Active Ingredient.

Calcium hydroxide - Lime has been used to kill pathogens for thousands of years! Lime is an important chemical with numerous chemical, industrial, and environmental uses in the United States. Certain evidence of its use as a lime mortar has been found at a site in what is now eastern Turkey dating between 7,000 and 14,000 years ago. More definite evidence of its use in mortars in the Near East dates from 8,000 years ago. In Tibet, it was used to stabilize clays in the construction of the pyramids of Shersi 5,000 years ago. The ancient Egyptians used lime as an ingredient in mortar and plaster. The Chinese, Greek, Roman, and other ancient civilizations used lime for construction, agriculture and medicinal purposes.

Lime Can Help Control Pathogens
Lime inhibits pathogens by controlling the environment required for bacterial growth. Calcium hydroxide (hydrated lime) is an alkaline compound that can create pH levels as high as 12.4. At pH levels greater than 12, the cell membranes of harmful pathogens are destroyed. The high pH also provides a vector attraction barrier (i.e., prevents flies and other insects from infecting the treated biological waste). Because lime has low solubility in water, lime molecules persist in biosolids. This helps to maintain the pH above12 and prevent regrowth of pathogens. In addition, when quicklime (calcium oxide, or CaO) is used, an exothermic reaction with water occurs. This heat release can increase the temperature of the biological waste to 70°C, which provides pasteurization and also helps dry out the solid waste.

Effect on Pathogen Growth
By raising the pH of water to 10.5-11 through the addition of lime and retaining the water in contact with lime for 24-72 hours, lime controls the environment required for the growth of bacteria and certain viruses. This application of lime is utilized where "phenolic water" exists, because chlorine treatment tends to produce an unpalatable water due to the phenol present. This process, called "excess alkalinity treatment," also removes most heavy metals.

Lime Can Help Control Odors
Lime treatment also reduces odors, particularly hydrogen sulfide, which is not only a nuance odor but also can be very dangerous if localized high concentrations build up. In addition to high pH, lime provides free calcium ions, which react and form complexes with odorous sulfur species such as hydrogen sulfide and organic mercaptans. Thus the biological waste odors are not 'covered over' but actually destroyed.

Lime Treatment is Cost-Effective
Lime treatment of animal wastes is economically attractive. For biosolids, lime treatment is often a least cost alternative—for example, unit treatment costs of lime stabilization of biosolids have been estimated to be less than half the costs of aerobic and anaerobic digestion. There are a number of innovative technologies that use lime or lime-derived materials to treat animal wastes and generate a usable agricultural product. Because of the versatility of lime it can be used for the treatment of most animal wastes, including hogs, cattle, dairy, and poultry.

Using Lime To Treat Drinking Water
In terms of annual tonnage, lime ranks first among chemicals used in the treatment of potable and industrial water supplies—in 2001, nearly a million metric tons. It is used by many municipalities to improve water quality, especially for water softening and arsenic removal. Indeed, the American Water Works Association (AWWA) has issued standards that provide for the use of lime in drinking water treatment.

Softening
In water softening hydrated lime is used to remove carbonate hardness (caused by bicarbonates and carbonates of calcium and magnesium) from the water. Hardness caused by other calcium and magnesium salts, called noncarbonate hardness, is generally treated by means of the lime-soda process, which entails the precipitation of magnesium by lime. The co-produced calcium salt reacts with the soda ash to form a calcium carbonate precipitate. Lime enhanced softening can also be used to remove arsenic from water. Recent changes to the national drinking water standard for arsenic have increased the need for this treatment. The U.S. EPA has issued new guidance on enhanced lime softening to remove arsenic, see http://www.epa.gov/safewater/mdbp/coaguide.pdf.

pH Adjustment/Coagulation
Hydrated lime is widely used to adjust the pH of water to prepare it for further treatment. Lime is also used to combat "red water" by neutralizing the acid water, thereby reducing corrosion of pipes and mains from acid waters. The corrosive waters contain excessive amounts of carbon dioxide (carbonic acid). Lime precipitates the CO2 to form calcium carbonate, which provides a protective coating on the inside of water mains.

