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Assessment of irrigation water quality (Ground water) of Melur block, Madurai district, Tamil Nadu

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Abstract
The irrigation water quality is gaining importance day by day due to the changes in the urbanisation and industrialisation which over utilise the under ground water. The ground water samples were collected from 15 revenue villages of Melur block, Madurai, Tamil Nadu during March, 2017 at variegated intervals, processed and analysed for the physico-chemical, anionic and cationic parameters to find out their quality by arriving calculated parameters viz., RSC (Residual Sodium Carbonate) and SAR (Sodium Absorption Ratio). Though the overall values lies well within the safe limit of water quality, the 25 percent water samples found to be alkaline, 42 percent found to slightly saline & two percent found to be critical in salinity levels. The highest value of 9.23, 2.62 dSm^{-1}, 3.52 and 8.51 of pH, EC, RSC and SAR were observed in the irrigation water samples. The good quality of 92.8 per cent, marginally saline 2.9 per cent and marginally alkali of 4.3 per cent of irrigation water samples have been recorded as per AICRP, 1989 classification.

Keywords: pH, EC, RSC, SAR, cations and water quality

Introduction
Soil and water quality assessment and monitoring is imperative for the sustainability in crop production. Across the world, the development of salinity and sodicity have been extensively reported due to irrigated agriculture (Verwey and Vermeulan, 2011) [9] and it was recorded in the states of Punjab and Haryana in India. Munn's (2005) [6] stated that almost 900 million hectares of agricultural land were resulted in salinity and sodicity which represented over 6% and 20% of world's agricultural and irrigated land respectively.

Irrigation water quality and quantity have direct and indirect impact on soil characteristics (physical, biological and chemical) and was depend on irrigation. The continued use of poor quality irrigation is the main cause of salinization and sodification and leads inevitably to increasing salinization and sodification problems and eventually results in increased cost of production and crop failures. Salinization is especially serious where saline groundwater is used for irrigation. In addition to effects of crop production, salinity and sodicity have been linked to environmental degradation and making soils more susceptible to erosion as the sodium ions acts as a deflocculating agent which leads to separation of soil particles.

Agriculture is the major occupation and driving force to enhance the economy in Melur block, Madurai district, Tamil Nadu. Soil and water quality is the major determine factor for increasing crop productivity. Due to high yielding high fertilizer responsive varieties there may be change with special reference to soil and water quality. Though most of the area is covered under Periyar Vaigai Canal, there are vast areas which are depending solely on ground water for their irrigation. Rice and sugarcane are the major crop of this region. The paradigm change on soil and water quality is being studied. The ground water quality parameters are dynamic hence it has to be assessed and monitored to develop appropriate database for research and technology transfer. Therefore the main objective of this study is to evaluate the water quality of Melur block, Madurai, Tamil Nadu.

We assured that data generated from this study on water quality will guide agricultural and environmental policy for sustainable irrigation schemes in Melur block of Madurai district,

Tamil Nadu. This will be an early warning indicator for taking water conservation measures.

Materials and Methods

The water samples were collected from the fifteen revenue villages of Melur block of Madurai district of Tamil Nadu during the pre monsoon season with latlong co-ordinates by using GPS to evaluate the irrigation water quality (Ground water). Melur block is the southernmost block of Madurai district of Tamil Nadu. It lies between 10.03' N Latitude and 78.34' E Longitude at an elevation of 121 m. The Geographical area of this block is 681 km^2 including 657.8 km^2 of rural area. The main source of irrigation is Periyar-Vaigai canal (6 Nos), 4628 wells, 42 tube wells and 18 tanks. The gross cultivated area is about 11,289 ha including 7179 ha of irrigated area and 4110 ha of rainfed area. The major crops are paddy and pulses.

