Potassium Chloride . . .

Alternative Regenerant for Softening Water

By Kim Polizotto and Charles Harms

A recent development in the water treatment industry is the use of potassium chloride (KCl) as a regenerant for water softeners.

POTASSIUM CHLORIDE is an excellent substitute for sodium chloride (NaCl) for both residential and commercial water softening processes. Using KCl will reduce the levels of sodium (Na) in tap water, eliminate the discharge of Na into the environment, and help provide additional potassium (K) in people's diets.

How KCl Softens Water

Softening of water involves removal of the hardness ions . . . calcium (Ca^{++}) and magnesium (Mg^{++}) . . . from the incoming water. Ordinary water softeners are cation exchangers which contain synthetic ion exchange resins. Resin beads contain many negative charge sites which are occupied by positively charged cations. The resin beads have a preference for attraction of different cations with the order generally being $Ca^{++} > Mg^{++} > K^+ > Na^+$. Since the resins prefer Ca^{++} and Mg^{++}, these ions can easily be exchanged with K^+ or Na^+. In the process, the K which was on the resin is released into the softened water. Softening water with KCl can be characterized by equation 1:

Equation 1.

$$\text{Resin-}K_2 + Ca^{++} + Mg^{++} \rightarrow 2\ K^+ + \text{(Ca-Mg)-Resin}$$

The K in soft water is present as bicarbonate and carbonate rather than chloride (Cl). Chloride is removed with the waste generation stream (equation 2).

Regeneration or Recharge Cycle

After a given volume of "hard" water is passed through the exchange resin, a majority of the negative charge sites will have Ca and Mg attached (adsorbed) to them. Once this occurs, the resin's ability to remove additional Ca and Mg from incoming water is essentially zero. At this point, the resin must be regenerated or recharged. During this cycle a concentrated KCl brine is passed through the resin bed. The very high concentration of K ions forces the Ca and Mg ions off of the negatively charged resin and the K ions take their place. After a brief rinse to remove the excess KCl brine, the resin is again ready to remove Ca and Mg from the incoming water. The regeneration or recharge cycle can be explained by equation 2:

Equation 2.

$$\text{(Ca-Mg)-Resin} + 2\ KCl \rightarrow \text{Resin-}K_2 + MgCl_2 \text{ and } CaCl_2$$

Why Make the Switch?

Probably the most important issue is that use of KCl can reduce or eliminate Na in drinking and/or cooking water. If NaCl is used in the softener, each Ca or Mg ion removed from the incoming hard water results in two Na ions being released into the softened water. The harder the water, the higher the Na content after softening (**Table 1**). If KCl is used instead, two K ions are released for each Ca or Mg ion adsorbed onto the resin.

Table 1. Potassium or Na added to water softened with KCl and NaCl.

Water hardness, grains/gallon	KCl softened K added, mg/l	NaCl softened Na added, mg/l
10	133	78
20	266	157
30	400	236
40	533	314

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If the incoming hard water contains Na, softening with KCl initially removes the Na from the water. However, as the resin is expended, the Na that was initially captured in the cycle releases back into the softened water (**Figure 1**). The levels of Na in softened water are always lower when using KCl than when using NaCl, however.

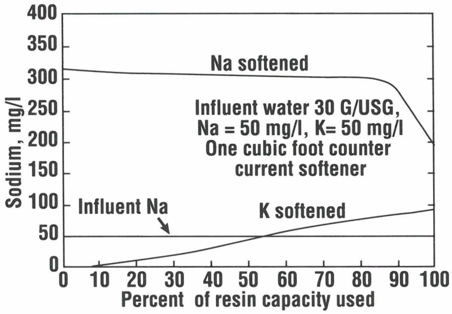

Figure 1. Sodium content of water softened with NaCl and KCl.

Brine Disposal

Another issue of water softening is disposal of the brine solution after regeneration. Several cities in California, Florida and Michigan are taking aim at the water softening industry for discharging high levels of Na and Cl into municipal sewage treatment facilities. Some cities are finding it difficult to meet discharge standards set for "no degradation" of groundwater.

Other cities want to develop secondary markets for their wastewater such as selling it to agricultural producers for irrigation purposes. Since some crops are sensitive to Na and/or Cl, the discharge from wastewater treatment facilities may not be suitable for resale if NaCl is the predominant salt used for water conditioning in the community.

