, typically ranging from 55 to 65% solids. It can settle and freezes at 32°F, therefore should be stored in agitated tanks. It can also be supplied as a fine powder.

Two new areas where magnesium hydroxide is being utilized are municipal sanitary collection systems and treatment plants.

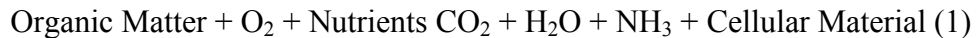
Property	50% NaOH	30% Ca(OH)₂	58% Mg(OH)₂
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% Hydroxide	42.5	45.9	58.3
Solubility in Water g/100 ml	42	.0185	0.0009
Reactive pH	14	12.5	9.0
Freezing Point °F	61	32	32
Weight Equivalency	1.37	1.27	1

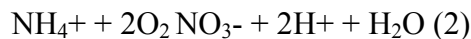
Wastewater Treatment Plants

Aerobic processes

Aerobic processes have been employed by municipal and industrial wastewater treatment systems for the removal of organics, the biological conversion of ammonia to nitrates, reduction of sludge mass and volume, and reduction of pathogenic organisms. Aerobic digestion consists of two steps; direct oxidation of biodegradable matter, and subsequent oxidation of microbial cellular material.



If the digestion process is provided with sufficient oxygen and detention time, or a separate nitrification system is utilized, ammonia will nitrify and form nitrates. The nitrification process may result in a decrease of both pH and alkalinity as a result of acid generation during the process:



This reaction results in the consumption of about 7.1mg alkalinity per each mg $\text{NH}_4^+\text{-N}$ oxidized. Influent treated with Thioguard[®] from the collection system generally arrives at the digester very near pH 7.5, the optimum pH for bacterial growth in both aerobic and anaerobic processes. If the wastewater does not have sufficient alkalinity to compensate for losses in the nitrification reaction, it will result in a pH drop and could, if the pH drops too low, result in bacterial deactivation.

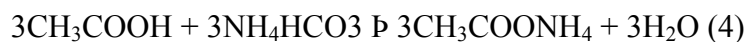
The use of Thioguard offers the following advantages over caustic soda and lime. Magnesium hydroxide buffers to a controlled pH near 9.0, even when over dosed. This buffering capacity results in better pH control and makes pH excursion less likely to occur. Magnesium hydroxide has higher neutralizing value per dry pound. Therefore, less magnesium hydroxide is required compared with caustic or lime. Unlike lime,

magnesium hydroxide does not cause large volumes of sludge and scaling in the collection system or treatment plant equipment.

Anaerobic Digestion

Anaerobic digestion is the solubilization and reduction of complex organic substances by microorganisms in the absence of oxygen. The products of digestion are methane, carbon dioxide, trace gases and stabilized biosolids. The microbial population responsible for this conversion can be divided into three groups: solubilization, acid formation and methane formation (methanogens).

Proteins, lipids, carbohydrates and complex organics are solubilized by hydrolysis. These products are converted into short-chain organic acids, such as, acetic, propionic and lactic. These acids are then converted into methane and carbon dioxide. The acid forming bacteria are tolerant to environmental changes such as pH and temperature. In contrast, the methane forming bacteria are intolerant to environmental changes.



Equation 3 represents acid formation. The acid is then neutralized, equation 4, by bicarbonate present in the system. The buffer consumed in equation 4 is then regenerated in the methane forming step. There is therefore an equilibrium between buffer formation and consumption. The optimum pH range for methanogens is also 6.5 to 7.5. In a digester upset, net consumption of buffer occurs and the process is in danger of pH failure. When this happens an external source of alkalinity must be added. Magnesium hydroxide can be added to the digester to neutralize any excess acid not consumed by the methanogens. Magnesium hydroxide when used in anaerobic digesters will have all the benefits apparent in aerobic processes.

