



# SWITCHING TO CALCIUM PRODUCTS FROM CAUSTIC SODA FOR pH CONTROL HAS MANY ADVANTAGES



Lime products have long been used in many applications for many different reasons ranging from pH adjustment, and coagulation and flocculation, to lime softening and metals removal.

Lime products maintain proper pH for the best utilization of coagulation/flocculation chemicals, and they provide cations to neutralize negative surface charges. Lime softening has been proven to remove a wide variety of contaminants including tannins, arsenic, barium, lead, nickel, cadmium, chromium and other metals.

This article will focus primarily on pH adjustment, and compare the advantages and disadvantages of lime products vs. caustic soda.

Slaked lime,  $\text{Ca}(\text{OH})_2$  in excess water, also known as lime slurry, and caustic soda,  $\text{Na}(\text{OH})$ , are both common alkali chemicals used for pH adjustment.

Both chemicals operate the same way to neutralize acid by providing a source of hydroxide. However, there are important differences between the two, and each has advantages and disadvantages.

Lime products generally come in four forms. Limestone,  $\text{CaCO}_3$ , is the most unrefined lime product from which all other lime products are ultimately derived. Limestone is of course a solid stone product that can come in a wide variety of size ranges. Limestone can be used for acid neutralization in some special applications, but will be considered outside of the scope of this document. Quicklime,  $\text{CaO}$ , is limestone that has been calcined in a kiln. This product is shipped as a solid, but will generally be chemically converted into lime slurry by the consumer at their facility. Hydrated Lime,  $\text{Ca}(\text{OH})_2$ , is a product derived from quicklime that has been hydrated with a controlled amount of water to remove its exothermic heat of reaction. Hydrated lime is a dry product with a powdery size and consistency. Finally, CALSAFE, more generally called lime slurry, is the only liquid form of calcium products.

Lime products are not as hazardous as caustic soda and are the more economically favorable alkaline reagents for acid neutralization, pH adjustment and metals removal. Quicklime also has stronger neutralizing capacity per dry ton; so less material needs to be used. An investment of equipment is needed, and a sludge is often produced, but it is often low-volume and easy to handle.





Caustic soda is available as liquid in both 20% and 50% solutions and does an excellent job in adjusting pH. It is easy to handle and disperses well, and its more simple storage, handling, and pumping equipment can be easier to maintain than lime. It also produces less sludge than lime. However, it is extremely hazardous in terms of exposure to the skin and eyes. While caustic soda does not require the initial equipment capital investment that lime does, it still can be significantly more expensive overall because of its high cost per ton.

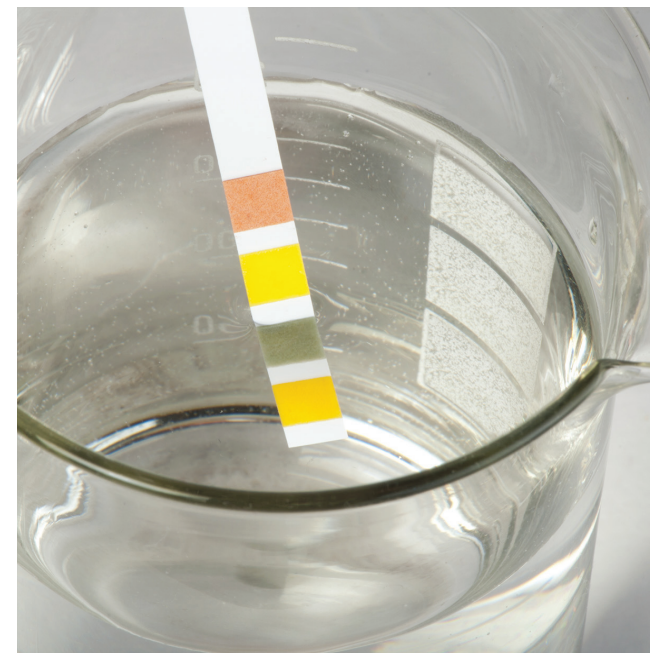
Let us look in more detail at a comparison of their physical characteristics, solubility, pH, reaction products formed and cost.

