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EVALUATION OF THE QUALITY OF UNDERGROUND WATER IN THE DESERT AND SEMI-DESERT AREAS IN RAJASTHAN AND GUJARAT

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Work on the quality and extent of utilisation of underground water in irrigating the desert and semi-desert areas of Rajasthan and Gujarat has been reviewed. The quality of the ground water has been assessed mainly by finding its salt-load with electrical conductivity method and also by determining its boron content. Studies have revealed that the quality varies with the nature of the soil strata, drainage conditions and that the water quality in turn affects cropping pattern and leaching requirements of the soils, etc. It has been shown that the quality of ground water is equally important as the quantity, in influencing the crop land pattern. Role of soil and sub-strata properties, climate etc., has been emphasised. Accordingly, the ground water rating have been assessed and superimposing the same on soil maps, water-suitability maps for some areas in the desert and semi-desert regions have been drawn. Such maps at once clearly depict the effects of good and bad water on the soils, and thus help in the adoption of suitable cropping and irrigation patterns.

INTRODUCTION

In assessing the suitability of ground waters of an area, the soil, water, crop and climate inter-relation must be taken into consideration. This calls for detailed soil and ground water survey and adoption of suitable cropping and irrigation patterns. The effect of fertilisers and manure in mitigating the bad effect of comparatively more saline and alkaline water should also be considered. Some aspects of the problem of the salinity of underground water in Rajasthan and Gujarat are presented below (Committee on Natural Resources, Planning Commission, 1963).

SURVEY OF THE QUALITY OF UNDERGROUND WATER

Rajasthan :

In Rajasthan the underground water is a major source of irrigation which covers about 1,340,000 ha. of irrigated land. According to the Directorate of Economics and Statistics (1962-63 report), 57% of the net area under irrigation are generally saline and in some cases they are also alkaline. The distribution of good and bad water poses no particular problem, though generally in the zones of alluvial and black soils, good quality waters are of more common occurrence. According to the Agricultural Chemist, Rajasthan, in the Districts of Jaisalmer, Barmer, Jalore, Jodhpur, Bikaner, Churu, Sriganganagar, Nagaur, Sikar, Jhunjhunu and parts of Jaipur, Pali, Ajmer, Bhilwara, Alwar and Bharatpur, at least more than 50% waters are highly saline and the salinity varies from 3 to 20 mmhos. The saline waters of Rajasthan contain mostly sodium sulphate and sodium chloride and in some cases sodium bicarbonates also. In most cases the Ca/Na ratio is very low and forms 90% of the total cations. According to general standard for quality rating of waters, they are extremely saline. Based on the conductivity of the irrigation water, the well waters of the districts of Rajasthan (Table I), are divided into various categories along with the percentage of well water falling in each category.

From these data it would appear that according to quality, the well waters in the different districts of Rajasthan can be classed under 4 groups as shown below in Table II.

It must be mentioned that this classification is based on very meagre data and, therefore, no generalisation is possible. However, it is evident that in the districts of group 1, there is a possibility of the extension of well irrigation by tapping the ground water which is generally of good quality. Concerted efforts should be made to make detailed survey of ground water, depth of ground water and types of soils in this area so as to clearly demarcate the zones in which percolation of well and tubewell irrigation should be intensified.

In the districts of Bikaner, Jodhpur, Jalore, Churu, Pali, Nagaur and Bhilwara where well water is highly saline, the use of ground water for irrigation has its limitation.

TABLE I

*Distribution of irrigation water of different districts of various categories**

S. No.	Division and district	No. of water samples	Percentage of water samples in each category according to electrical conductivity				
			A	B	C	D	E
			0—1000	1000—2000	2000—3000	3000—5000	5000 and above
1	Jodhpur	50	26	Nil	12	20	42
2	Nagaur	45	6.6	31.1	17.7	31.2	13.3
3	Jalor	51	24	24	24	25.5	2.5
4	Pali	39	15.6	10.2	28.2	18.0	28.2
5	Bikaner	4	25	25	50	—	—
6	Churu	7	14	—	—	—	—
7	Udaipur	34	61.8	17.6	3.0	11.8	5.8
8	Bhilwara	34	9.7	16.1	48.4	19.35	6.45
9	Chittorgarh	2	100	—	—	—	—
10	Banswara	5	100	—	—	—	—
11	Kotah & Bundi	317	72.4	23.3	1.8	2.0	0.3
12	Jaipur	21	66.6	9.52	23.8	0.4	—
13	Sawaimadhopur	6	100	—	—	—	—
14	Sikar	1	100	—	—	—	—
15	Jhunjhunu	1	—	100	—	—	—
16	Alwar	2	—	50	—	—	—

TABLE II*

Percent of water samples falling into different categories

Group	Name of the district	Category A 0—1000	Category (A+B) 0—2000	Category (C+D+E) 2000—5000
1	Udaipur, Chittorgarh, Banswara, Kotah, Bundi, Sawaimadhopur, Sikar, Jaipur	60—100	75—100	Nil
2	Bikaner, Jodhpur, Jalore	20—30	25—50	50—75
3	Pali and Churu	10—20	15—25	75—85
4	Nagaur and Bhilwara	10	25—40	60—75

*Source : Personal communication from Shri K. M. Mehta, formerly Agricultural Chemist and Director of Agriculture, Rajasthan.