Some Benefits of Thioguard Slurry in Biological Treatment Processes

Thioguard magnesium hydroxide slurry offers the following advantages for biologic processes:

Provides Alkalinity and nutrient. Magnesium hydroxide not only supplies alkalinity, but also supplies magnesium, an essential micro-nutrient for controlled bacterial growth.

Buffers at the pH maximum. Magnesium hydroxide buffers to a maximum pH of 9.0, even when over-dosed. This buffering effect provides better pH control in the critical pH operating ranges between 7.0 and 9.0. Caustic and lime are very easily overdosed with a rapid and dramatic change in pH that can reach pH 14 and 12.5 respectively. This results in bacterial kills and can, in severe cases, deactivate the process. Even when not overdosed, the point of addition for caustic or lime will often produce localized hot spots that kill bacteria.

Although magnesium hydroxide buffers at a maximum of 9.0, it provides more alkalinity than caustic and lime. Because its solubility is substantially lower, it acts like a slow release agent contributing needed hydroxyl ions only when required.

Safe to handle. Magnesium hydroxide is safe to handle, is non-toxic and non-corrosive, unlike caustic soda and lime. Caustic and lime react exothermically when added to water.

Has a greater neutralizing capacity per pound. Magnesium hydroxide has a higher neutralizing value per dry pound when compared with caustic (which requires 37% more) and lime (which requires 27% more).

Other benefits include improved clarifier and DAF performance, reduced sludge volume index (SVI), more dense filter cake with lower press cycle times, enhanced activated sludge performance, lower effluent TSS, phosphorus removal and sludge conditioning, metals precipitation and reduced effluent BOD5. Thioguard can also be used for lagoon odor control, and suspended growth nitrification.

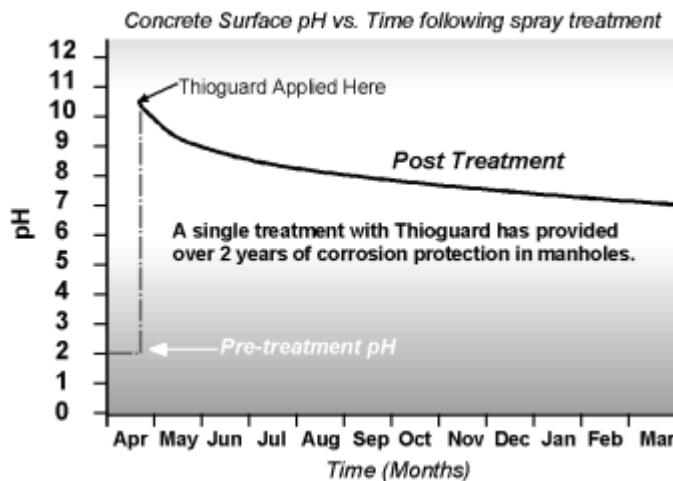
Preventing Corrosion in Sanitary Collection Systems

Odor and corrosion problems in concrete sanitary sewer systems is a wide spread problem. The corrosion is the result of a two step biological process. Sulfate reducing bacteria present in the collection system convert sulfates into hydrogen sulfide gas. A series of oxidizing bacteria that reside on the sewer crown convert hydrogen sulfide gas into sulfuric acid which will eventually result in a substantial lowering of pH, frequently to values below 2.0, see Figure 1. Low pH conditions and corrosion problems are also similarly experienced in maintenance holes. This acid attacks the concrete, reducing it to a soft putty like gypsum. According to a 1992 EPA report, maintaining a surface pH of 4 or higher is sufficient to prevent an unacceptable corrosion rate.

An effective method to combat the corrosion problem is to spray the corroded sewer crown with a modified magnesium hydroxide suspension, that is formulated to resist surcharging. Field studies conducted in the City of Los Angeles demonstrated that a single application provided enough alkalinity to protect concrete surfaces for over a year. The treatment process involves spray painting the magnesium hydroxide suspension onto the concrete surface requiring protection, to achieve a coating thickness of 100-125 mils. The magnesium hydroxide neutralizes any sulfuric acid present on the surface and raises the pH up to about 10.0.