To delineate the irrigation water quality, 69 irrigation water samples were collected for pre monsoon analysis in the month of March, 2017. The samples were collected in such a manner that it represents irrigation water quality of all the revenue villages and overall irrigation water quality of Melur block. The irrigation water samples were collected either from wells or tube-wells at random with GPS co-ordinates. From each revenue village, a minimum of one to maximum of nine number of water samples were collected. Running tube-wells distantly apart within each village were selected randomly for collection of water samples. Each selected tube-well was run for 20 minutes and then the samples were collected in thoroughly cleaned plastic bottles, properly labelled and brought to the laboratory for further chemical analysis.

The collected water samples were analyzed for various parameters by adopting the standard procedures *viz.,* pH by Potentiometry (Jackson, 1958), EC by Conductometry (Wilcox, 1950), Ca&Mg by Versanate titration (Cheng & Bray, 1951 & Diehl *et al*., 1950), Na & K by Flame photometry (TOTH *et al*, 1948), Cl, CO3 & HCO3 by Volumetric method (A. O. A. C. - 1950) and sulphate by Turbidimetry (Chesin and Yein's, 1950) procedures. The analyzed irrigation water samples of pre monsoon and post monsoon season were classified into different quality levels based on its EC, SAR and RSC values used in the AICRP classification (1989-91).

Results and Discussion

Physico chemical properties of ground water quality, Melur block (Table 1)

The individual ground water samples analysed for pH which ranged from 7.04 to 9.23 with a mean value of 7.82. The highest pH of 9.23 was recorded at T.Vellalapatti village and it was followed by 8.55 at Kidaripatti village and the lowest of 7.04 was recorded at Thiruvadavur village. Among the 69 ground water sample analysed, seventeen samples (25 per cent) have recorded alkalinity ie., more than pH 8.0 and twenty samples (29 per cent) recorded nearby alkaline (pH 7.8- 8.0). The mean values reflected that four of the revenue villages have fallen in the alkaline category (Kidaripatti, Surakundu, A. Kovilpatti and T. Vellalapatti) among the fifteen revenue villages. The pH is positively correlated with the presence of sodium content in ground water. Singh and Bajwa (1991) [7] observed an increase in pH with increase in sodium content of irrigation water particularly in the associated anions are carbonates and bicarbonates.

The EC of ground water quality ranged from 0.38 to 2.68 dSm^{-1} with a mean value of 1.06 dSm^{-1} which indicated that most of the water turned to be slightly saline. The highest EC of 2.68 $dSm^{-1}$was recorded at Thandavanpatti village and it was followed by 1.81 dSm^{-1} at Arittapatti village and the lowest of 7.04 was recorded at Poonchuthi village. Among the 69 ground water sample analysed, twenty nine samples (42 per cent) have recorded slight salinity ie., more than EC 1.0 $dSm^{-1}$and two samples (2.8 per cent) recorded nearby critical (EC 2.0 - 4.0 dSm^{-1}). The mean values reflected that seven of the revenue villages have fallen in the alkaline category (Arittapatti, Surakundu, Thandavanpatti, Thiruvadavur and Manickampatti, Kottakudi and Ambalakaranpatti) among the fifteen revenue villages. The electrical conductivity of irrigation water was found to be correlated with soluble salts, ie., chloride and sulphate content. Sree Ramulu (1962) [8] reported that EC value of water was highly correlated with cations and anions and the contribution to conductivity decreased in the order of $Cl^- > SO_4^{2-} > HCO_3^{2-}$ and $K^+ > Na^+ > Mg^{2+} > Ca^{2+}$ for anions and cations respectively.

The RSC values ranged from -9.64 to 2.58 with a mean value of -2.14 which indicated that there is less problematic water in this zone. The highest RSC of 3.52 was recorded at T.Vellalapatti village and the lowest of -9.64 was recorded at Therkutheru village. Among the 69 ground water sample analysed, nine samples (13 per cent) have recorded critical range of RSC and three samples (4.0 per cent) recorded problematic (RSC > 2.5). Though the RSC recorded problematic in some patches, the overall mean RSC values recorded non- problematic. The RSC values are positively correlated with the presence of sodium carbonate and pH. Bajwa *et al*. (1973) [1] reported that the bulk of irrigation and tube well samples of Punjab had high RSC values. Low salinity waters may be found dominant in sodium bicarbonate, high salinity waters will be found dominant in sodium chloride reported by Gupta (1986) [3].

