Water Quality of the Kolar River Basin

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Electrical conductivity (EC) and sodium absorption ratio (SAR) values were determined for the surface water of Kolar river during post-monsoon and pre-monsoon periods. The analytical results show erratic EC and SAR values mainly due to tidal ingression. The point source effluent from the ash bund disposal waste water from Koradi Thermal Power Station of Maharashtra State Electricity Board (MSEB) shows higher values which decrease with river water dilution. However, when used for irrigation, it may affect the soil, crops, human life and cattle. The utility of Kolar river water for irrigation has been discussed. The river water contains low medium salinity. the calculated values of SAR, sodium per cent and magnesium hazard are in the ranges of 5.4 to 18.49, 36.06 to 74.50 and 15.78 to 48.79.

INTRODUCTION

The suitability of natural water for a particular purpose depends upon the standards of acceptable quality for that use. Water for domestic purposes should meet the physiological needs, whereas for generation of thermal power, the water used should not allow wastage of heat by formation of scales and corrosion of metal parts. Water for irrigation purposes should satisfy the needs of the soil and the crops as the liquid phase in the soil-water plant system plays an important role in plant growth and crop production.

Water quantity and quality are the most essential parameters for agriculture. The concept of river valley projects and the utilization of river water in irrigation is emerging in India and warrants study of the quality of water[1–5] and its utility for agriculture. The present study with repetitive samples for 4 post-monsoon (September to December 1998) and 4 pre-monsoon (January to April 1999). periods has been undertaken so as to obtain information regarding the utility of the surface water of Kolar river for irrigation.

EXPERIMENTAL

Six samples were collected in polythene bottles and were analysed as per standard procedures[6]. Water sample No. 1 (WS1) was collected from the water fall of ash bund disposal waste water. Water sample No. 2 (WS2) was collected from the confluence point of effluent discharge into Kolar river. Water sample No. 3 (WS3) was collected from a distance of 1 km upstream from the confluence point while water sample No. 4 (WS4) was collected from 1 km down stream from the confluence point. Water sample No. 5 (WS5) was collected from agriculture use intake point and water sample No. 6 (WS6) was collected from domestic water use

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uptake point. Quality of the water for the purpose of irrigation is evaluated on the basis of four main parameters namely electrical conductivity (EC), sodium absorption ratio (SAR), sodium percent and magnesium hazard. The EC in micromho/cm at 25°C was measured on conductivity bridge and the SAR value was computed using the formula

$$SAR = Na^+ \sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}$$

where all values of Na^+, Ca^{2+} and Mg^{2+} are expressed in epm. The sodium hazard of irrigation water is usually described by two sodium related but separate parameters. These are known as sodium percent (Na %) and sodium absorption ratio (SAR) which are given respectively by the following relations:

$$Na\ \% = \frac{Na + K}{Ca + Mg + Na} \times 100$$

Since concentration of magnesium ions plays an important role in crop production, magnesium hazard ratio is used on an index of magnesium hazard[7] for irrigation water. It is calculated as:

$$Mg\ hazard = \frac{Mg + 100}{Ca^{2+} + Mg^{2+}}\ ratio$$

RESULTS AND DISCUSSION

Water Quality Evaluation for Domestic Purpose

The hydrochemical data for the two sets of samples are presented in Tables-1 and 2. The pH values were in the range 7.8 to 8.5 which is within the limits prescribed by World Health Organisation (WHO) and Bureau of Indian Standards (BIS) for drinking water[8, 9]. The electrical conductivity varied from 400 to 650 µs/cm while the alkalinity values varied from 182 to 207 mg/L during September 1998 and from 156 to 239 mg/L during January 1999. The presence of carbonates, bicarbonates and hydroxides is the most common cause of alkalinity in natural water. The TDS values varied from 273 to 380 mg/L during September 1998 and from 356 to 2369 mg/L during January 1999. TDS values are much beyond the permissible limit. The high values of TDS observed in the study area at some places may be attributed to ash bund disposal waste water discharged into the Kolar river.

The sodium concentration in the Kolar river water varied between 48 to 63 mg/L during September 1998 and between 56 to 75 mg/L during Janurary 1999. Calcium, magnesium and total hardness in the water are inter-related. Calcium and magnesium ranged from 40 to 52 mg/L and 13 to 19 mg/L during September 1998 and from 44 to 52 mg/L and 13 to 15 mg/L respectively during January 1999.