Lime is used in conjunction with alum or iron salts for coagulating suspended solids incident to the removal of turbidity from "raw" water. It serves to maintain the proper pH for most satisfactory coagulation conditions. In some water treatment plants, alum sludge is treated with lime to facilitate sludge thickening on pressure filters.

Removal of Impurities
One of the most common methods of removing silica from water is the use of dolomitic lime. The magnesium component of this lime is the active constituent in silica removal. Lime is also used to remove manganese, fluoride, organic tannins and iron from water supplies. Lime serves a myriad of uses in the food industry. Some examples:

- **Dairy Industry**--When cream is separated from whole milk, lime water is often added to the cream to reduce acidity prior to pasteurization when butter is produced. The skimmed milk is next acidified to separate casein. The casein is mixed with lime and a small amount of sodium fluoride to produce calcium caseinate, a form of glue. Fermentation of the remaining skimmed milk (whey) and the addition of lime forms calcium lactate, which is marketed as a medicinal or acidified to produce lactic acid.

- **Glue and Gelatin**--Waste materials from rendering plants are treated with lime in slurry form. This process swells the collagen, thereby facilitating subsequent hydrolysis. After liming, the treated stock is washed to remove lime, albumin, and mucin. The washed stock is dried, and the final product is sold as glue or gelatin.

• **Baking Industry**--In the preparation of a common type of baking powder, monocalcium phosphate is required as an ingredient. This is made by reacting pure phosphoric acid with a high calcium lime.

• **Fruit and Vegetables**--In the controlled atmospheric storage of fruit and vegetables, bags of hydrated lime are placed on racks in the storage room to absorb CO2 that exudes from the ripening fresh produce. In this manner a higher ratio of oxygen to CO2 is maintained, permitting vegetables and fruit to be stored fresh for much longer periods. When placed in close proximity to the produce, carbon dioxide penetrates easily through the multiwall paper bags into the lime. For apples lime consumption averages about 1 to 1.5 lb./bushel. Pears, plums, and tomatoes, in addition to apples, have been stored in this way in Canada and the Northeastern U.S., as well as in Oregon and Washington. In California this technique is commonly employed in storing lettuce.

• **Miscellaneous**--All quality tortillas are treated with lime. Corn is first soaked in milk-of-lime before its conversion to cornmeal. Lime is also used in the burgeoning corn chip business. The refuse, grape lees, from wineries is treated with lime, precipitating calcium tartrate, which is sold as such or converted to tartaric acid. Several prominent recipes for making watermelon pickles require the melon rind be soaked in milk-of-lime.

Using Lime To Treat Hazardous Waste

Lime is widely used to treat hazardous wastes both currently generated process wastes and previously disposed or abandoned materials. Lime stabilizes most metals by converting them to more chemical stable forms that are less likely to leach. In addition, lime can react with soils to solidify materials, further reducing the leaching of hazardous wastes. Lime can also be used to neutralize acidic materials.

Under the U.S. EPA's land disposal restrictions regulations, currently generated hazardous wastes that are to be land disposed must be pretreated using the Abest demonstrated available technology. For hazardous wastes containing metals, metals stabilization or metals precipitation is frequently required, and lime is identified by EPA as suitable to treat these wastes (see 40 C.F.R. Part 268.42).

EPA also endorses lime stabilization as a key technology for hazardous waste site cleanups (see, e.g., Handbook for Stabilization/Solidification of Hazardous Wastes (EPA/540/2-86/001, June 1986). In 1997, for example, EPA announced a proposed cleanup plan as part of the Anaconda Regional Water, Waste, and Soils Project for 14,000 acres in Anaconda, Montana. A key element of the plan is to treat arsenic-containing soils with lime and organics. Copper mining created environmental contamination in the 300 square mile area and concern about potential human exposures. EPA recommended in-place lime treatment over the option of excavating and treating the tailings and contaminated groundwater. (Nearby, the Warm Springs Pond is already being used to capture and treat water contaminated with metals (copper, zinc, and arsenic) that threaten the Clark Fork River. The contaminated waters are treated with a lime solution.)

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