The SAR (Sodium Absorption Ratio) values are well within the limit and has no problematic water. The SAR values ranged from 0.58 to 8.54 with a mean value of 3.24 which indicated that there is less problematic water in this zone. The highest SAR of 8.54 was recorded at Thiruvadavur village and the lowest of 0.58 was recorded at Kattayampatti village. The SAR of water increased as the HCO_3 concentration decreased after the equilibration of water with $CaCO_3$ and vice versa.

Cationic and Anionic parameters of ground water quality - Melur block (Table 2 & 3)

The cations (Ca^{2+}, Mg^{2+}, Na^+ & K^+) present in the irrigation water samples have been presented in the table 2. The cations are ranged from 0.21 to 7.36 me L^{-1}, 0.41 to 9.68 me L^{-1}, 1.1 to 14.2 meL^{-1} and 0.05 to 2.83 me L^{-1} for Ca, Mg, Na & K respectively. The mean values are 2.62, 3.53, 5.39 and 0.21 meL^{-1} for Ca, Mg, Na & K respectively. The highest calcium of 7.36 me L^{-1} recorded at Kottakudi, magnesium of 9.68 me L^{-1}recorded at Poonchuthi, Sodium of 14.2 me L^{-1}recorded at thandavanpatti and potassium of 2.83 me L^{-1}recorded at Thiruvadavur. Eventhough the highest sodium recorded more than 10 me L^{-1} in many of the villages, only two villages thandavanpatti and thiruvadavur exihibited mean sodium content more than 10 me L^{-1}. Gajbhiye *et al*. (1973) [2] observed in the water samples registering high salinity, the magnesium content was more than the calcium content in the irrigation waters of Western Rajasthan. Singh and Bajwa (1991) [7] observed an increase in pH with a increase in sodium content of irrigation water and the associated anions are carbonates and bicarbonates. Bicarbonate reacts with

calcium to form calcium carbonate and render the calcium unavailable in high pH soils. As a result the reduced amount of free calcium and magnesium in soil allows sodium to compete for and occupy the negatively-charged exchange sites on clay particles, Kahimba, F.C. *et al*., (2016) [5].

The anions (CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-}) present in the irrigation water samples have been presented in the table 3. The carbonates was in the range of 0.0 me L^{-1} (Poonchuthi village) to 6.0 me L^{-1} (T. Vellalapatti) where as the bicarbonates reached low at A. Kovilpatti (0.1 me L^{-1}) and high at sithakoor (5.9 me L^{-1}). The chlorine content was in the range of 2.33 me L^{-1} (Surakundu village) to 19.8 me L^{-1} (Thandavanpatti) where as the sulphates reached low at many villages (0.02 me L^{-1}) and high at Kidaripatti (0.19 me L^{-1}). The means values of 2.07, 1.95, 6.85 and 0.05 me L^{-1} of CO_3^2, HCO_3^-, Cl^- and SO_4^{2-} respectively. Bicarbonate is also toxic to roots and reduces shoot growth, reduces uptake of phosphorus and many of the micronutrients (Hajiboland *et al.*, 2003) [4].

