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Quality of Irrigation Waters in the Amaravathy Ayacut Area, Coimbatore District

by

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Introduction : The Government of Madras sanctioned a scheme of irrigation soil survey in the Amaravathy Reservoir Project ayacut area in early 1959. In addition to arriving at a classification of the soils into irrigation suitablity classes, the scheme envisages the zoning of areas which might deteriorate on irrigation due to salts or alkali and suggesting suitable remedial measures for their reclamation. Quality of water is an important consideration in an appraisal of salinity or alkali conditions in an irrigated area. Therefore, a study of the quality of canal and well waters in the area has been made and reported in this paper.

Amaravathy Project : The river Amaravathy is a major tributory of Cauvery. It rises in the Western Ghats near Munar at about 5,000 ft. above M. S. L. and flowes through the dense forests of the Anamalais range of hills. It enters the plains near the present dam site at Amaravathinagar at about 1,100 ft. above M. S. L. The Amaravathy canal taken out from the dam and running parallel to the river will provide irrigation on 21,500 acres distributed between the canal and the river in Udumalpet and Dharapuram taluks of Coimbatore District. The new irrigation on 21,000 acres consists of 3,000 acres of sugarcane, 1,000 acres of paddy and 17,500 acres of dry crops. The irrigation season for the new ayacut is from 1st August to 31 January. Water was first let into the canal for irrigation in 1958. Irrigation in the ayacut area is also practised from a large number of wells. The dry crops raised are cholam and cumbu. Irrigated groundnut is also common.

Soils of the ayacut area : A rapid tour in the commanded area has enabled a broad classification of soils into two series : Udumalpet and Dharapuram. The entire ayacut area is undulating with a general fall in level from the canal to the river. Several small rivulets drain the area into the river. The difference between these two series exists in the calcareous nature of the parent material occuring in Dharapuram taluk. Both the series are red soils of 2 to 6 feet depth and of a light soil texture at all depths. Abundant kankar nodules occur in the soils of the latter series.

Throughout the ayacut area many drainage-ways are silted up. This in conjunction with a fairly rolling topography has given rise to several ill-drained phases where saline and alkali conditions exist.

Review of literature : Literature on the quality of irrigation water is very extensive. Numerous methods of analysis, interpretation and categorization of waters in suitable classes have been worked out and adopted by various workers. The most pioneering work in this branch has been done in the United States, specially in the west and particularly at the United States Salinity Laboratory, Riverside, California. Very voluminous data have been collected and published by the United States Geological survey pertaining to waters from all over that country. Comprehensive methods of laboratory examination of irrigation waters and a tentative scheme of classification were initially proposed in the preliminary manual of the U. S. Salinity Laboratory, Edited by Richards (1947).

The progress of entire work was reviewed by Wilcox (1948) in his technical bulletin wherein he also proposed a chart for classifying water into five classes based on electrical conductivity and Sodium percentages. Divisions between Sodium percentage groups were determined by calculations based on the mass-action equation of Gapon (1933) to give the percentages of sodium that would provide certain exchangeable Sodium percentages on soil clay when the solutions and clay were in equilibrim. This chart was modified by Thorne and Thorne (1951) to provide a binomial classification system giving five classes for salt and five for increasing Sodium adsorption hazards.

On the basis of observations on irrigation with waters of the Nile and the Euphrates Rivers, Eaton (1950) proposed that carbonates and bi-carbonates may have an indirect effect on water quality through the precipitation of Calcium and Magnesium, thereby increasing the Sodium percentage. The effect is particularly important in the presence of "residual Carbonates" defined as $(CO_3^{--} + HCO_3^{-}) - (Ca^{++} + Mg^{++})$. The residual carbonates represent the excess of the carbonates over the lime elements. Waters with more than 2·5 m. e./*l* residual carbonates are not suitable for irrigation purposes. Waters containing 1·25 to 2·5 m. e./*l* are marginal, and those containing less than 1·25 m. e./*l* are probably safe. It is believed that good management practices and proper use of amendments might make it possible to use successfully some of the marginal waters for irrigation. These conclusions are based on limited data and are, therefore, tentative.

In 1953, The United States Salinity Laboratory proposed a new expression of Sodium hazard called Sodium-Adsorption Ratio (SAR). This ratio is related to the adsorption of Sodium by the soil from salt solutions or irrigation waters and is therefore, a definite improvement over previous indices for sodium or alkali hazard from irrigation waters. The waters have been categorised into four grades of salinity, denoted as C1 to C4, and four grades of alkalinity, expressed as S1 to S4, in the form of SAR values, making up 16 classes in all.