This high pH has the added benefit of deactivating the bacteria responsible for the acid generation, since they cannot tolerate high pH conditions. The magnesium hydroxide coating will also react with hydrogen sulfide gas thus helping to reduce potential odor problems. The coating is intended to be sacrificial, slowly being consumed by hydrogen sulfide, and will need to be replenished on a regular maintenance schedule. It has been estimated that annual treatment of sewers using magnesium hydroxide may extend sewer life by 20 years. Typical spray treatment will cost approximately 200 times less than rehabilitation.

Representative field results from spray treatment of concrete surfaces using Thioguard are presented in Figure 1.



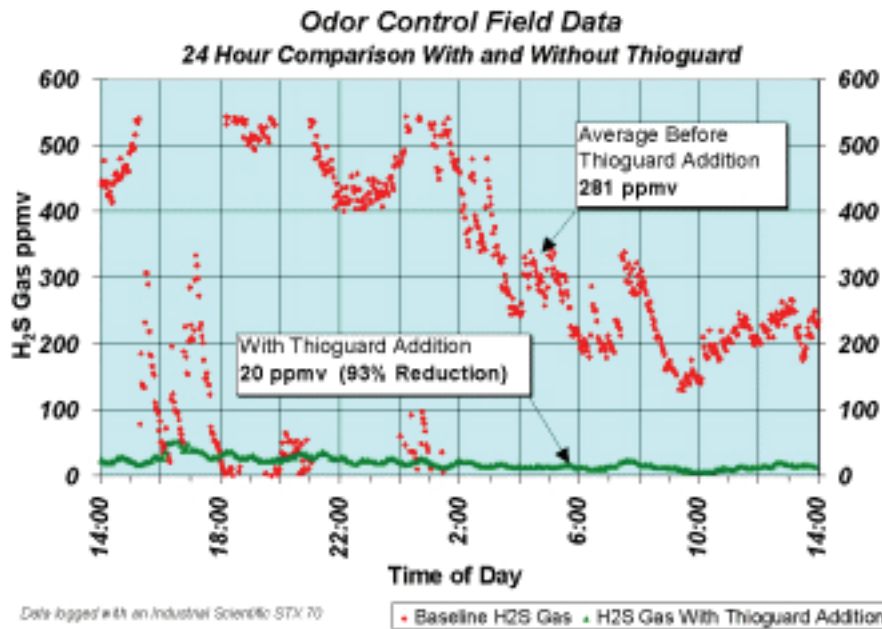
Odor Prevention with Continuous Thioguard Addition

Adding magnesium hydroxide to municipal wastewater suppresses hydrogen sulfide gas formation via an increase in pH. At near neutral pH, relatively small adjustments in pH results in large changes in hydrogen sulfide dissociated in solution, via the equilibrium reaction:



At pH 7.0 approximately 50% of the hydrogen sulfide remains dissociated. However, at pH 8.0, only 8.3% is present as hydrogen sulfide, and at pH 9.0 hydrogen sulfide levels drop to less than 1.0%. Small additions of magnesium hydroxide sufficient to raise wastewater pH in this range can significantly reduce hydrogen sulfide gas emissions, and thus help control odor/corrosion problems.

Field results using continuous addition of Thioguard for hydrogen sulfide odor control are presented in Figure 2.



Summary

Although magnesium hydroxide has traditionally been utilized in industrial wastewater treatment, it is now being recognized as having many uses in Municipal wastewater treatment. It has many advantages over more common alkalis, and is considerably safer to handle.

Glossary

NO_3^- – Nitrate anion

NO_2^- – Nitrite anion

H^+ – Hydrogen ion (acid)

NaOH – Caustic soda

$\text{Ca}(\text{OH})_2$ – Hydrated lime