not available in India. It is hoped that gamma-ray diffraction facility will become available in the near future, in view of its superiority in certain respects over XRD and ND.

1. Bacon, G. E., *X-ray and Neutron Diffraction*, Pergamon Press, London, 1966.
2. Glasstone, S., *Sourcebook on Atomic Energy*, Affiliated East-West Press, New Delhi, 1971.
3. Kaplan, I., *Nuclear Physics*, Addison-Wesley, Massachusetts, 1964.
4. Zachariasen, W. H., *Acta Crystallogr.*, 1967, **23**, 558–564.
5. Schneider, J. R., *J. Appl. Cryst.*, 1976, **9**, 394–402.
6. Freund, F. and Schneider, J. R., *J. Cryst. Growth*, 1972, **13/14**, 247–251.
7. Schneider, J. R., Pattison, P. and Graf, H. A., *Philos. Mag.*, 1978, **38**, 141–154.
8. Jauch, W., Schneider, J. R. and Dachs, H., *Solid State Commun.*, 1983, **48**, 907–909.
9. Hansen, N. K., Schneider, J. R. and Larsen, F. K., *Phys. Rev.*, 1984, **B29**, 917–926.
10. Schneider, J. R., *J. Appl. Cryst.*, 1975, **8**, 530–534.
11. Schneider, J. R., *J. Appl. Cryst.*, 1974, **7**, 541–546.
12. Schneider, J. R., *J. Cryst. Growth*, 1983, **65**, 660–671.
13. Alkire, R. W. and Yelon, W. B., *J. Appl. Cryst.*, 1981, **14**, 362–369.
14. Gani, S. M. A., Clark, G. F. and Tanner, B. K., in *Microscopy of Semiconducting Materials*, Institute of Physics, London, 1981.
15. Schneider, J. R. and Graf, H. A., *J. Cryst. Growth*, 1986, **74**, 191–202.
16. Kretschmer, H. R. and Schneider, J. R., *Solid State Commun.*, 1984, **49**, 971–975.
17. Willis, B. T. M., *Acta Crystallogr.*, 1969, **A25**, 277–289.
18. Coppens, P., in *Neutron Diffraction* (ed. Dachs, H.), Springer, Berlin, 1978.
19. Born, M. and Haung, K., *Dynamical Theory of Crystal Lattices*, Oxford University Press, London, 1968.
20. Alte da Veiga, L. M., Andrade, L. R. and Gonschorek, *Z. Kristallogr.*, 1982, **160**, 171–175.
21. Jauch, W., Schultz, A. J. and Schneider, J. R., *J. Appl. Cryst.*, 1988, **21**, 975–979.
22. Palmer, A. and Jauch, W., *Phys. Rev.*, 1993, **B48**, 10304–10310.
23. Stewart, R. F., *Acta Crystallogr.*, 1976, **A32**, 565–574.
24. Jauch, W., Palmer, A. and Schultz, A. J., quoted in ref. 22.
25. Schneider, J. R., *J. Appl. Cryst.*, 1974, **7**, 547–551.
26. Palmer, A. and Jauch, W., *Solid State Commun.*, 1991, **77**, 95–97.
27. Schneider, J. R., Goncalves, O. D. and Graf, H. A., *Acta Crystallogr.*, 1988, **A44**, 461–467.
28. Palmer, A. and Jauch, W., *Acta Crystallogr.*, 1995, **A51**, 662–667.
29. Becker, P. J. and Coppens, P., *Acta Crystallogr.*, 1974, **A30**, 129–147 and 1975, **A31**, 417–425.
30. Sabine, T. M., in *International Tables for Crystallography*, Kluwer, Dordrecht, 1992.
31. Welter, J. M., Bremer, F. J. and Wenzl, H., *J. Cryst. Growth*, 1983, **63**, 171–173.
32. Bastie, P., Bornarel, J., Lajzerowicz, J., Vallade, M. and Schneider, J. R., *Phys. Rev.*, 1975, **B12**, 5112–5115.
33. Bastie, P., Lajzerowicz, J. and Schneider, J. R., *J. Phys.*, 1978, **C11**, 1203–1216.
34. Mollenback, K., Kjens, J. K. and Smith, S. H., *Electron–Phonon Interactions and Phase Transitions*, Plenum Press, New York, 1977.
35. Smith, S. R. P. and Tanner, B. K., *J. Phys.*, 1978, **C11**, L717–L720.
36. Bastie, P. and Bornarel, J., *J. Phys.*, 1979, **C12**, 1785–1798.
37. Blaschko, O., Klemencic, R., Weinzeirl, P. and Eder, O. J., *J. Phys.*, 1978, **F8**, L149–L151.