The chloride content ranged from 32 to 56 mg/L during September 1998 and 54 to 83 mg/L during January.1999. The sulphate concentration ranged from 28 to 85 mg/L during September 1998 and 35 to 64 mg/L during January 1999. The distribution of nitrite indicates its level below the permissible limit.

Water Quality Evaluation for Irrigation Purpose

Water used for irrigation always contains measurable quantities of dissolved substances whic'h as a general collective term are called salts. They include relatively small but important amounts of dissolved solids originating from dissolution or weathering of the rocks and soils, lime, gypsum and other salt sources as water passes over or percolates through them. The salts present in the water besides affecting the growth of the plants directly, also affect the soil structure, permeability and aeration, which indirectly affects the plant growth. The total concentration of soluble salts in irrigation water can thus be expressed for the purpose of classification of irrigation water as follows:

Zone	TDS (mg/L)	Conductivity (μs/cm)
Low salinity zone	< 200	< 250
Medium salinity zone	200–500	250–700
High salinity zone	500–1500	750–2250
Very high salinity zone	1500–3000	2250–5000

In the study area the TDS values varied from 273 to 380 mg/L during September 1998 and from 356 to 2369 mg/L during January 1999.

Fig. 1 furnishes the locations of samples collected and Tables 3 and 4 their EC and SAR, sodium percent and Mg hazard. The ash bund disposal waste water discharge from Koradi thermal power station (KTPS) had white milky colour which declined after dilution with the river water. However, it shows slighly white milky colour even after dilution.

The results of the chemical analysis of Kolar river water samples are given in Tables 3 and 4. The tolerance limits for various relevant parameters recommended

