Judicious Use of Brackish Underground Water for Sustainable Agriculture

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Introduction

Water is indispensable for human, animal, and plant life. Groundwater constitutes the most important component of supplemental irrigation in arid and semi-arid regions in India. Due to the limited availability of good quality waters, it is necessary to use poor quality waters for sustainable crop production. The indiscriminate use of poor-quality water can adversely affect crop production and soil health due to the resulting soil salinity and sodicity. In addition to the chemical composition of water, the nature of the crop to be grown, soil characteristics, climate, and management practices are important factors for its potential use as irrigation water.

Indian agriculture continues to depend heavily on its groundwater reserves especially in arid and semi-arid regions, where water quality is poor. In these areas, the underground tubewell waters contain a high concentration of salts. These waters are either saline (containing chlorides and sulphates of sodium) or sodic (containing carbonates and bicarbonates of sodium). Some of these waters may also contain toxic elements like boron. In the case of saline waters, the salts accumulate in the soil after the applied water is lost through evapotranspiration, which prevents the growth of most crops unless adequate measures are taken to keep the root zone relatively free of excessive salts. The salt content of water measured and reported as electrical conductivity is a good measure of the salinity hazard of water. In case of prolonged use of sodic water, the soil structure deteriorated and dispersion of clay particles takes place resulting in very poor permeability of the soil. In some areas, the problem is mainly due to high sodicity (expressed in terms of residual sodium carbonates, RSC) in groundwater. Irrigation with waters having a very high concentration of salts is not recommended but waters having low salinity or sodicity can be used by following specific management practices. Following guidelines can be helpful for the safe use of poor-quality waters for sustainable crop production.

1. Get the water tested for its irrigation quality

The first step while dealing with water quality is to get the water analyzed for its chemical composition. Determination of the quality of irrigation water is essential because continuous use of poor-quality irrigation water results in poor soil health (salinity, sodicity, and toxicity) which ultimately reduces the crop yield. The chemical composition of water can be obtained by getting it tested from the soil and water testing laboratory. For that purpose, the water sample should be collected in a clean bottle after running the tubewell for about 30 minutes. The information about the depth of bore, type of bore, crops to be grown, soil type, etc. also needs to be supplied to the laboratory along with the water sample. Based on the chemical composition of water, critical limits for its use have been worked out for different crops and soils. By knowing the quality of water, if it is poor then we can take the remedial measures to save our soil resources and get a better crop yield.

For assessing the quality of irrigation water, main parameters determined are: salt content (Electrical Conductivity, dS/m), sodium adsorption ratio ($SAR = Na/(Ca+Mg/2)^{1/2}$ expressed as $(m\ mole/l)^{1/2}$ and residual sodium carbonate [$RSC = (CO_3^{-2} + HCO_3^{-1}) - (Ca^{+2} + Mg^{+2})$ expressed as me/l]. The presence of excess boron and fluoride in some waters may cause a deleterious effect on crops raised under such conditions. Several classifications of groundwater have been suggested, but the most acceptable and widely used classification is that given by CSSRI Karnal. According to this classification, the groundwaters are classified in the following categories, based on their EC, SAR, and RSC.

Criteria and categorization of brackish waters

Category	EC (dSm^{-1})	SAR ($m\ mole\ L)^{1/2}$	RSC ($me\ L^{-1}$)
Good	< 2	< 10	< 2.5
Marginally Saline	2-4	< 10	< 2.5
Saline	> 4	< 10	< 2.5
Sodic	< 4	> 10	> 2.5
Saline-Sodic	> 4	> 10	< 2.5

2. Ensure adequate drainage

Agricultural drainage is required to remove excess soil water in the plant root zone. Leaching of excess salts through proper drainage must be ensured in areas receiving poor quality water to maintain a favorable salt and water balance. Surface drains are cheaper than sub-surface drains.

3. Uniform land leveling is a pre-requisite

Small changes in the micro-relief in the field lead to unequal distribution of water and salts. So proper leveling of fields should be ensured for uniform leaching of soluble salts from the soil surface.

4. Application of amendments

Poor permeability of soils is commonly observed where irrigation waters with high RSC levels (sodic waters) are used. Application of gypsum is recommended when RSC of irrigation water exceeds 2.5 me/l. The quantity of gypsum to be applied should be got calculated from a soil and water testing laboratory. Gypsum should be applied on a cumulative basis (calculated based on the number of irrigations) in one doze after the harvest of a crop. If the soil has already deteriorated, apply gypsum on a soil test basis. After mixing gypsum in the surface soil, heavy irrigation should be given to leach the soluble salts before sowing the next crop. Don't use gypsum in the case of saline waters or saline soils. Application of farmyard manure and incorporation of crop residues also help to improve the soil quality.