ACKNOWLEDGEMENTS. Grateful thanks are due to the referee for a critical reading of the manuscript and for several suggestions which have improved the quality and content of this article. Dr B. J. Rao (TIFR), Prof. K. G. Subhadra and Dr T. Kumara Swamy are acknowledged for much help and cooperation.

Received 4 October 1996; revised accepted 20 March 1997

RESEARCH ARTICLE

Evaluation of water quality index of the river Cauvery and its tributaries

A. Chetana Suvarna and R. K. Somashekar

Department of Botany, Bangalore University, Jnana Bharathi, Bangalore 560 056, India

Water quality of the river Cauvery and its tributaries – Arkavathi and Vrishabhavathi – was assessed by using Bhargava's water quality index. Significant seasonal variation was revealed by the spatially measured physico-chemical characteristics. The water quality index is categorized as class III (satisfactory range) for the Cauvery and Arkavathi rivers and class IV (poor range) for the Vrishabhavathi. The spatial homogeneity of quality was determined by using Duncan's multiple range test.

THE Cauvery river system, revered as the Ganges of Southern India, is of great economic importance as apart from being the main source of drinking water, it is utilized for industrial and agricultural purposes. It has been subjected to rapid deterioration over the years due to increasing pollution stress from various sources. Cauvery's sub-tributary Vrishabhavathi receives most of the urban wastes generated in Bangalore City before joining the river Arkavathi, which finally joins Cauvery.

Physico-chemical and biological studies on the river Cauvery have been undertaken[1–4]. However, rivers Arkavathi and Vrishabhavathi have received little attention.

Several reports on river water quality assessment using physico-chemical and biological indices have been published[5-10]. Until now the river Cauvery has not been subjected to water quality evaluation using the physico-chemical indices. In this article we evaluate the water quality using Bhargava's index[5] and determine the spatial changes in the water quality.

Study area

The river Cauvery traverses 800 km through Karnataka, Kerala and Tamil Nadu flowing from west to the east before emptying into the Bay of Bengal. It originates at Talacauvery in the Brahmagiri range of Western Ghats in Coorg district of Karnataka at an altitude of 1341 m above MSL. It has a drainage area of 81,155 sq km with a mean annual flow of 20,950 m^3 and storage capacity of 5.478 million m^3. It receives agricultural, domestic and industrial wastes. The sampling stations selected on this river are situated between 77°18′25″ to 77°27′5″ longitude and 12°6′50″ to 12°18′5″ latitude.

The river Arkavathi, a tributary of Cauvery has its source near a tank in the south western region of Nandi Hills (Karnataka) at an elevation of 1480 m. It has an average flow of 850 m^3. It takes a south westerly course passing through Bangalore rural district for 190 km before confluencing with Cauvery at Kanakapura. The discharges are usually from industries, sewers and agricultural fields. The sampling stations are situated between 77°22′10″ to 77°24′10″ longitude and 12°18′30″ to 12°36′10″ latitude.

The river Vrishabhavathi, a sub-tributary of Cauvery is known to originate in Bangalore city and traverses through the city before joining river Arkavathi near Muduvadidurga. Seventynine industries in Bangalore discharge effluents into it, of which 21 are major and 58 are small scale industries. Fiftytwo per cent of the major and 7% of the small industries have treatment plants. The river also receives copious amount of domestic waste from Bangalore city. The sampling stations are situated between 77°25′30″ to 77°26′12″ and 12°46′30″ to 12°47′30″ longitude and latitude respectively.