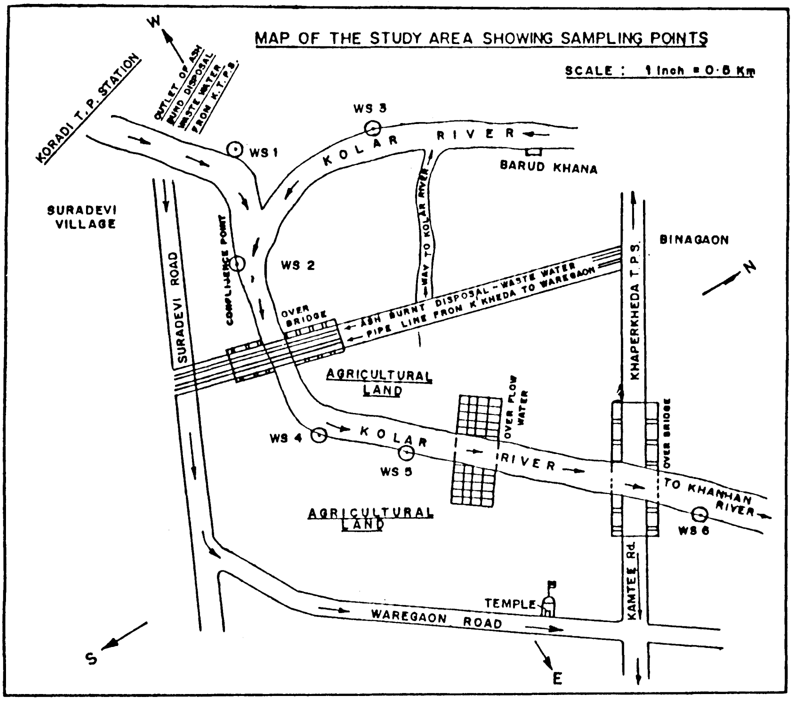

Fig. 1

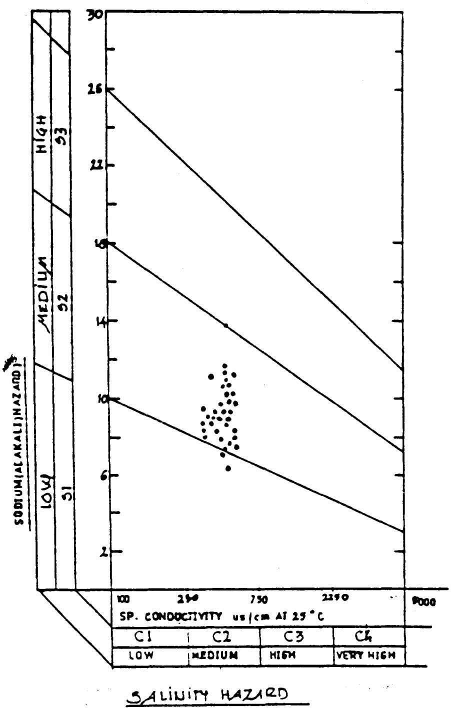

Fig. 2. SEC vs. SAR post-monsoon samples

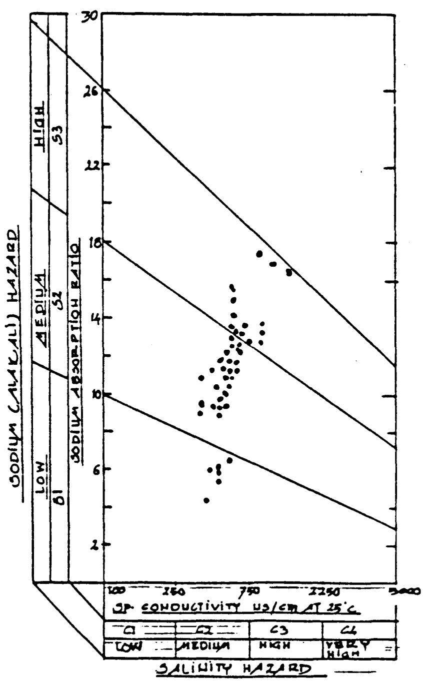

Fig. 3. SEC vs. SAR pre-monsoon samples

TABLE-1
HYDRO-CHEMICAL DATA FOR THE KOLAR RIVER WATER SAMPLES (SEPTEMBER 1998)

Station No.	Sample location	pH	Cond. μs/cm	TDS	Alka-linity	Cl^-	SO_4^{2-}	NO_2^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	Hard	PO_4^{3-}
WS1	Ash bund disposal waste water from KTPS	8.2	410	334	182	48	85	1.0	58	6.3	52	16	199	1.5
WS2	Confluence point	8.2	460	380	182	51	76	0.5	63	7.1	51	13	180	1.7
WS3	1 km upstream away from confluence point	8.5	410	273	207	33	28	0.9	48	4.6	40	24	198	1.2
WS4	1 km downstream from after confluence point	8.3	400	292	207	44	40	0.6	49	4.8	49	17	194	1.3
WS5	Agriculture use point	8.1	400	280	193	32	38	1.2	49	4.8	49	16	190	1.2
WS6	Domestic use point	8.2	400	291	207	56	42	0.8	49	4.8	47	19	196	1.3

TABLE-2
HYDRO-CHEMICAL DATA FOR THE KOLAR RIVER SAMPLES (JANUARY 1999)

Station No.	Sample location	pH	Cond. μs/cm	TDS	Alka-linity	Cl^-	SO_4^{2-}	NO_2^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	Hard	PO_4^{3-}
WS1	Ash bund disposal waste water	7.8	480	356	156	54	64	1.2	65	6.0	52	17	199	1.75
WS2	Confluence point	7.8	500	402	156	58	65	0.6	56	6.8	52	15	194	1.65
WS3	1 km upstream away from confluence point	8.0	650	486	239	83	35	0.8	75	4.9	44	31	239	1.75
WS4	1 km downstream from after confluence point	8.2	570	1655	196	61	52	0.7	56	7.0	47	23	213	1.75
WS5	Agriculture use point	8.2	570	406	189	64	54	1.0	64	5.8	44	23	207	1.05
WS6	Domestic use point	8.3	560	2369	179	64	53	0.9	64	6.0	47	22	209	1.30