Table 1: Physico chemical properties of ground water quality, Melur block

Sl No	Village name	No. of sample	pH			EC (dSm^{-1})			RSC			SAR		
			Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1	Arittapatti	9	7.52	8.15	7.90	0.83	1.81	1.27	-5.3	1.70	-0.76	1.16	8.14	4.73
2	Kidaripatti	5	7.62	8.55	8.04	0.51	1.57	0.80	-3.3	1.66	-0.53	1.97	7.65	4.05
3.	Surakundu	3	7.95	8.12	8.06	0.78	1.35	1.02	-2.4	1.31	0.05	1.01	4.04	2.04
4.	Sithakoor	3	7.68	8.13	7.89	0.70	1.42	0.99	-1.0	2.20	0.27	0.93	1.97	1.48
5.	Poonchuthi	4	7.25	7.86	7.53	0.38	1.52	0.74	-9.24	0.14	-2.87	1.17	2.82	1.96
6.	Veppadappu	8	7.28	8.46	7.73	0.58	1.11	0.80	-5.14	1.28	-2.06	0.72	8.08	2.20
7.	A.kovilpatti	5	7.84	8.32	8.06	0.70	0.77	0.73	-3.26	2.48	0.12	1.02	3.80	1.88
8.	Thandavanpatti	3	7.51	8.12	7.72	1.13	2.62	1.95	-5.68	1.3	-3.46	3.66	5.80	4.82
9	Kattayampatti	4	7.35	7.97	7.62	0.73	1.28	0.96	-6.56	-5.16	-6.12	0.58	5.13	2.02
10	Thiruvadavur	3	7.04	7.77	7.48	1.54	1.69	1.62	-6.24	-3.48	-5.25	3.99	8.54	5.96
11	Manickampatti	5	7.63	8.00	7.80	0.81	1.77	1.08	-7.76	1.08	-2.13	1.90	4.92	3.08
12	T.Vellalapatti	8	7.48	9.23	8.03	0.53	1.40	0.91	-5.36	2.58	-1.07	1.18	8.12	3.55
13	Therkutheru	1	7.56	7.56	7.56	0.91	0.91	0.91	-9.64	-9.64	-9.64	1.15	1.15	1.15
14	Kottakudi	6	7.40	7.99	7.72	0.92	1.69	1.28	-9.0	0.26	-5.04	1.93	4.41	3.58
15	Ambalakaranpatti	2	7.42	7.75	7.59	0.90	1.58	1.27	-3.0	0.94	-1.03	2.06	6.01	4.04
	Total/ Avg	69	7.04	9.23	7.82	0.38	2.62	1.05	-9.64	3.52	-2.14	0.58	8.54	3.24

Table 2: Cationic parameters of ground water quality - Melur block

Sl No	Village name	No. of sample	Ca (me L^{-1})			Mg (me L^{-1})			Na (me L^{-1})			K (me L^{-1})		
			Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1	Arittapatti	9	1.32	4.86	2.98	0.48	4.60	2.70	2.1	13.2	7.51	0.12	0.37	0.24
2	Kidaripatti	5	1.12	1.52	1.35	1.59	5.12	3.05	2.8	9.8	5.92	0.05	0.12	0.08
3.	Surakundu	3	1.76	4.24	3.11	0.41	6.56	3.71	2.1	4.2	2.89	0.16	0.17	0.16
4.	Sithakoor	3	2.00	3.60	2.93	2.80	7.20	5.47	2.1	4.5	3.00	0.06	0.11	0.09
5.	Poonchuthi	4	1.36	2.56	1.94	0.48	9.68	3.66	2.1	3.2	2.83	0.08	0.13	0.10
6	Veppadappu	8	1.36	4.24	2.69	1.20	5.68	2.94	1.2	10.9	3.42	0.09	0.32	0.17
7	A.kovilpatti	5	0.80	3.70	1.86	1.84	3.76	2.76	1.7	4.9	2.72	0.08	0.16	0.11
8.	Thandavanpatti	3	0.80	3.60	2.53	4.40	8.80	7.09	5.9	14.2	10.7	0.17	0.22	0.20
9	Kattayampatti	4	1.20	4.20	2.61	3.36	6.16	4.36	1.1	9.9	3.84	0.09	0.16	0.13
10	Thiruvadavur	3	1.28	2.78	2.00	3.60	4.32	4.05	7.0	13.3	10.2	0.17	2.83	1.06
11	Manickampatti	5	1.44	4.30	2.67	2.84	5.28	3.96	4.0	10.2	5.66	0.12	0.34	0.24
12	T.Vellalapatti	8	0.21	2.40	1.64	1.16	5.60	3.93	1.78	11.6	5.58	0.13	0.24	0.19
13	Therkutheru	1	5.84	5.84	5.84	4.60	4.60	4.6	2.63	2.63	2.63	0.19	0.19	0.19
14	Kottakudi	7	1.50	7.36	4.44	1.04	3.60	2.33	4.50	7.71	6.28	0.21	0.30	0.27
15	Ambalakaranpatti	2	2.56	4.80	3.68	1.20	3.1	2.15	3.58	10.1	6.84	0.14	0.17	0.16
	Total/ Avg	69	0.21	7.36	2.62	0.41	9.68	3.53	1.1	14.2	5.39	0.05	2.83	0.21