Description of sampling stations

Station 1. Muththathi, an upstream station of Cauvery situated 120 km from Bangalore is a recreation spot. The flow of water is rapid and annual fairs are conducted near the Bheemeswari temple with the water being used for bathing and washing.

Station 2. This station is about 18 km from Bangalore near Shanumangala. The flow of water is slow and it is occasionally brownish. Water is used for irrigating fodder crops and vegetables.

Station 3. It is 2½ km downstream station 2 near Hanchipura. The low level of water results in stagnancy during summer and it becomes brownish occasionally. Water is used to irrigate vegetable plots.

Station 4. It represents a point on the outlet of the Byramangala tank situated 4 km downstream Hanchipura. The water is usually green or bluish green due to recurrence of algal blooms. *Eichhornia crassipes* L. is abundantly found along the entire stretch of the tank. The water is used for irrigating several crops (Figure 1).

Station 5. It is situated 48 km from Bangalore near

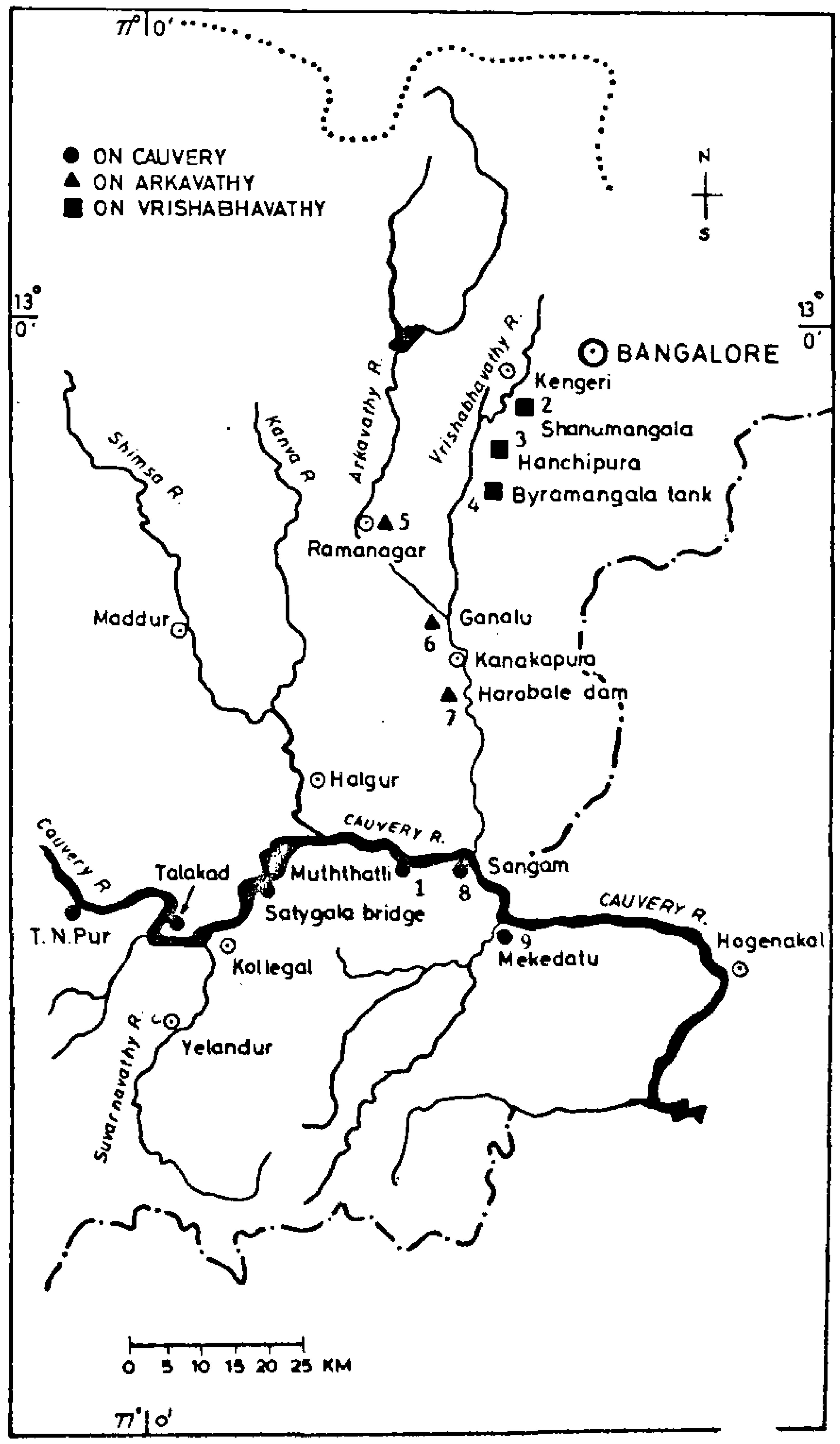

Figure 1. Map showing the locations of sampling stations.

Ramnagar. This point remained completely dry for three months (February 1991 to April 1991) during the study period. Sufficient rainfall increased the level of water during the remaining period of study.

Station 6. This is the point after the confluence of Arkavathi and Vrishabhavathi near the village Ganalu, about 8 km down station 5. This point also remained dry from February 1991 to April 1991. The water is used for bathing, washing animals and clothes.

Station 7. Located near Harobale, situated about 26 km from station 6, is the site of the construction of a dam (Harobale dam). The dam was under construction at the beginning of the study and nearing completion at the end of sampling period.

Station 8. It is situated 16 km from Muththathi. This place is called Sangama and it represents the confluence point of the tributaries (Arkavathi and Vrishabhavathi) with Cauvery. It is a famous tourist spot with water being used for washing and non-contact recreation.

Station 9. It is located 6 km down station 8. The width of the river gets reduced as it passes through a gorge, namely Mekedatu, the goat's leap. This region is undisturbed except on occasions (Figure 1).