This classification has been represented by the workers of the U. S. Salinity laboratory on a diagram.

The U. S. Salinity Laboratory suggests that waters above 2,250 Micromhos in conductivity are generally unfit for irrigation. There are, however, many important irrigation waters with salt concentrations great enough to give conductivities much higher than this. For such areas Thorne and Peterson (1954) suggested additional classes above 2,250 Micromhos/cm.

Very few publication have dealt with the quality of irrigation waters of the Indian Sub-continent and so only little information is available on the subject. Mention may be made of the studies on the water from drains, rivers, and canals of the Puñjab by Asghar and Dhawan (1947). They estimated conductivity, total salt content, Calcium-Sodium ratio pH values and made comparison of relationships between these values and 'salt index' proposed by Taylor, Puri and Asghar (1935). Recently, a study and classification of irrigation waters in Uttar Pradesh has been reported by Agharwal, Mehorotra and Gangwar (1956). In this study canal and well waters of three typical districts of Utter Pradesh were chemically analysed and the data compared with the water categorization system put forward by the U. S. Salinity Laboratory.

In classification of irrigation waters it is assumed that the water will be used under average conditions with respect to soil texture, drainage, quantity of water used, climate, and salt tolerance of crop. Large deviations from the average for one or more of these variables may make it unsafe to use what, under average conditions, would be a good water ; or may make it safe to use what, under average conditions, would be a water of doubtful quality. This relationship to average conditions has been emphasised by the workers of U. S. Salinty Laboratory to be kept in mind while using any general method for the classification of irrigation waters.

Materials and Methods: Irrigation water samples from the different sources: wells, river and canal, were collected at a number of places in the Amaravathi ayacut area in August 1959. All the samples were collected within a week thus keeping the time of collection of the samples as uniform as possible.

The quality of irrigation water depends upon its content of salt constituents. Among the most important salt factors in water quality are (1) total concentration, (2) the proportion of Sodium to other cations, and (3) the presence of special toxic ions such as borate or, for some crops, possibly Chloride, Sodium or Bi-carbonate.

Each sample was analysed for total concentration by evaporating an aliquot of the water to dryness, weighing the dry residue and expressing as parts per million. Total salt concentration was also measured as electrical conductivity and expressed as micromhos per centimeter ($EC \times 10^6$) at 25° C. These two values for each sample were used to check the approximate relationship between them Viz. $\frac{\text{Parts per million}}{0{\cdot}64} = EC \times 10^6$

Each sample was also analysed for cations and anions by the usual laboratory methods. The difference between the total anionic concentration and the sum of the bivalent cations, Viz. Ca and Mg was taken as Na. All were expressed as milliequivalents per liter.

Percent Sodium was calculated as $100 \times Na/\text{Total Cations}$; Residual alkalinity as $(CO_3 + HCO_3) - (Ca + Mg)$; and Sodium absorption ratio as $Na/\sqrt{(Ca+Mg)/2}$

The following approximate relationships among the total cations, electrical conductivity and total soluble salts as established by the United States Salinity Laboratory workers were used to check the values obtained.

$EC \times 10^6/100 = $ Total Cations in Me./Litre

Total soluble salts p. p. m./64 = Total Cations in Me/Litre.

Results: Then analytical data of the water samples obtained in these studies were averaged on the basis of soil characteristics. The average composition thus obtained for each soil class is presented in Table I. The deviations observed in electrical conductivity and in percent Sodium in each soil class are given in Table II.

An examination of the data presented in Table I reveals that the composition of well waters is one of moderate salinity. Comparatively higher contents of dissolved salts are generally met with in the wells of the Dharapuram Taluk. The average percent sodium is about 50 in both the taluks. The balance chiefly is calcium. The anionic portions of the well waters contain predominently bicarbonate ions. In Dharapuram taluk the sulphate ions are also as high as the bicarbonate ions. Significant amounts of carbonates are absent since the average values in both the taluks are only a little over 5 percent of the total anions. The reaction however is on the alkaline side of neutrality but the pH is only about 8.5 or less on the average.

The salt content of canal as well as river water increases with distance though not in a regular fashion. The average figures for the taluks indicate that it is of low salinity in Udumalpet but of moderate salinity in Dharapuram taluk. The percent Na. is much lower than that of the well waters in respective taluks. The anionic portion is predominantly bicarbonate in Udumalpet taluk, while it is sulphate in Dharapuram. The pH gradually increases from about 7.5 to 8.5 as the distance increases.