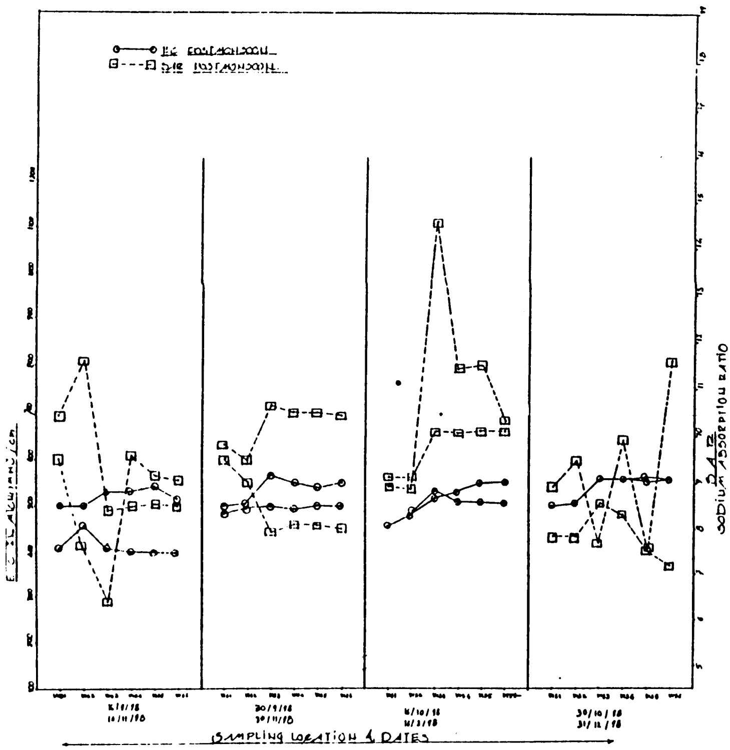

Fig. 4 (a) EC and SAR values vs. distance from ashbund disposal wastewater to agriculture use

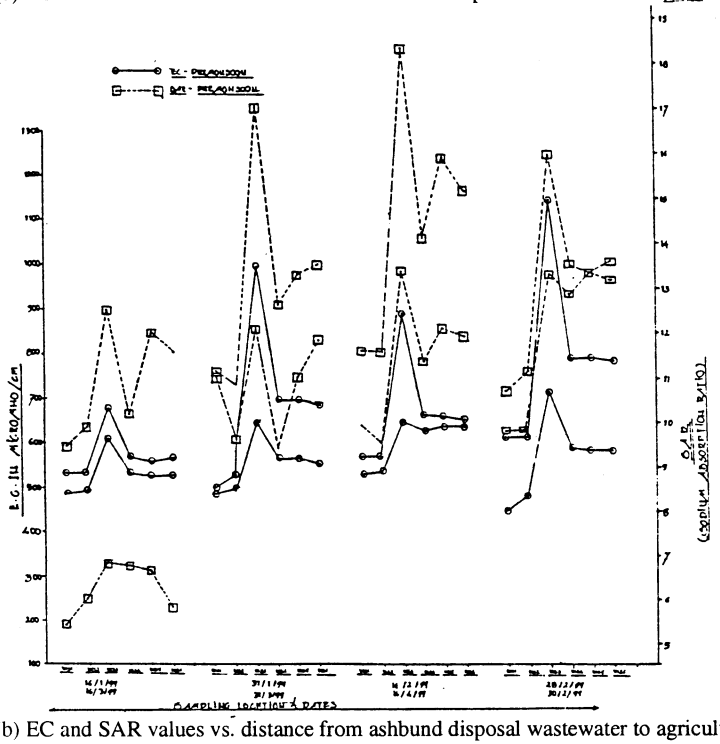

Fig. 4 (b) EC and SAR values vs. distance from ashbund disposal wastewater to agriculture use by the Bureau of Indian Standards (BIS)[10] in their code IS-2296 for water for irrigation use are given in Tables 5–7. Classification of irrigation water according to its most important parameters, *viz.*, sodium percent, sodium absorption ratio, electrical conductivity and magnesium hazard are given in Tables 3 and 4.

Using all the criteria we find that the surface water samples all along the strech from ash bund disposal waste water to agricultural use water categorically belonged to the good water class as shown by EC and SAR plots in Fig. 2 and 3 As far as the utility for irrigation is concerned, the post-monsoon surface samples were of good quality. Due to inadequacy of continuous flow of ash bund disposal waste water in the Kolar river to the down-stream of agriculture use point. Beyond the ash bund disposal waste water and up to the agriculture use point, all the surface water samples showed low sodium hazard and were consequently suitable for irrigation.