The various stations on Cauvery and its tributaries are given in Table 1.

Material and methods

Water samples were collected in jerricans (5 l capacity) with well-fitted caps for a period of two years from August 1990 to July 1992. Samples for estimating dissolved oxygen (DO) and biochemical oxygen demand (BOD) were collected separately in polythene bottles. Water temperature was recorded on the spot. The samples were transported to the laboratory in ice boxes and standard methods of preservation were used[11].

The parameters estimated and the methods used are given in Table 2.

Results

The surface water temperature recorded lower ranges in winter while the higher ranges were encountered either during monsoon or summer. In Cauvery, the temperature ranged from 21.5 to 31.5°C, in Arkavathi from 22.5 to 31.5°C and in Vrishabhavathi from 22 to 29.25°C (Table 3).

Electrical conductivity exhibited higher ranges (0.74–2.10 mmhos/cm) at Vrishabhavathi and lower ranges (0.28–1.44 mmhos/cm) at Arkavathi. However, the annual averages for conductance were lowest in Cauvery. The conductivity decreased with dilution following rains. However, during summer the concentrate effect brought about by evaporation of water and culminating in the accumulation of salts produced a reverse trend among the stations of Vrishabhavathi.

The stations on Cauvery, namely Muththathi (131.95 mg/l), Sangama (161.22 mg/l), Mekedatu (145.89 mg/l) along with those of Vrishabhavathi (Shanumangala 239.45 mg/l) and Arkavathi (Ramnagar – 170.56 mg/l) exhibited higher winter values of total hardness. However, Hanchipura and Byramangala (300.83 and 259.33 mg/l respectively) showed higher summer averages. Ganalu and Harobale on Arkavathi registered higher monsoon averages (255.06 and 220.44 mg/l). Nonetheless low monsoon averages were evident in Cauvery and Vrishabhavathi while Arkavathi was characterized by low summer values.

The principal pollution indicator, DO showed marked seasonal variations. All stations of Cauvery and a few on the tributaries (1.56–6.52 mg/l) showed lower summer averages. However, Hanchipura exhibited lower monsoon (0.74 mg/l) and Ganalu registered lower winter (5.81 mg/l) average. Further, Byramangala, Ramnagar, Ganalu and Harobale on the tributaries along with Sangama and Mekedatu which together form a continuous stretch, exhibited higher monsoon mean.