## PHYSICAL CHARACTERISTICS

Lime products include quicklime,  $\text{CaO}$ , a solid material available in a variety of sizes from pebble down to fines, hydrated lime,  $\text{Ca(OH)}_2$ , as a powder or as a slurry. Caustic is available both as a liquid 20% or 50% solution. So, different handling equipment is needed. There is also a difference with the freezing point of each. Lime slurry begins to freeze at  $32^\circ\text{F}$ , while 50% caustic begins to freeze at  $60^\circ\text{F}$ .

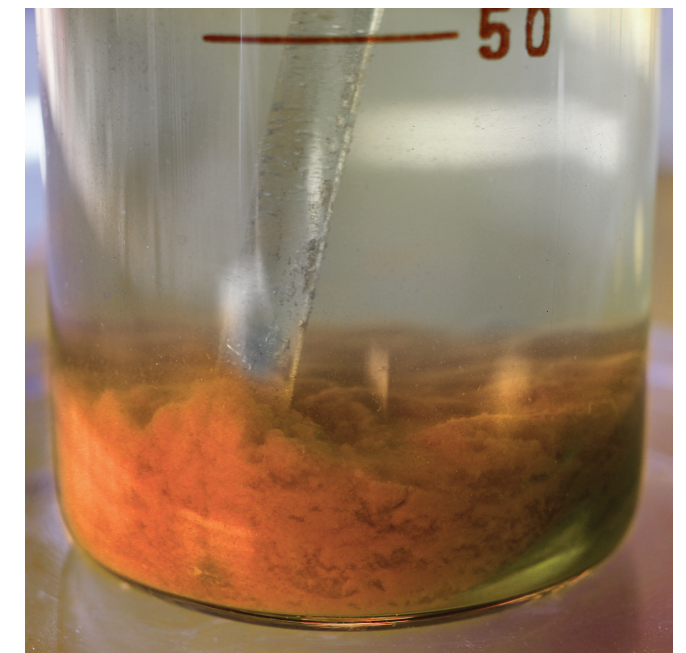
## SOLUBILITY

Hydrated Lime has a solubility of 1.73 grams/L at  $20^\circ\text{C}$ , while caustic is very soluble, existing as a true solution. Hydrated lime slurry on the other hand, is a suspension of solid particles floating in water and requires constant mixing and has the potential for scaling issues.



## pH

Lime has a pH of 12.45 at  $25^\circ\text{C}$ , and caustic has a pH of 14.0. The pH of caustic is hazardous, and lime has more strength pound for pound. As an example, to neutralize a given acid, 1,140 lbs. of quicklime per ton  $\text{H}_2\text{SO}_4$  or 1,540 lbs. of quicklime per ton HCL is needed for neutralization. Comparatively, for caustic soda, 1,630 lbs. of dry caustic soda per ton of  $\text{H}_2\text{SO}_4$  is needed or 2,190 lbs. of dry caustic soda per ton HCL. That's an increase in consumption of approximately 42% by weight of caustic compared to quicklime.



## REACTION PRODUCTS FORMED

For both lime and caustic, reaction products can be formed when treating hard water or metals. If neutralizing hydrochloric acids, no solids are typically formed with either lime or caustic. If neutralizing sulfuric acids, lime forms solids but caustic does not. Metals precipitate using either reagent, but lime is more efficient at metals precipitation. The additional solids formed from using lime could be difficult to handle for customers switching from caustic to lime products as solids handling equipment may be insufficiently sized or not present at all. Carmeuse Applications Specialists are available to discuss your setup to help you understand if your system is ready for the switch.

## SAFETY

With a risk of dust getting in the eyes or mucus membranes, protective equipment should be used when working with dry lime products. Eye protection such as safety glasses, chemical goggles and/or a face shield can be worn. Contact lenses should not be worn when working with lime products. Also, as with any chemical that can irritate unprotected skin, protective gloves and clothing that fully covers arms and legs are recommended. In most cases, nuisance dust masks can be worn as well.

Caustic soda has those same safety issues, but it also is much more corrosive and can damage skin tissue with just a drop or two in a very short period of time.

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COST

Quicklime must be slaked to transform it to lime slurry and is the least-expensive option in terms of reagent cost, but it requires more manpower and has more expensive capital costs up front for slaking equipment. Hydrated lime is a more expensive reagent, but requires less manpower. CALSAFE liquid lime can be the most expensive lime products option, but requires the simplest storage and handling equipment, reducing capital cost and manpower requirements. Caustic soda can be a lot more expensive to use than either lime option.