According to Taylor and associates (1955), the Pali region lies in a single and relatively thin zone of saturation which extends through continguous belts of the alluvium and of igneous and metamorphic and consolidated sedimentary rocks. The regional geology precludes the existence of deep artesian aquifers.

A study of water table depth in 374 unused wells shows, that 90% of the wells lie between 3 to 18 metres below the land surface in this region. The average chemical composition of well waters derived from various rock systems in this region is shown in Table III.

TABLE III

Chemical composition of well waters within various geological formations in Rajasthan

Rock system	No. of samples	Percentages of water of different types			
		HCO_3	CI	SO_4	Mixed
Alluvial (Younger)	(15)	20.0	80.0	—	—
Alluvial (Older)	(151)	29·1	58.3	0.7	11.9
Vindhyan Limestone	(14)	5.9	87.3	0.0	11.8
Malani Volcanic	(8)	37.5	0.0	12.5	50.0
Jalor Granite	(88)	34.1	45.4	4.6	15.9
Aravalli Slate	(82)	30.5	54.9	0.0	14.6

There is an indication of high concentration of dissolved salts in normal ground waters of most of the Pali region. Chlorides (NaCl) are the most abundant. Carbonates are generally absent or present as traces. Bicarbonates are however, quite abundant. Sulphates are generally slightly less than bicarbonates. In the above table, the percentage of well waters with more than 50% of the anions of HCO_3 Cl,

SO_4 or mixed type is also shown. Thus it would appear that in Malani Volcanic, Jalore Granite and Aravalli Slate Systems, the percentage of waters of bicarbonate type is more than in others. Groundwater occurs in varying quantities in the geological formations namely, Pre-cambrians, Gondwanas, Tertiaries and Sub-Recent to Recent sediments. The chemical quality of ground water occurring in individual rock formation is controlled by the geohydrological conditions. Study by Sinha (1966) of results of complete chemical analysis of water samples from the northern part of Barmer district and from the adjoining part of the Jaisalmer district shows that chloride is the most prominent anion followed by either sulphate or bicarbonate. Amongst the cations, sodium is the most prominent followed either by calcium or magnesium; waters having calcium as the dominant cation followed either by sodium or magnesium also occur. Handa (1966) while discussing the quality of groundwater of shallow aquifers in Rajasthan to predict the sodium and salinity hazards has expressed the view that many of the types of ground water belonging to the S2 and S3 sodium classes can be ameliorated by adding requisite quantities of gypsum. He has further predicted that due to predominantly sandy nature of the soils (low clay content) ground water which falls in the salinity class S4 can all be used, provided proper water management practice be employed, and the salt tolerant crops be chosen. Addition of organic matter to soil will also help to counteract partially the sodium hazards from irrigation water.

Mandal and Gupta (1966) have determined the boron content of 176 groundwater samples from four development blocks of Jalore, Ahor, Saila and Siwana of the Central Luni Basin in western Rajasthan. The results indicated a range from 0.28 to 7.66 ppm water. In 23.3% of the waters, the boron content was within the tolerance limits for sensitive crops, that is, below 1 ppm. In 50% of the waters, it was within limits for semi-tolerant crops (below 2 ppm). Quite a large number of open wells have therefore water with high boron content which should be avoided for irrigation purposes, particularly in the absence of free calcium in the soil. High boron waters are generally associated with high salinity and high SAR values.

From the foregoing discussion it is evident, that in Rajasthan even though the well water are highly saline, they are still being used extensively. The use of such waters, no doubt, makes difference between the failure and success of a crop, but the continuous use of such waters has resulted in salinity and alkalinity problem in the soil. To ward off the effect of such waters, the common practice with the farmers is to leave the fields fallow for 1 to 4 years. The idea is to allow the rain water during monsoon to leach the salts, which takes 2-4 seasons, when the irrigation water contains high salts. Wheat and barley, which are resistant to saline waters are the most common crops. Among the varieties of wheat *kharachi* (wheat) is commonly grown as it has acclimatised itself to highly saline waters. The yields in most cases are low and have been so during the last few years, but the same practice is continuing, because there is no other source of irrigation and no solution to improve these waters. The farmers have learnt by experience, that by using farmyard manure the bad effect of the saline water can be mitigated. No doubt, these irrigation waters produce salinity and alkalinity but the farmers are obliged to use them because of the general scarcity of rain. Generally, most of the wheat and barley produced in Rajasthan are due to irrigation by these well waters. The Agricultural chemist, Rajasthan, has observed that 10 tonnes of farmyard manure on average, resulted in an increase of 394 kg of wheat per hectare when saline water of electrical conductivity 6.0 mmhos/cm. was used. The *p*H of the soil was 8.1 and conductivity 1.15 mmhos/cm as against a *p*H of 8.3 and electrical conductivity of 2.2 in the control. It shows, that besides providing nutrients, farmyard manure treatment also mitigates the salinising effects of water.