BOD was minimum in winter and maximum in summer at all the stations of Cauvery and ranged from 0.13 to

Table 1. Stations on Cauvery and its tributaries

Station	River
Muththathi	Cauvery
Shanumangala	Vrishabhavathi
Hanchipura	Vrishabhavathi
Byramangala tank	Vrishabhavathi
Ramnagar	Arkavathi
Ganalu	Point after the confluence of Arkavathi and Vrishabhavathi
Harobale	Arkavathi and Vrishabhavathi
Sangama	Cauvery
Mekedatu	Cauvery

Table 2. Parameters and methods used for the analysis of water samples

Parameter	Method
Temperature	Direct measurement[11], p. 126.
Conductivity	Systronics conductivity meter, Model 304 (ref. 11), pp. 76–80.
Dissolved oxygen	Modified Winkler's method[11], pp. 418–419
Biochemical oxygen demand	Modified Winkler's method[11], pp. 525–532.
Chlorides	Argentometric method[11], pp. 287–288
Total hardness	EDTA titrimetric method[11], pp. 210–214
Ammoniacal nitrogen	Preliminary distillation step[11], pp. 379–380 Nesselerization method[11], pp. 377–379

22.67 mg/l. Ramnagar and Harobale recorded 3.61 and 5.75 mg/l of BOD during summer while during winter the average demand was 1.94 and 1.55 mg/l. Ganalu recorded lower summer (1.51 mg/l) and higher winter (3.97 mg/l) average. In Vrishabhavathi, Shanumangala registered lower monsoon (14.86 mg/l) and higher summer (21.19 mg/l) averages whereas Hanchipura and Byramangala exhibited high (21.68 and 20.32 mg/l) winter averages.

Chlorides, the chemical component indicative of pollution of animal origin[12], exhibited variable seasonal trends among stations of Cauvery. On Arkavathi higher concentrations were noted during monsoon (95.88–153.88 mg/l) while low summer (47.42 and 114.88 mg/l) values were seen at Ramnagar and Harobale.

Ammoniacal nitrogen, another indicator of pollution of animal origin, is toxic to fish in higher quantities. At Sangama and Mekedatu, lower summer (0.12–0.13 mg/l) and higher monsoon (0.52–0.69 mg/l) ranges were observed while at Muththathi, the minima (0.09 mg/l) was during winter. Ganalu and Harobale on Arkavathi (0.03–1.28 mg/l) and all the stations of Vrishabhavathi (0.38–4.87 mg/l) showed variations similar to those of Sangama and Mekedatu. Ramnagar showed lower summer (0.19 mg/l) and higher winter (1.49 mg/l) averages.

The use of water was grouped into five categories as suggested by Bhargava[5] with different water quality parameters for each beneficial use. The factors were given weightage based on its relevance to any particular use. The water quality index (WQI) was determined according to Bhargava's method[5].

The simplified model for WQI for a beneficial use is given by

$$\mathrm{WQI} = [n_{i=1}^{n}\ fi\,(Pi)]^{1/n} \times 100\,,$$

where n is the number of variables considered more relevant to the use and $fi\,(Pi)$ is the sensitivity function of the ith variable which includes the effect of weighting of the ith variable in the use.

To evaluate the overall WQI at a point where the river is simultaneously used for several beneficial uses, the weight of each beneficial use is taken into consideration. The extent of change in the sensitivity function value would depend on the variable's degree of relevance to the use (Table 4).

On stations of Cauvery, hardness and temperature contributed to deterioration in water quality for some of the beneficial uses. At stations of Arkavathi, chlorides along with the hardness and temperature decreased the quality of water considerably. DO, BOD and ammoniacal nitrogen affected the water quality significantly in Vrishabhavathi.

At several stations, the overall water quality decreased during summer and improved during monsoon. The overall water quality index was placed under class II for Cauvery, class III for Arkavathi and class IV for Vrishabhavathi. In Vrishabhavathi for several uses, the quality fell under class IV or V. Ramnagar of Arkavathi is grouped under class II or III while the other stations come under class III or IV for most uses and class V for agricultural use. At Muththathi, the index was comparatively higher than Sangama and Mekedatu, being classified under class I or class II for varied uses (Table 5).

