SALINE WATER UTILIZATION - AN INTERNATIONAL PERSPECTIVE

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In 1977, I attended an International Workshop on Biosaline Research, cosponsored by the National Science Foundation and the Kuwait Institute for Scientific Research. The biosaline concept espoused there (San Pietro 1978) envisions the "harmonious interplay of high solar radiation, high temperature, and saline water availability as the foundation of a unique, renewable resources program for desert lands focused on biogrowth in a saline environment." The organizers challenged the participants to put aside traditional ideas of irrigated agriculture, and to concentrate instead on new ways to use the world's immense resources of saline environments.

Potential approaches included: 1) expanded utilization of plant species native to arid and saline environments; 2) breeding for increased salinity tolerance; 3) harvesting of marine flora (macro-algae) for food; and 4) modification of the environment through controlled-environment agricultural technology. The latter technique allows a broad range of conventional and unconventional crops to be grown with limited supplies of fresh or saline water in greenhouses.

Potential users of the biosaline concept include virtually every country in the world, but for differing reasons. The less-industrialized countries could profit tremendously through increased food production and greatly improve their peoples' quality of life. The highly industrialized countries could make better use of underutilized land, and divert fresh water supplies to alternate uses -- domestic or industrial.

Over the last few months, I have had the opportunity: 1) to discuss examples of biosaline research with several representatives of the less-industrialized countries; 2) to witness experiments in the USSR and Israel; and 3) to conduct my own work here in New Mexico. My purpose here today is to share some of my experiences with you.

Saline Water Resources and their Classification

At first glance, the scientific literature and practical experience would lead one to believe that there is nothing new that needs to be learned about utilizing "saline" waters. Farmers, for example, have apparently used "saline," "salty," or "brackish" waters for years. The critical element, however, is in the definition of saline; the level of total dissolved solids (TDS).

The state of New Mexico (U.S. Department of the Interior 1976) classifies water according to the values given in Table 1. Examples of each salinity class are given for reference.

Most (>95%) of the water used for irrigation in the USA has TDS <1,500 mg/l, and much of the published research has been with this quality water. However, there are numerous recent reports of saline-water research utilizing waters with 2,500-5,000 mg/l TDS (Jury et al. 1978; Miller 1979; Moore and Murphy 1978). Epstein and Norlyn (1977) used Pacific Ocean water while Boyke (1967) describes research with Caspian Sea and Mediterranean Sea water. Our work

Table 1. Saline Water Classification* and Examples

Class	TDS (mg/l)	Example
Fresh	< 1,000	Most irrig. waters (USA)
Slightly Saline	1,000-3,000	Shallow wells (Mesilla Valley), Irrig. return flow
Moderately Saline	3,000-10,000	Caspian Sea, Groundwaters (New Mexico)
Very Saline	10,000-35,000	Pacific Ocean, Groundwaters
Brines	> 35,000	E. Mediterranean Sea, Hot Springs

*After U.S.D.I. 1976 New Mexico Water Resources: Assessment for Planning.

(O'Connor 1979) at New Mexico State University utilized waters from 1,250-15,000 mg/l TDS and simulated groundwater resources in the state. Quality-wise, many natural waters with TDS >1,500 mg/l have NaCl as the dominant salt. This abundance of Na has been a major concern because of problems in maintaining soil physical properties and has likely discouraged exploitation of saline-water resources.

Saline waters are abundant worldwide and are often in close proximity to semiarid and arid regions ideally suited to the biosaline concept. Saline groundwaters in New Mexico are estimated at 15 billion acre-feet. Add to this the estimated 1,060 trillion acre-feet of ocean waters and the millions of acres of arid lands, and the potential impact of biosaline concept starts to come into focus. The potential is truly immense. What efforts have been made to utilize this almost boundless resource?

Some of the earliest and most extensive research in saline-water utilization was conducted by Israeli scientists. Boyko (1967) described experiments started in 1929 that utilized very saline groundwaters to grow nonhalophytic trees and conventional agronomic crops, such as sugar beets and barley.

Although Israel is usually considered the forerunner in salinity research, several other countries have experimental programs and extensive histories of saline-water utilization (Table 2).