Some observations on effect of waters on soil and role of ammendents in ameliorating the soil have been made. But there is a necessity of evolving suitable techniques for reducing the salinity of waters and for introducing such crops or varieties of crops which may not be susceptible to high salinity. Determination of leaching requirements and gypsum requirements for saline waters as to remove most of the salts from the root zone of plant and cultivation of salt tolerant crops are some of the other important methods of using saline waters. Date palm, *falsa*, guava, sugarbeet, barley, wheat etc., are some of the important economic crops, which can be grown under such conditions. There is a need for breeding or selecting more salt tolerant varieties of important economic plants so as to make the best use of available ground waters.

Gujarat

In north Gujarat tubewells were drilled in the non-saline areas after thorough geochemical investigations. The waters of these tubewells were found suitable for irrigation purposes according to current standards. Later on, the Exploratory Tubewell Organisation of the Government of India undertook to drill trial bores in the areas which were demarcated as saline. All these yielded waters, which contained some amount of sodium chloride. There was a popular demand from the villagers where these trial wells were drilled to retain them for irrigation purposes, even though the water may be of marginal quality or unfit for irrigation. The problem is inherent in the arid region of north Gujarat, where the ground water is likely to be saline and there is no alternative source of sweet water. Shaligram (1961) has reported analysis of data in respect of 373 irrigation wells along with the crop and soil condition from Viramgam Lakhtar area in North Gujarat.

The classification of these waters has been made by the same author and is shown in Table IV.

The groundwaters are thus of a moderate to highly saline nature. Sodium chloride forms the bulk of the constituent. Its content varies from 50.40% of the total soluble salts. Their *p*H value does not exceed 8.4 and most of them have *p*H between 7.4 and 7.8. The good quality water in 61 % cases produced good crop, but bad quality water (Class V) produced good crops only in 2% cases.

The samples of soil from the irrigated and non-irrigated fields were collected to find out the changes in soil due to irrigation. The results proved that use of irrigation water with electrical conductivity of more than 2000 micromhos/cm at 25°C increased the salt content in the soil to a considerable extent. The soil in most cases had a light

TABLE IV

Chemical analysis of Irrigation well waters in North Gujarat

Class	Electrical conductivity ($EC \times 10^6$)	Percentage of well waters falling in each category	Effect on crops (% cases)		
			Average crops	Poor crops	Bad to failure
I	Less than 1000	4.8	61.1	38 9	Nil
II	1000—2000	21.2	23.45	39.25	17.28
III	2000—3000	18.1	22.05	54.41	23.52
IV	3000—5000	31.3	17.07	37.8	45.70
V	5000 and above	33.4	2.0	20.0	78.9

texture varying from sandy to sandy loam. The salts get leached with the monsoon rains. Where the soil is not so light textured, the use of saline waters of class higher than III would spell a disaster, unless cultural treatment and restricted intensity of irrigation are adopted.

Shaligram (1961) has proposed the following criteria for water and soils of Gujarat as shown in Table V.

TABLE V

Different categories of irrigation waters and soils in Gujarat (in parts per 100,000

Water class	I	II	III	IV	V	VI
Total salts	100	150	200	250	300	More than
NaCl	40	60	100	125	150	those in
$Na_2 CO_3$	8	10	12	20	20	Class V in
Ca/Na	1.4	1.4	1.4	1.6	1.6	each case

The system seems to be very sound but along with the salinity hazard and the sodium hazard of water, its boron content should also be considered.

Kaira District — The Kaira District of Gujarat State with an annual rainfall of 64 cms and sandy loam alluvial soil has 34,858 hectares under irrigation. Out of this area, 24, 615 ha. are irrigated by wells and tubewells. The important crops of the tract are tobacco and bajra. According to B.V. Mehta (personal communication) 85% of the water is suitable for irrigation purposes, 10% for mariginal purposes and 5%, wholly unfit.

Mehsana District — Mehsana district has an average rainfall of 51-64 cm. The soils are sandy to sandy loam in the major parts of the district. The total irrigated area is 138,562 ha. The area irrigated by wells and tubewells is 120,932 ha. About 80% of the well waters is fit for irrigation proposes. Bajra, jowar, wheat, cotton tobacco, oilseeds and vegetables are the important crops of the area.

The unfit or marginal waters are in the saline sub-soil pocket of Harchanasma, Mehsana, Patan and Sidhpur talukas. There is possiblity of using these waters, upto 10-15% in scarcity years only. At present there is no canal irrigation in this district. If the Sabarmati and Saraswati river valley projects materialise, up to 15% of the unirrigated area, i.e. about 20,243 ha. can be brought under irrigation.

In the districts of Kaira and Mehsana where good quality water is available, more and more wells and tubewells should be sunk so as to make the best use of this natural resource.

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