WATER QUALITIES AND NEEDS IN RELATION TO CROP YIELDS

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Evaluation of water quality from the standpoint of irrigation agriculture frequently has been attempted without regard for soil, crop, climate, and management conditions where the water will be utilized. A natural consequence of this approach has been that standards for salinity, sodium, and boron, the three most important chemical characteristics of irrigation water, have been set at the lowest concentration levels that can be considered safe under the worst combination of conditions. In practice, irrigation waters that do not meet these high-quality standards have been used successfully for decades when other conditions are favorable. Numerous examples of this fact could be cited in the Southwest, alone, and in particular in southern New Mexico and west Texas.

Attempts to develop a water classification that actually reflects the interrelations of water, soils, crops, and climate, and that would be useful to farmers in a local area, have led to the setting of different quality standards in different areas. We have done that for New Mexico by establishing three sets of standards, and the El Paso Valley experiment station has devised another for west Texas. However useful these local standards may be, they are based upon average conditions that may or may not be representative of conditions on an individual farm. The purpose of this paper is to point out some of the factors besides the chemical characteristics of irrigation water that determine whether a water is or is not suitable for continued and successful use.

Table 1 is an example of a conventional set of water quality standards that attempts to show what constitutes "satisfactory" irrigation water. It is patterned after quality standards for potable water, where the underlying assumption is that water coming within the established limits is safe to use under all but exceptional conditions. The principal defect in this type of classification system is that it implies that water exceeding these limits is unsatisfactory, whereas such, frequently, is not the case. If it were true, farmers in the lower Pecos Valley would have been out of business years ago. As with any classification system, the limits set forth in Table 1 must be used with a strong dose of common sense, based upon knowledge of when exceptions can be made safely.

The four remaining tables show some of the soil, crop, climate, and management factors that should enter into the evaluation of water quality.

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Two soil conditions are of primary importance in determining whether a salt, sodium, or boron problem will develop when a particular water is used, Table 2. They are soil permeability and depth to a water table. For soil permeability, the desirable condition is one where the permeability to water exceeds one inch per hour. If the permeability is less than that, a problem won't necessarily arise, but it indicates that care should be taken to assure that salts do not accumulate as a result of inadequate leaching. A high-water table is a hazard because water can move up to the soil surface, be evaporated, and leave behind the salts it carried. The likelihood that this will happen is quite small if the water table is more than five feet below the surface.

Plant tolerance to salts, sodium, and boron varies widely among species. Table 2 presents suggested limits for desirable conditions. If an irrigation water contains less salt, sodium, or boron than a plant is capable of tolerating, it means that the chances are good that the water can be used satisfactorily. Cotton, barley, and sugar beets are representative of plants that are included in the "desirable" range of tolerance for salt and sodium; sugar beets and alfalfa are highly tolerant of boron.

An often-overlooked factor affecting suitability of water for irrigation is the climate of the area. Salt problems, as an example, are less serious in cool regions than in hot, dry regions, at the same salt level in the soil. Greater evaporation and transpiration, as well as temperature differences, account for the variation in response. The climatic factor is considered in Table 4 in two ways: evaporation measured from a Weather Bureau pan, and amount of soil leaching by rainfall. Pan evaporation is the resultant of the effect of humidity, temperature, and wind movement, all of which affect plant transpiration, too. Soil leaching by rainfall must be evaluated for those cases, such as in winter rainfall areas of the Pacific Coast, where much or all of the salt that accumulates in the soil in summer is leached out in the winter. When that happens, highly saline water may be able to be used without harmful results.

Other factors, in addition to soil, crop, and climate, are important for water quality evaluation under a particular set of conditions. Three of these are the quantity of water available, the irrigation method, and the completeness of land leveling, Table 5. Water quantity, meaning water supply, determines whether there is enough water for leaching excess salts, sodium, and boron. In a water-deficient area, soil problems can arise rapidly, even when all other conditions are favorable, if a little water must be spread over a lot of land. Among the principal management factors, border irrigation is likely to cause the least increase of salts, double-row beds are less desirable, single-row beds even less desirable, and sprinkler irrigation with saline water is the most hazardous irrigation method. Lastly, land leveling must be evaluated. In the final analyses, whether or not land is properly leveled to avoid high spots may well be the most important factor of all in determining what the odds are for salt problems arising. Certainly, the possibility of using saline water with success on a poorly leveled field is very low.

Putting all these factors together into one water quality classification system has not been done. Some progress is being made, and we hope to have a reasonably satisfactory classification worked out before long. In the meantime, we can use the presently established criteria as rough guides.

TABLE 1. Water Quality Standards for Irrigation

	Satisfactory Water
Salinity, EC x 10^6	less than 750
Sodium-adsorption-ratio	less than 10
Boron, ppm	less than 0.3
Residual sodium carbonate, me/l	less than 1

TABLE 2. Soil Factors of Importance in Water Quality Evaluation

Factor	Desirable Condition
Soil permeability (water)	more than 1.0 inches per hour
Water table	more than 5 feet below soil surface

TABLE 3. Plant Factors of Importance in Water Quality Evaluation

Factor	Desirable Condition
Salt tolerance	tolerates $EC_e \times 10^3$ more than 12
Sodium tolerance	tolerates ESP more than 50
Boron tolerance	tolerates boron concentration in irrigation water of more than 4 ppm

TABLE 4. Climate Factors of Importance in Evaluating Water Quality

Factor	Desirable Condition
Pan evaporation	less than 100 inches per year
Rainfall	sufficient to leach soil to depth of 5 feet

TABLE 5. Other Factors of Importance in Evaluating Water Quality

Factor	Desirable Condition
Quantity of water available	sufficient to meet leaching requirement
Irrigation method	border
Land leveling	no high spots