# The Role of Alkalinity in Aerobic Wastewater Treatment Plants: Magnesium Hydroxide vs. Caustic Soda

Modern day wastewater treatment plants must use a variety of physical, chemical and biological processes to meet effluent treatment guidelines. During the course of treatment these plants consume a variety of different chemicals. In some treatment plants an alkali is used to provide the alkalinity required to maintain effective biological activity and for pH control. This paper will discuss the role that alkalis play in wastewater treatment. Therefore, this report will have three sections. The first section defines the term alkalinity, what it is and what it is not. The second section examines why alkali chemicals are used for wastewater treatment. The third and final part presents facts as to why magnesium hydroxide is the alkali of choice for these applications.

**Alkalinity, Definition and Composition**

Alkalinity can be defined as the ability of a water to neutralize acid or to absorb hydrogen ions. It is the sum of all acid neutralizing bases in the water. In municipal and industrial wastewater there are many factors which contribute alkalinity. Factors which contribute to alkalinity include the type of dissolved inorganic and organic compounds present in the water, the amount of suspended organic matter in the water, whether the water is strongly or weakly buffered, the presence or absence of free hydroxyl alkalinity, the amount of bicarbonate in the water, the bicarbonate to dissolved $CO_2$ ratio and is indirectly correlated to the amount of dissolved solids in the water.

The pH is the measure of the hydrogen ion concentration of the water but it does not determine how many hydrogen ions that water can absorb. pH is a useful indicator of the transition between carbonate and bicarbonate alkalinity. pH is also used to determine the point at which alkalinity stops and free acidity begins. The pH of a water serves as a guide to the types of alkalinity present in the water but is unrelated to the alkalinity content of a water.

The bacteria and other biological entities which play an active role in wastewater treatment are most effective at a neutral to slightly alkaline pH of 7 to 8. In order to maintain these optimal pH conditions for biological activity there must be sufficient alkalinity present in the wastewater to neutralize acids generated by the active biomass during waste treatment. This ability to maintain the proper pH in the wastewater as it undergoes treatment is the reason why alkalinity is so important to the wastewater industry.

The standard test for alkalinity measures quantity of acid neutralizing bases and represents this value in milligrams (mg) of $CaCO_3$ equivalents per liter (l) of wastewater. The term mg/l and the term ppm are used interchangeably in the wastewater industry. The amount of alkali that is added during waste treatment is determined by means of this standard test. Various treatment plant operators will express the test results in different ways. Some operators will express the results in mg/l, some in ppm, some use pounds/gallon, others like the expression pounds per day while still others use the term pounds/million gallons. Different terminology is used to ask the same question. How much alkalinity has to be added to the treatment system in order to neutralize acid and maintain the proper pH? The operator is looking for the number of gallons of magnesium hydroxide slurry, or caustic soda which need to be added to the system on a daily or hourly basis.

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### Nitrification and Alkalinity

One of the primary pollutants in municipal and food processing wastewaters is ammonia. The nitrification process is used to convert the ammonia in the wastewater to nitrate. Nitrification is a two-step biological process utilizing two species of nitrogen converting bacteria. These species of bacteria are most active in the pH range of 7 to 8. During the nitrification process, hydrogen ions are released and alkalinity is consumed as the acid is neutralized. For every 1.0 mg of ammonia converted to nitrate, 7.14 milligrams (mg) $CaCO_3$ equivalent are consumed. The generation of acid during ammonia conversion, and the need to maintain the proper pH, is the reason why an alkali is added to the system. Nitrification of the wastewater is the single largest factor which leads to the consumption of alkalinity and the need to add alkali to the treatment system.

How much alkali is added to the system is dependent on a number of interrelated factors. The amount of alkali added is determined by the amount of pollutants in the incoming waste, the type of treatment that is used in the plant, the amount of natural alkalinity in the influent water, the pH of the influent waste stream, the permitted pH of the effluent discharged from the plant, the number of gallons of waste processed by the plant, and whether the plant denitrifies the effluent prior to final treatment and discharge.

### Alkalis and Alkalinity

One of the most common alkalis used to provide alkalinity in wastewater treatment is caustic soda. However, magnesium hydroxide has properties which make it a clearly superior product in providing alkalinity to wastewater treatment systems. The chemical properties comparing these two alkalis are summarized in Table 1.

**TABLE 1**
**PROPERTIES OF MAGNESIUM HYDROXIDE vs. CAUSTIC SODA**
**PRODUCT COMPARISONS**

| | MAGNESIUM HYDROXIDE | SODIUM HYDROXIDE |
|---|---|---|
| **TRADE NAME** | **FloMag® H** | **Caustic Soda** |
| Chemical Formula | $Mg(OH)_2$ | NaOH |
| Percent Solids | 62 | 50 |
| Pounds of Dry Solid per Gallon | 7.965 | 6.043 |
| Alkalinity, lbs $CaCO_3$ per Dry Pound | 1.68 | 1.23 |
| Alkalinity, lbs $CaCO_3$ per Dry Ton | 3361 | 2440 |
| Alkalinity, lbs $CaCO_3$ per Gallon | 13.38 | 7.55 |

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As can be seen from Table 1, magnesium hydroxide provides 1.68 lbs of $CaCO_3$ equivalent alkalinity per dry pound as opposed to 1.23 lbs of $CaCO_3$ equivalent alkalinity per dry pound of caustic soda. Magnesium hydroxide provides 39% more alkalinity than caustic soda on a per dry pound basis. However, it is on a delivered product basis that magnesium hydroxide clearly demonstrates its superiority to caustic soda. The data in Table 1 clearly shows the advantages of FloMag H over 50% caustic soda. FloMag H provides 13.38 lbs of $CaCO_3$ equivalent alkalinity per gallon. Caustic soda delivers only 7.55 lbs of $CaCO_3$ equivalent per gallon. FloMag H provides 81% more alkalinity per gallon when compared to caustic soda.

FloMag H supplies more alkalinity than 50% caustic soda. Some of the additional important benefits of magnesium hydroxide slurry are that it buffers to a pH of about 9.0, is much safer to handle than caustic soda and provides long lasting alkalinity and pH control. The combination of the benefits combine to make magnesium hydroxide slurries clearly superior to caustic soda when used in the wastewater treatment industry.

### Alkalinity Applications for Wastewater Treatment

**1 Gallon of FloMag** H:

- Replaces 1.77 gallons of 50% caustic soda
- Replaces 7.69 lbs of lime
- Replaces 2.85 gallons of 34% $Ca(OH)_2$ slurry

### Benefits of Magnesium Hydroxide

- Supplies more alkalinity per gallon than caustic soda.
- Safer to handle than caustic soda.
- Does not cause the scaling problems of lime solutions.
- Non-toxic, safe for the environment.
- Buffers to a moderately alkaline pH of 9.0.
- Uses the same pumps as caustic soda.
- Provides long lasting alkalinity.
- Provides soluble $Mg^{+2}$ for cellular respiration.



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