There are some remarkable deviation from the average values for conductivity and percent Sodium. These are only few as indicated in Table II and are associated with Hydromorphic areas. The other values are distributed close to the mean value.

Discussion : Wilcox (1948) proposed the following grades for electrical conductivity and percent Sodium.

Grade	Conductivity Ec x 10^6 at 25°C	Percent Na
1. Excellent	less than 250	less than 20
2. Good	250 to 750	20 to 40
3. Permissible	750 to 2000	40 to 60
4. Doubtful	2000 to 3000	60 to 80
5. Unsuitable	more than 3000	more than 80

According to this categorization the canal and river waters throughout are "excellent to good" while the well waters are of 'permissible' quality.

The above was modified by Thorne and Thorne (1951) for the classification of irrigation waters of Utah. The categories of classification are designated by 25 symbols viz.: 1A 1B 1C 1D

1E.....5A 5B 5C 5D 5E. The number refers to the rating with respect to increasing concentrations of total salt and the letters to increasing proportions of Sodium in the water or to different Sodium percentages. The categories to which the average values of the different sources of irrigation water fall are shown in Table III. The well water in both the taluks belong to 2A and the canal and river waters belong to 1A. This means that the well waters may not cause any sodium accumulation in soils but may cause salt accumulation where drainage is poor. The canal and river waters in general can be used safely on all soils.

In terms of Eaton's (1950) "Residual Carbonate" concept the average values indicate that well waters of Dharapuram taluk are only of a marginal quality, while those of Udumalpet as well canal and river waters throughout the ayacut are safe to be used for irrigation. Even these marginal waters according to Eaton can be used successfully if accompanied by good management practices and proper use of amendments. There are several positive diviations from these average values mainly associated with Hydromorphic areas. They are alkali areas and require special management practices.

The water analysis data were also compared in detail with the water categorisation system put forward by the U. S. Salinity Laboratory in their manual (1953) wherein the use of S A R values, apart from the salinity classes have been made in place of Sodium percentage for assessing the Sodium hazard. The U. S. Salinity Laboratory workers suggest that waters above 2,250 Micromhos in conductivity are generally unfit for irrigation. There are however some well waters in the ayacut area with salt concentration great enough to give conductivity values greater than 2,250. Thus it would appear that further classes must be added to the U. S. Salinity Laboratory classification system in range above 2,250 micromhos per cm. The following additional classes therefore, above 2,250 micromhos/cm are adopted as suggested by Thorne and Peterson (1954) in such cases:

Class 4- 2,250 to 40,00; class 5- 4,000 to 6,000, and class 6- above 6,000.

Table IV shows the distribution of the irrigation waters amongst the different conductivity classes. It will be seen from this table that as high as 80% of the samples fall under "moderate" and "medium to high" salinity classes.

Average values of conductivity representing the different taluks as presented in Table I indicate, that the well waters in both the areas can be categorised as medium to high salinity class. Both canal and river waters are of low salinity in Udamalpet taluk but gradually take up salt and turn to be moderately saline when they flow through Dharapuram taluk. The values of S A R calculated for all the water samples were utilised along with the conductivity values for classifying water. For this, use was made of the diagram proposed by the U. S. Salinity Laboratory (1953) and later modified by Thorne and Peterson (1954) for higher salt classes. In this diagram waters have been categorised into 6 grades of salinity with increasing hazards from total salt concentrations and into four grades of S A R values representing increasing hazards from exchangeable sodium accumulation in irrigated soils. The lines dividing the S A R classes are emperical and based on green house and field tests. These are diagonal lines with negative slope to take into account the dependence of the Sodium hazard on total salt concentration. By plotting the values for individual samples in the diagram it was observed that the irrigation waters in the area fall in general in C_2S_1 and C_3S_1 classes. The waters in Udamalpet taluk mostly belong to C_2S_1 and those of Dharapuram to C_3S_1. Waters belonging to higher alkali hazard classes are few in both the taluks. Thus with respect to Sodium hazard the waters in general in the entire ayacut area belong to S_1 i. e. Low Sodium class which can be used on almost all soils without any danger of Sodium accumulation.

In the light of the above discussion it may be inferred that the canal and river waters in the ayacut area in general are of low Sodium and of low salinity. They may be used for irrigation with most crops on most soils with little likelihood that soil salinity or high exchangeable Sodium will develop. Some leaching is required but this will occur under normal irrigation practices except in cases where the soil has extremely low permeability. The well waters on the other hand are of medium to high salinity. Owing to the presence of a good proportion of bivalent cations in the total soluble salts, the Sodium hazard for these waters also is of a low order. The waters can be used only on soils of medium to good permeability to prevent serious salinity problems. Plants with moderate to good salt tolerance may be grown.