Table 3: Anionic parameters of ground water quality – Melur block

Sl No	Village name	No. of sample	CO_3 (me L^{-1})			HCO_3 (me L^{-1})			Cl (me L^{-1})			SO_4 (me L^{-1})		
			Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1	Arittapatti	9	0.8	5.9	2.32	1.0	4.8	2.60	3.0	12.0	8.13	0.02	0.13	0.06
2	Kidaripatti	5	0.5	3.6	1.54	0.3	4.7	2.34	3.0	11.1	5.90	0.04	0.19	0.10
3.	Surakundu	3	3.0	4.0	3.53	0.4	4.8	3.33	0.5	5.8	2.33	0.02	0.06	0.05
4.	Sithakoor	3	3.1	4.6	3.97	2.4	5.9	4.70	0.5	4.8	1.83	0.02	0.06	0.04
5.	Poonchuthi	4	0.0	1.6	1.20	1.0	2.0	1.53	2.0	11.0	4.77	0.03	0.13	0.07
6.	Veppadappu	8	0.8	4.0	1.81	0.2	2.8	1.75	0.9	9.1	4.13	0.03	0.09	0.05
7.	A.kovilpatti	5	0.8	7.0	3.18	0.1	3.1	1.56	2.0	8.1	4.41	0.03	0.05	0.04
8.	Thandavanpatti	3	4.0	4.5	4.17	2.0	2.0	2.00	6.0	19.8	15.0	0.03	0.08	0.05
9	Kattayampatti	4	0.4	0.8	0.60	0.2	0.4	0.25	6.1	14.2	9.89	0.02	0.05	0.03
10	Thiruvadavur	3	0.0	0.4	0.27	0.0	1.0	0.53	11.0	14.7	13.1	0.04	0.07	0.06
11	Manickampatti	5	0.4	3.0	1.70	0.2	5.5	2.80	2.0	15.4	6.67	0.03	0.08	0.05
12	T.Vellalapatti	8	0.4	6.0	3.09	0.2	4.5	1.41	1.0	12.8	4.73	0.02	0.05	0.04
13	Therkutheru	1	0.0	0.0	0.00	0.8	0.8	0.80	10.0	10.0	10.0	0.05	0.05	0.05
14	Kottakudi	7	0.24	1.0	0.51	0.4	3.0	1.22	6.0	15.0	10.6	0.03	0.07	0.05
15	Ambalakaranpatti	2	1.6	2.7	2.15	1.4	3.9	2.65	6.1	9.1	7.59	0.04	0.08	0.06
	Total/ Avg	69	0.0	6.0	2.07	0.1	5.9	1.95	0.5	19.8	6.85	0.02	0.19	0.05

Conclusion

By analysing the water samples in Melur block, it was revealed that most of the water turns to be slightly alkaline. The EC of ground water quality ranged from 0.38 to 2.68 with a mean value of 1.06 which indicates most of the water turns to be slightly saline. The RSC (Residual Sodium Carbonate) values indicated that there is less problematic water in this zone. The SAR (Sodium Absorption Ratio) values are well within the limit and have no problematic water. After considering the values of EC, RSC and SAR, the entire irrigation water has been divided into three categories viz., Good (64 samples, 92.8 per cent), Marginally saline (2 samples, 2.9 per cent) and marginally alkali (3 samples, 4.3 per cent) as per the Irrigation water quality classifications (AICRP 1989-91). The effective management practices can be made in specific problematic areas.

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