TABLE-3
(POST MONSOON)

Station No.	Sample location	Sample collection date	EC micromho/cm at 25°C	SAR	Na%	Mg hazard
		16/09/98				
WS1	Ash bund disposal waste water from KTPS		410	9.94	48.60	23.52
WS2	Confluence point		460	11.13	52.38	20.31
WS3	1 km upstream away from confluence point		410	8.40	45.11	25.75
WS4	1 km downstream from after confluence point		400	8.50	45.13	25.75
WS5	Agriculture use point		400	8.60	45.51	24.61
WS6	Domestic use point		400	8.50	45.55	27.94
		30/09/98				
WS1	Ash bund disposal waste water from KTPS		480	9.50	48.14	28.35
WS2	Confluence point		495	9.02	46.42	30.43
WS3	1 km upstream away from confluence point		500	7.94	41.87	31.50
WS4	1 km downstream from after confluence point		490	8.16	42.81	31.94
WS5	Agriculture use point		500	8.13	43.13	31.42
WS6	Domestic use point		500	8.00	42.78	28.16

Station No.	Sample location	Sample collection date	EC micromho/cm at 25°C	SAR	Na%	Mg hazard
		16/10/98				
WS1	Ash bund disposal waste water from KTPS		460	9.20	47.12	27.53
WS2	Confluence point		480	9.20	47.53	23.51
WS3	1 km upstream away from confluence point		520	10.21	46.96	36.82
WS4	1 km downstream from after confluence point		530	10.16	47.75	32.39
WS5	Agriculture use point		550	10.2	42.02	34.72
WS6	Domestic use point		550	10.14	47.95	34.28
		31/10/98				
WS1	Ash bund disposal waste water from KTPS		500	7.83	42.97	26.02
WS2	Confluence point		510	7.80	42.97	23.18
WS3	1 km upstream away from confluence point		560	8.58	42.85	35.52
WS4	1 km downstream from after confluence point		560	8.32	42.30	30.66
WS5	Agriculture use point		565	7.51	40.00	30.60
WS6	Domestic use point		560	7.22	40.83	33.80
		16/11/98				
WS1	Ash bund disposal waste water from KTPS		500	9.59	53.53	32.60
WS2	Confluence point		500	7.60	42.62	24.28
WS3	1 km upstream away from confluence point		530	6.43	36.93	37.14
WS4	1 km downstream from after confluence point		530	9.60	46.87	32.35
WS5	Agriculture use point		540	9.20	45.60	32.35
WS6	Domestic use point		520	9.10	45.96	35.82

Station No.	Sample location	Sample collection date	EC micromho/cm at 25°C	SAR	Na%	Mg hazard
		30/11/98				
WS1	Ash bund disposal waste water from KTPS		500	9.80	48.07	24.28
WS2	Confluence point		510	9.50	47.24	22.53
WS3	1 km upstream away from confluence point		570	10.70	40.53	39.72
WS4	1 km downstream from after confluence point		550	10.50	48.10	28.37
WS5	Agriculture use point		540	10.50	48.35	41.66
WS6	Domestic use point		550	10.40	48.63	40.00
		16/12/98				
WS1	Ash bund disposal waste water from KTPS		460	8.90	45.96	26.76
WS2	Confluence point		480	8.80	44.01	33.75
WS3	1 km upstream away from confluence point		530	14.60	59.70	22.22
WS4	1 km downstream from after confluence point		510	11.40	50.97	36.61
WS5	Agriculture use point		510	11.20	51.79	38.02
WS6	Domestic use point		510	10.30	48.64	38.57
		31/12/98				
WS1	Ash bund disposal waste water from KTPS		500	8.90	44.60	15.78
WS2	Confluence point		500	9.50	47.52	21.73
WS3	1 km upstream away from confluence point		560	7.70	41.66	28.70
WS4	1 km downstream from after confluence point		560	9.97	47.60	34.28
WS5	Agriculture use point		560	7.66	41.17	30.55
WS6	Domestic use point		560	11.74	51.33	36.61

TABLE-4
PRE-MONSOON

Station No.	Sample location	Sample collection date	EC micromho/cm at 25°C	SAR	Na%	Mg hazard
		16/01/99				
WS1	Ash bund disposal waste water from KTPS		488	5.4	48.19	25.71
WS2	Confluence point		490	6.0	38.39	21.42
WS3	1 km upstream away from confluence point		619	6.8	36.06	38.46
WS4	1 km downstream from after confluence point		538	6.3	39.25	35.38
WS5	Agriculture use point		536	6.2	38.39	39.33
WS6	Domestic use point		536	5.8	37.03	23.35
		31/01/99				
WS1	Ash bund disposal waste water from KTPS		480	11.0	62.83	24.63
WS2	Confluence point		500	9.6	48.38	22.36
WS3	1 km upstream away from confluence point		650	12.2	51.58	41.33
WS4	1 km downstream from after confluence point		570	9.4	47.36	32.85
WS5	Agriculture use point		570	11.0	51.02	34.32
WS6	Domestic use point		560	11.8	50.35	31.88
		16/02/99				
WS1	Ash bund disposal waste water from KTPS		530	9.90	47.32	21.12
WS2	Confluence point		545	9.56	47.02	19.71
WS3	1 km up stream away from confluence point		650	13.36	55.75	30.15
WS4	1 km down stream from after confluence point		630	11.34	50.20	22.97
WS5	Agriculture use point		640	12.17	60.84	40.00
WS6	Domestic use point		640	11.09	51.43	28.76