The soil texture of the ayacut area is in general sandy to sandy loam. Such soils are not only permeable, but also will permit higher exchangeable Sodium percentage without developing undesirable

physical properties. Moreover, the tract has an average rainfall of about 25" which may be sufficient to wash away the salts accumulated by irrigation water. Being mostly grown to dry crops, the area requires only light irrigation with these waters. It is thus possible to use the well waters of the area without any adverse effect on soils and plants provided the drainage is not impaired by inefficient drainage-ways or by the occurrence of any indurated pan or a high water table.

Summary: A quality appraisal of the irrigation waters from wells, canal and river of the Amaravathy ayacut area in Coimbatore District, has been made by using the recent water categorization schemes adopted in the U. S. The canal and river waters are of good quality while those of wells are of medium quality

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TABLE I

Average Chemical Composition of irrigation water in the Amaravathy Reservoir Project Ayacut area

Taluk	Nature of Soil	No. of Samples	EC Micro mhos cm	pH	Cations ME/*l*			Anions/ME/*l*				Total Soluble Salts ppm	Total Cations ME/*l*	Soluble Na Na×100/ total cations
					Ca	Mg	Na	Co_3	HCo_3	Cl	So_4			
					Well water									
Udumalpet	Red earth developed on non-calcarious parent material	44	825	8·20	2·09	1·12	4·05	0·37	3·36	2·04	1·35	353	7·36	47·61
					Canal water									
		4	113	7·47	0·70	...	0·25	...	0·50	0·42	0·12	61·25	0·95	25·00
					River water									
		2	175	7·70	0·75	...	0·35	...	0·75	0·35	...	91	1·10	35·50
					Well water									
Dharapuram	Red earth developed on calcarious parent material	57	1217	8·54	3·35	1·87	6·41	0·61	4·22	2·78	3·82	999	11·63	50·63
					Canal water									
		6	366	8·03	1·42	0·65	1·68	0·18	1·26	0·37	1·63	261	5·45	32·00
					River water									
		3	333	7·90	1·50	0·43	1·60	...	1·43	0·40	1·71	229	3·53	27·00

TABLE II

Deviation from the average values of electrical conductivity and Percent Sodium in the Irrigation waters of the Amaravathy Ayacut Area.

Taluk	Source	Average Micro Mhos/cm	Deviations		Average Na %	Deviations	
			Max	Min		Max	Min
Udumalpet	Well	825	3500	300	47·61	83	3
	...	...	2500	350	...	78	8
	...	...	1600	400	...	76	15
	...	...	1200	...	...	80	...
	Canal	113	150	100	25·00	73	11
	River	175	350	150	35·50	50	21
Dharapuram	Well	1217	7800	200	...	85	13
	...	...	2700	250	50·63	80	9
	...	...	2800	300	...	77	14
	...	...	2500	...	...	72	5
	...	...	7000	..	...	...	11
	Canal	366	900	150	32·00	80	19
	River	333	750	100	27·00	56	7

TABLE III

Average derived ratios for the different Irrigation waters in the Amaravathy Ayacut Area

Taluk	% of Na	Residual alkalinity	S. A. R.	Water quality		
				Wilcox :	Thorne & Thorne	Thorne & Peterson
Udumalpet						
Wells	47·61	1·01	3·21	Permissible	2A	$C_2 S_1$
Canal Water	25·00	0·13	0·62	Excellent to Good	1A	$C_1 S_1$
River Water	35·00	0·05	0·77	Do.	1A	$C_1 S_1$
Dharapuram						
Well Waters	50·63	1·38	4·00	Permissible	2A	$C_2 S_1$
Canal Waters	32	0·26	1·72	Excellent to Good	1A	$C_1 S_1$
River Water	27	...	1·30	Do.	1A	$C_1 S_1$

TABLE IV

Distribution of water amongst the conductivity classes.

Conuctivity Range Micromhos/cm at 25 c		Water quality	No. of Samples	Approximate %
C-1	Less than 250	Low salinity	15	13
C-2	251 to 750	Moderate salinity	57	49
C-3	751 to 2250	Medium to high	36	31
C-4	2251 to 4000	High salinity	6	5
C-5	4001 to 6000	Very high salinity	...	...
C-6	More than 6000	Excessive salinity	2	2