> **Potassium chloride (KCl)** is currently available as a water softening product, under the trade names of Softouch, Envirosoft, K-Life and Soft Care. The price may be up to twice that of sodium chloride (NaCl). Thus, consumers who pay $100 per year for NaCl salt would pay $150 to $200 per year for KCl. However, several consumer group studies indicate that health and environmental benefits of KCl overcome the price issue for many potential users.

For both groundwater standards or re-use of wastewater, reduced Na and Cl levels are desirable. Not only will the switch to KCl reduce Na in the system but Cl concentrations will also be decreased. Potassium chloride has a lower molecular percentage of Cl compared to NaCl. In most softening systems, this would equate to a 10 to 20 percent reduction in the amount of Cl discharged during each cycle.

Dietary Potassium

Another major benefit in the use of KCl is that additional K is available in people's diets. Potassium is vital for human health. A good diet consists of enough fruit, vegetables and dairy products to supply adequate K on a daily basis (**Table 2**). Potassium is not stored in the human body so a continual supply is needed. Modern fast food diets and rushed life-styles do not lend themselves to adequate dietary K. Potassium chloride water softening could help supply the additional needed K.

Table 2. Some leading food sources of K.

Food/serving	K content
8 oz. whole milk	370 mg.
1 medium banana	451 mg.
1 cup fresh orange juice	496 mg.
3 oz. broiled sirloin steak	299 mg.
1 medium baked potato	844 mg.

Plant Nutrient Potassium

Potassium is an essential plant nutrient utilized in high concentrations for a large variety of chemical reactions and water relations in plants. Sodium is also taken up by plants, but has no essential role. Many plants expend energy to isolate Na so it doesn't interfere with normal growth and development. Potassium in water softener brine can be readily utilized by all plants. Disposal of the waste generation stream from KCl brines on agricultural lands is

Intensive Wheat Management Conference Set for March 10-11, 1994

PLANS for the 1994 Intensive Wheat Management Conference have been announced by the Potash & Phosphate Institute (PPI) and the Foundation for Agronomic Research (FAR). This Conference is one of a continuing series of educational programs focusing on the need for intensified crop management to improve producer profitability and the production of quality wheat.

The Conference is slated for March 10-11, 1994 at the Stouffer Concourse Hotel in Denver, CO. Wheat production practices across the U.S. and Canada will be addressed in a series of presentations by growers, researchers, Extension personnel, and representatives of agriculture supply industries. The orientation of the Conference presentations will be on why and how intensified crop management can improve production and grower profitability.

Specific program topics will include the importance of variety choice, stand establishment, seed size, seed treatments, and plant population in intensive management; the relation of plant growth stages to crop management decisions; use and practicality of tramlines; individualized phosphorus and potassium management decisions; yield variability and optimum fertilization; using chloride to suppress diseases and boost yields; pest management for intensive cropping systems; the impacts of intensive cropping systems on water use efficiency, pest management, input needs, economics and environment; economic impacts of better crop management for individuals and communities; and risk management in wheat production.

A proceedings of the Conference papers will be available to all registrants. Extra copies will be available by mail.

For more information, contact the PPI office in Manhattan, KS; phone (913) 776-0273, FAX (913) 776-8347. ■

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an option that can be considered. The waste contains calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$) and any KCl not consumed by the ion exchange resin. The K in softened water is also usable as a plant nutrient. When using K-softened water on house plants, large volumes should be utilized to prevent accumulation of soluble salts in the plant container.

In many farm operations, water softening/treatment is an important management component. All livestock producers monitor nitrate levels in their wells, veal producers watch iron levels closely, and many dairy operators treat their water to make milk house clean-up easier. Using KCl for water treatment is an option in each of these situations. In many operations, barn water and regenerate wastewater are routed into the manure pit, enriching the manure with K which is returned to cropland. This bypasses the septic system for wastewater treatment and decreases the amount of salts in water that enters the drain field.

Also of note, white KCl which is used as fertilizer cannot be substituted for the KCl used in the water softening market. The anti-caking and anti-dusting agents used to facilitate bulk handling of KCl for fertilizer could damage the exchange resins in water treatment systems. Potassium chloride water softening salt is a very clean industrial grade material which is very highly compacted into pellets at least 3/8-inch in size and packaged in 40 lb bags.

Summary

In conclusion, Na really has no redeeming value in the environment outside of saltwater or brackish water ecosystems. If alternatives to NaCl for water treatment can be developed, they should be used. Potassium chloride is a logical choice to reduce Na discharge from water softening systems, to provide additional K in human diets and to serve as a nutrient source for plants. ■