Station No.	Sample location	Sample collection date	EC micromho/cm at 25°C	SAR	Na%	Mg hazard
		28/02/99				
WS1	Ash bund disposal waste water from KTPS		450	9.70	47.76	28.97
WS2	Confluence point		480	9.72	48.86	23.43
WS3	1 km upstream away from confluence point		720	13.91	74.50	45.00
WS4	1 km downstream from after confluence point		590	12.86	54.33	33.82
WS5	Agriculture use point		580	13.33	51.64	34.78
WS6	Domestic use point		580	17.26	50.24	31.42
		16/03/99				
WS1	Ash bund disposal waste water from KTPS		530	9.46	47.08	21.42
WS2	Confluence point		530	9.80	47.76	30.00
WS3	1 km upstream away from confluence point		670	12.50	52.50	43.05
WS4	1 km downstream from after confluence point		570	10.23	48.21	29.57
WS5	Agriculture use point		560	12.00	52.15	34.28
WS6	Domestic use point		570	11.66	51.48	32.85
		31/03/99				
WS1	Ash bund disposal waste water from KTPS		500	11.23	53.88	29.82
WS2	Confluence point		530	10.89	51.84.24	25.00
WS3	1 km up stream away from confluence point		1000	17.17	58.66	45.12
WS4	1 km downstream from after confluence point		700	12.69	54.20	33.82
WS5	Agriculture use point		700	13.36	56.46	36.50
WS6	Domestic use point		680	13.57	56.23	31.81

Station No.	Sample location	Sample collection date	EC micromho/cm at 25°C	SAR	Na%	Mg hazard
		16/04/99				
WS1	Ash bund disposal waste water from KTPS		577	11.66	51.35	25.00
WS2	Confluence point		570	11.66	51.54	27.77
WS3	1 km upstream away from confluence point		885	18.49	60.37	48.79
WS4	1 km downstream from after confluence point		669	14.11	54.94	22.36
WS5	Agriculture use point		664	15.94	58.57	32.39
WS6	Domestic use point		655	15.26	58.57	26.15
		30/04/99				
WS1	Ash bund disposal waste water from KTPS		622	10.70	51.06	24.63
WS2	Confluence point		622	11.23	52.24	22.36
WS3	1 km up stream away from confluence point		1145	16.08	57.24	45.21
WS4	1 km downstream from after confluence point		794	13.55	54.98	33.33
WS5	Agriculture use point		799	13.33	55.16	30.55
WS6	Domestic use point		786	13.66	55.41	30.55

Further, the quality classification of water for irrigation based on EC after Wilcox[11] is furnished in Tables 5–7. According to this classification, the samples irrespective of the seasons could be grouped into the excellent or good category. Even, a sample of ash bund disposal waste water before 1 km from confluence point post-monsoon which had EC value of 570 micromho/cm was not contaminated. High value of ash bund disposal waste water before 1 km from confluence point with EC 1145 micromho/cm may be due to local contaminants and it is doubtful to unsuitable type which is mainly due to the high dissolved constituents, especially the sewage water from Binagoan, which makes the water saline.

SAR has adverse effects on crops if in excess. Irrigation water is high in sodium through exchange from the soil. This results in an increase in soil sodium causing deflocculation of soil particles impairing soil porosity, the infiltration rate and affecting the soil structure[12].