5. Apply poor quality waters in light-textured soils

The underground brackish water should be used preferably on light-textured soils because the high infiltration rate of these soils facilitates the leaching of salts with irrigation water. The accumulation of salts in soil under normal drainage is nearly one-half that of irrigation water in light-textured soils (loamy sand & sand), equal to irrigation water in medium-textured (sandy loam), and more than two times in heavy textured soils (clay & clay loam).

Thus, waters of high EC of 12 dSm^{-1} can be used for tolerant, semi-tolerant crops in light-textured soil provided annual rainfall are more than 400 mm, whereas in heavy textured soils, the water of even 2 dSm^{-1} EC would often create problems. Therefore, salinity/sodicity builds up at a slower rate in light-textured soils.

6. Rainfall – a key consideration

In an area of annual rainfall less than 250 mm, saline waters of EC > 4 dS/m will cause salt toxicity in most of the crops. But in areas where rainfall is more than 500 mm, water up to 16 dS/m could be gainfully utilized for crops like wheat and barley when grown on light-textured soils, provided such waters are not used in summer (*kharif*).

7. Grow salt-tolerant and less water requiring crops

Different crops and varieties of crops differ in tolerance to soil salinity and sodicity. Sowing of salt-tolerant crops is always preferred when soil or irrigation water is of poor quality. Only salt-tolerant and semi-salt tolerant crops like barley, wheat, mustard, senji, spinach, turnip, sugar beet, raya, and millets should be grown. Cotton is sensitive at the germination stage but can be grown if proper germination is ensured by pre-sowing irrigation with good quality water. The crops with high water requirements such as rice, sugarcane, and berseem should preferably not be grown with poor quality water. Pulse crops are more sensitive to salinity and sodicity and should not be grown using poor-quality water. The relative tolerance of various crops to salinity is given below:

Sensitive Crops	Semi-tolerant	Tolerant
Beans	Pearl-millet	Barley
Groundnut	Sorghum	Sugar beet
Berseem	Maize	Cotton
All pulse crops	Field pea	Mustard
Rice		Safflower
Citrus		Wheat

8. Conjunctive use of brackish water- a safe and sustainable alternative

When a limited quantity of good quality irrigation water is available then poor-quality waters should preferably be used to supplement the good quality water. The poor and good quality waters can be used together, either alternately or by mixing with each other. For most crops, germination and early seedling establishment are the most sensitive stages. Therefore, the strategy to use non-saline water during early growth stages and poor-quality water at later stages would appear promising. Utilization of saline sub-soil water along with canal water will help in lowering the water table also.

9. Irrigation method and frequency of irrigation plays an important role

Adoption of various irrigation methods such as drip irrigation can enhance the threshold salinity level by modifying the pattern of salt distribution and through maintenance of constantly higher matric potentials. Furrow's system of irrigation may be harmful to crops. The irrigation water of two different qualities can be mixed and used but the relative proportion in which two qualities of water need to be blended will depend upon the salinity of ground (saline) water.

10. Success holds in continuous monitoring of salt build-up in the soil

When poor quality waters are used on a long-term basis, the build-up of salts in the soil should be regularly monitored by getting the soil samples tested at regular intervals. This will help in keeping a check on soil deterioration. Soil and water samples should be got tested simultaneously for a better understanding of the problem and better management.

If the above strategies to use these poor-quality waters are not followed effectively, then there might be a deleterious effect on soil health depending on the type of poor-quality water being used, soil type, climatic conditions, crop selection, etc and hence reduction in crop yields.

Effect of brackish water on soil properties and plant growth

Saline Water

- The harmful effect of saline water irrigation is mainly associated with the accumulation of salts in the soil and is manifested through reduced availability of water to plants, poor to delayed germination, and slow growth rate.
- Excessive salts in the soil can induce early wilting and the effects are almost similar to those of drought.
- Some of the visual symptoms are that the plants look stunted, leaves are smaller but thicker, and have often dark green color as compared to control.

Sodic/Alkali Water

- Sodic waters adversely affect soil physical properties. The increased ESP resulting from their long-term use leads to the breakdown of soil structure due to swelling and dispersion of clay particles.
- A thin crust is often formed at the surface, which acts as a barrier to penetration of water and seed and seedling emergence.
- Increase in soil pH, reduced availability of many plant nutrients like N, Zn, and Fe, etc.
- Decrease in the availability of Ca and Mg and toxicity of sodium.
- Excessive availability and consequent toxicity of elements like boron, molybdenum, fluorine, and selenium take place.