The following are comparisons of costs for quicklime, hydrated lime and caustic soda when using 500, 3,000 or 6,000 dry tons as scenarios. In all cases, significant cost savings are realized when using lime vs. caustic soda, and the cost savings become larger as the amount of material increases.

This cost breakdown will not include CALSAFE lime slurry in the analysis as CALSAFE price structure varies from one geographic territory to another, however Carmeuse can work with you to understand your specific cost breakdowns for reagent and capital costs associated with switching to CALSAFE. In general though, CALSAFE reagent pricing falls between dry hydrated lime and caustic soda and the capital costs for associated equipment similarly fall between these two products as well as CALSAFE is more simple to handle and requires no processing that quicklime and hydrated lime both require.

Prices can vary, but for the following calculations, the prices used include \$510/dry ton for caustic soda, \$130.50/ton for quicklime as delivered and \$153.10/ton for hydrated lime as delivered and also include necessary capital costs.

It should be noted that these lime costs are derived from Tabel 5 of the 2017 Minerals Yearbook authored in conjunction with the USGS plus an assue \$20/ton of transportation related costs.

<https://prd-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/atoms/files/myb1-2017-lime.pdf>

Caustic prices of \$510/ton are derived from the middle values of recent caustic pricing (\$490/dry ton) as of 18-June-2020 from EChemi.com pricing chart linked below plus an assumed \$20/ton of transportation related costs.

<https://www.echemi.com/productsInformation/pd20150901041-caustic-soda-pearls.html>.

Cost Savings Scenario 1 — 500 Dry Tons		
Material	Dry Tons/Year	Dollars/Year
Caustic	500	\$255,000
Quicklime	350	\$45,743
Hydrated Lime	463	\$70,904

The customer in this scenario would use 463 tons of hydrated lime per year, saving \$184,096/year in reagent cost vs. caustic. While the customer would need to invest about \$450,000 in new equipment. With a 20-year write off assuming a cost savings of \$184,096 per year and no additional personnel needed, the payback will be:



**\$450,000 Capital Cost**  
**NPV \$704,584**  
**ROI 260%**  
**Payback = 3.3 Years**



Cost Savings Scenario 2 — 3,000 Dry Tons		
Material	Dry Tons/Year	Dollars/Year
Caustic	3,000	\$1,530,000
Quicklime	2,103	\$274,457
Hydrated Lime	2,779	\$425,424

The customer in this scenario would use 2,103 tons of quicklime per year, saving \$1,255,543/year in reagent cost vs. caustic. While the customer would need to invest about \$650,000 in new equipment. With a 20-year write off assuming a cost savings of \$1,255,543 per year and one additional person needed (assumption that person will be paid \$50/hour including benefits for 40 hours a week at a cost of \$104,000/year, the payback will be:



**\$650,000 Capital Cost**  
**NPV \$7,535,196**  
**ROI 1259%**  
**Payback = 6 Months**

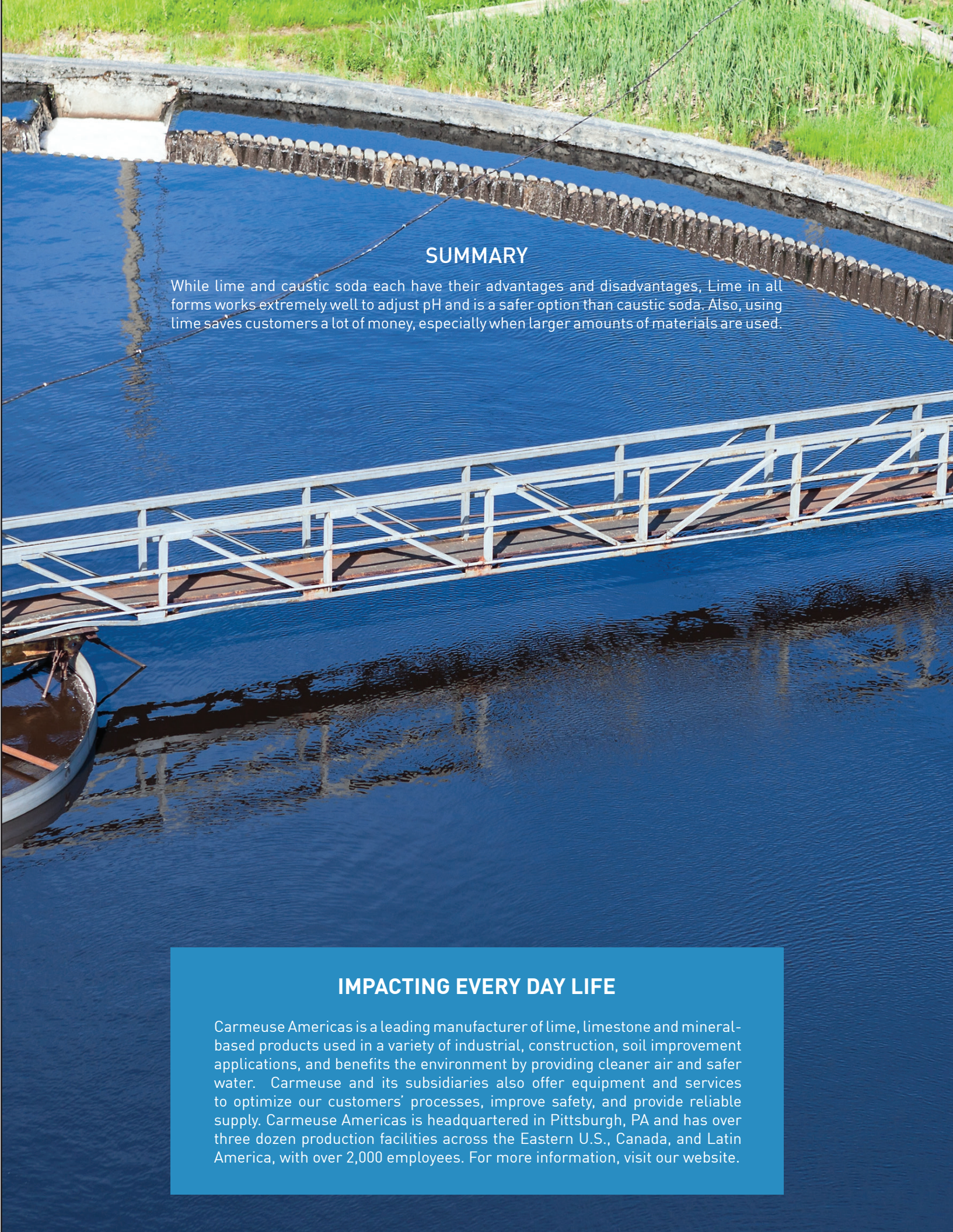
Cost Savings Scenario 3 — 6,000 Dry Tons		
Material	Dry Tons/Year	Dollars/Year
Caustic	6,000	\$3,060,000
Quicklime	4,206	\$548,914
Hydrated Lime	5,557	\$850,848

The customer in this scenario would use 4,206 tons of quicklime per year, saving \$2,511,086/year in reagent cost vs. caustic. While the customer would need to invest about \$650,000 in new equipment. With a 20-year write off assuming a cost savings of \$2,511,086 per year and one additional person needed (assumption that person will be paid \$50/hour including benefits for 40 hours a week at a cost of \$104,000/year, the payback will be:



**\$650,000 Capital Cost**  
**NPV \$15,017,695**  
**ROI 2410%**  
**Payback = 4 Months**

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### SUMMARY

While lime and caustic soda each have their advantages and disadvantages, Lime in all forms works extremely well to adjust pH and is a safer option than caustic soda. Also, using lime saves customers a lot of money, especially when larger amounts of materials are used.

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Carmeuse Americas is a leading manufacturer of lime, limestone and mineral-based products used in a variety of industrial, construction, soil improvement applications, and benefits the environment by providing cleaner air and safer water. Carmeuse and its subsidiaries also offer equipment and services to optimize our customers' processes, improve safety, and provide reliable supply. Carmeuse Americas is headquartered in Pittsburgh, PA and has over three dozen production facilities across the Eastern U.S., Canada, and Latin America, with over 2,000 employees. For more information, visit our website.





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