TABLE-5
CLASSIFICATION OF WATER BASED ON EC VALUES

Water class	EC micromho/cm at 25°C	Number of samples surface	
		Post-monsoon	Pre-monsoon
Excellent	< 250	—	—
Good	250–750	48	42
Permissible	750–2000	—	6
Doubtful	2000–3000	—	—
Unsuitable	> 3000	—	—

TABLE-6
CLASSIFICATION OF WATER BASED ON SAR VALUES

Water class	EC micromho/cm at 25°C	Number of samples surface	
		Post-monsoon	Pre-monsoon
Excellent	< 10	34	14
Good	10–18	14	33
Fair	18–26	—	1
Poor	> 26	—	—

TABLE-7
CLASSIFICATION OF WATER BASED ON SODIUM PERCENTAGE

Water class	Sodium percentage Na %	Number of samples surface	
		Pos-tmonsoon	Pre-monsoon
Excellent	< 20	—	—
Good	20–40	1	5
Permissible	40–60	47	39
Doubtful	60–80	—	4
Unsuitable	> 80	—	—

Based on SAR classification (Table-7) for irrigation, majority of the samples belonged to excellent to good category. Where surface water (pre-monsoon) had sodium per cent values of 60.37%, 62.83% and 74.50%, the point source samples showed higher values and were doubtful to unsuitable. The unusual rise in value

74.50% (sodium percentage) may be on account of the drained sewage upstream from Binagoan situated near Kolar river.

The high values at these locations were mainly due to the sewage drained from Binagoan, which are also passed on to the agricultural fields. Though channels to carry the disposal liquid waste from Binagoan to Kolar river are laid, effluents find their way to the river, hence the deterioration of water quality.

Similar to magnesium ions, chloride ion concentrations also deserve attention according to Ayers and Branson[13]. When chloride in irrigation water is > 10, epm is likely to pose severe problems and affect crop production adversely. Since epm values of chloride ions in present case are less than 10, Kolar river water is rated as suitable for irrigation. According to them, when this value exceeds 50, the magnesium hazard is likely to be developed in the soil profiles. As values of chloride are much below 50 in all the samples (Tables 3 and 4), it may be concluded that water from study area is free from magnesium hazard and can be used for irrigation.

TABLE-8
SALINITY LABORATORY CLASSIFICATION TABLE

Sample			
Date	Post-monsoon	Date	Pre-monsoon
16/9/98	C2S1—1, 3, 4, 5, 6	16/1/99	C2S1—1, 2, 3, 4, 5, 6
	C2S2—2		
30/9/98	C2S1—1, 2, 3, 4, 5, 6	31/1/99	C2S1—2, 4
			C2S2—1, 3, 5, 6
16/10/98	C2S1—1, 2	16/2/99	C2S1—1, 2
	C2S2—3, 4, 5, 6		C2S2—3, 4, 5, 6
31/10/98	C2S1—1, 2, 3, 4, 5, 6	28/2/99	C2S1—1, 2
			C2S2—3, 4, 5, 6
16/11/98	C2S1—1, 2, 3, 4, 5, 6	16/3/99	C2S1—1, 2
			C2S2—3, 4, 5, 6
30/11/98	C2S1—1, 2	31/3/99	C2S2—1, 2, 4, 5, 6
	C2S2—3, 4, 5, 6		C3S2—3
16/12/98	C2S1—1, 2	16/4/99	C2S2—1, 2, 4, 5, 6
	C2S2—3, 4, 5, 6		C3S3—3
31/12/98	C2S1—1, 2, 3, 4, 5	30/4/99	C2S2—1, 2
	C2S2—6		C3S2—3, 4, 5, 6

The chemical analysis data has also been processed as per the U.S. Salinity Laboratory classification[14] to examine the suitability of Kolar river water for irrigation purposes and the results are summarized in Table 8. It is evident from the results that during September to December 1998 (post-monsoon) and January to April 1999 (pre-monsoon), out of ninety six samples analysed, forty-eight samples were C2S1 type (medium salinity and low SAR) which is suitable for irrigation purposes. Forty-two samples were of C2S2 type (medium salinity and medium SAR) which is also fit for irrigation purposes. Five samples are of C3S2 type (high salinity and medium SAR) and unsuitable to be used on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good tolerance should be selected. One sample was of C3S3 type (high salinity and high SAR) which is not at all suitable for irrigation purposes. The deterioration at 1 km upstream from confluence point could be mainly due to discharge of sewage waste effluent from Binagoan into the Kolar river, hence the deterioration of water quality; high salinity is harmful for plant growth physically by reducing the uptake of water through modification of osmotic processes chemically by metabolic reaction caused by the toxic constituents. Besides this, the salinity of this magnitude changes the soil structure, permeability and aeration which in turn affect plant growth and yield of crop considerably.

Conclusions

Kolar river water is mostly of medium salinity and low SAR water. It can be used profitably for irrigation. Some of the Kolar river water is of medium salinity and medium SAR which is also fit for irrigation purposes.

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