In New Mexico, Stewart (1967) grew selected range shrubs and grasses with Tularosa Basin groundwater containing up to 16,000 mg/l TDS. More recently, Epstein and Norlyn (1977) were able to grow

Table 2. Countries Using Saline Waters to Grow Indicated Crops

Country	Water Quality	Crops
India	Seawater (various concentrations)	Wheat, tobacco, alfalfa
Italy	Groundwater (Up to 9000 mg/l)	Tomatoes, sorghum, cabbage
Spain	Seawater (33,000 mg/l)	Maize, potatoes pepper
Sweden	Seawater (6000 mg/l)	Pasture and meadow species
USA (NM)	Groundwater (Up to 16,000 mg/l)	Range shrubs and grasses
USA (Calif.)	Pacific Ocean water	Barley, tomatoes

barley and tomatoes on sand dunes with Pacific Ocean water. The list could be expanded, but I want instead to emphasize the research approaches currently being used to test the prospects of saline-water utilization.

Representative Current Research Approaches

1. Utilize naturally occurring halophytic (salt-tolerant) species to supplement traditional crops. Gary Cunningham (Biology Department, NMSU) is experimenting with saltgrass as a potential forage. Jim Fowler (Agronomy, NMSU) and Jim Hageman (Chemistry, NMSU) have evaluated Russian thistle as a forage. Both species occur naturally in saline or water-limiting environments and may represent good alternatives to traditional forages, if saline water is the only available source of irrigation water.

2. Breed or select for salt tolerance. Many of our conventional agricultural crops have been shown to possess sufficient genetic diversity to allow selection for greatly increased salt tolerance. This was the basis of Epstein's highly publicized research in California. Whether this increased salt tolerance will allow sufficient economic return, however, is open to question with some crops. Certain species of tomato, for example, tolerate salt very well; but the fruit is small, hard, and lacks other characteristics American consumers demand.

3. Supplement saline-water supplies with fresh water. Several experiments with "saline water" have proven successful when saline water was supplemented with fresh water irrigations or with natural rainfall. Many crops are most sensitive to salt damage early in their growth cycle. If fresh waters are available for early season irrigations, saline water can often be used to complete the irrigation season with minimal reduction in yield. In Mediterranean climates (for example, Israel), winter rains (150-200 mm) have been found effective to leach surface accumulations of salt. This leaching is often sufficient to create a desalinized environment in which crops may germinate and grow normally. We are currently investigating the extent to which saline waters can substitute for fresh water irrigations with sorghum.

Management Techniques

1. Successful utilization of saline irrigation water often requires different management than when only fresh waters are used. Perhaps the best-known technique in this regard is high frequency irrigation to reduce water stress between irrigations. Water stress and salinity stress are essentially additive effects. Minimizing water stress by high frequency trickle irrigation allows using more saline waters without reducing yields.

2. Saline waters often have high sodicity hazards as indicated by their high sodium absorption ratio values. Fortunately, the high salinity of these waters usually suppresses the effect of adsorbed sodium on soil structure and little effect on soil permeability is observed. But during rainstorms or fresh water irrigations, salts can be washed out allowing considerable soil dispersion and greatly reduced soil permeability. Some soils possess the ability to release additional salt quickly enough to maintain the critical salt level needed to suppress dispersion. Other soils, however, require the addition of amendments, usually gypsum, to supply the critical salt level. The Israelis are currently very active in determining which soils need gypsum and in what amounts.
3. There are several other techniques available that I will not describe in detail. These include: a) increased leaching; b) irrigating at night; c) switching to more salt-tolerant crops, etc. In general, utilization of saline water will require increased management. Thus, saline-water utilization may not be reasonable or economic in all agricultural settings.

Some words of caution are necessary for anyone planning to use saline water. Literature data and field data can be misleading as to the success of an operation.

Misleading Data

1. Most soils are much less saline now than they will be under saline-water irrigation. Soils are tremendous buffers, however, and may not exhibit the increased salinity over short periods. Even one- or two-year studies are often insufficient to show the steady-state effects that will develop with long-term use. Long-term studies of 3 to 5 years or more are needed before saline-water utilization can be safely recommended.
2. The second most common example of misleading data is from studies where natural precipitation is significant. When soil dispersion is controlled, winter rains or pre-season irrigations with good quality water often allow plants to grow with saline water without serious yield reductions. If rain is insignificant or falls during the cropping season, this good quality water may be of limited usefulness. Salinity problems may develop in the latter case where none are observed in the previous case.
3. A third factor, among several others, is the quality of saline water used. As discussed previously, saline means different things to different people. The water you use should be right for your crop and soil.

Saline-water utilization has tremendous potential in New Mexico and throughout the world. Although much research has been completed, more is needed for the specific waters, soils, and crops of a particular area. I hope that our research will supply some of that information in the coming years to farmers of New Mexico.

References

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