The analysis of variance and the results of the Duncan's multiple range test helped in grouping the stations on the basis of water quality. Multiple comparison of means was made to indicate significant differences in the means of water quality index. This test divides the means into subgroups such that any two means in a subgroup do not differ significantly. Accordingly, Shanumangala and Hanchipura formed one subgroup, Ganalu and Harobale the second subgroup and the stations of Cauvery, the third subgroup. Byramangala and Ramnagar were unique in their water quality and differed from all other subgroups.

Discussion

The fluctuations in water temperature followed the trend in atmospheric temperature. The higher ranges during monsoon were due to various factors like turbidity and non-return of monsoon[13]. Turbid streams are known to have a greater heating capacity than clear ones[14]. Further, turbidity interferes with deeper penetration of light whereby surface water gets heated up.

The conductance of water gives an estimate of the quantity of ionizable chemical substances and also the trophic status. The trophic status is in turn determined by the density of planktons. Accordingly, the trophic status varies from oligotrophic condition in clear water to polysaprobic nature in respect of polluted streams. The seasonal fluctuations in conductance were dependent on water discharge. Lower conductance during monsoon and highest in summer in the study on Ganga, Yamuna and Tons is reported[15].

The categorization of hardness[16] suggested that it ranged from moderately hard to very hard in Vrishabhavathi. However, the means during different seasons indicated very hard range (> 250 mg/l) except at Hanchipura, where during monsoon hardness decreased to hard range (200–250 mg/l). In Arkavathi, it varied from slightly hard (100–150 mg/l) to very hard range. In Cauvery, it ranged from soft (< 50 mg/l) to moderately hard (150–200 mg/l) range.

DO determines the quality and quantity of biota[15]. At Harobale, DO showed drastic fall (0.95 mg/l in March) and rise (4.19 mg/l in April) during summer which

Table 3. Range values of some physico-chemical parameters (mg/l) at different stations

Parameter	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9
Temperature (°C)	21.50–31.00	22.50–28.50	22.00–29.25	22.50–28.50	22.50–28.50	23.50–30.50	25.00–31.50	24.00–31.50	23.00–31.50
Electrical conductivity (mmhos/cm)	0.22–0.43	0.79–1.87	0.78–2.10	0.74–1.67	0.28–1.25	0.47–1.44	0.30–1.30	0.21–1.17	0.11–0.80
Total hardness	60.66–146.66	172.66–350.66	174.00–358.66	151.00–337.34	72.00–328.67	120.66–329.34	125.34–306.32	48.00–212.68	42.66–193.00
Dissolved oxygen	5.67–7.96	0.00–7.96	0.00–8.77	1.08–7.29	0.00–7.43	4.12–7.56	0.95–8.36	5.81–7.56	5.67–7.83
Biochemical oxygen demand	0.13–4.87	4.88–64.80	7.02–36.40	3.24–30.60	0.40–15.36	0.27–15.36	0.20–22.67	0.17–5.94	0.13–4.46
Chlorides	12.31–28.87	91.83–222.47	91.35–216.79	81.41–215.84	15.62–226.25	38.34–221.05	26.51–202.59	12.31–154.31	12.30–98.93
Ammoniacal nitrogen	0.01–1.96	0.02–8.75	0.01–13.34	0.01–6.31	0.01–8.65	0.02–2.03	0.01–3.10	0.02–2.10	0.01–1.06

Table 4. Suggested values of parameters for the various classes of the beneficial use

		Relevant parameter values					
Uses	Sensitivity function	Temp (°C)	DO (mg/l)	BOD (mg/l)	Chlorides (mg/l)	Hardness (mg/l)	NH_3 nitrogen (mg/l)
Bathing, swimming	1.0	–	> 8.0	< 1.0	–	–	0.0
	0.8	–	5.8	3.0	–	–	0.6
	0.5	–	4.0	6.5	–	–	1.5
	0.2	–	2.5	10.0	–	–	2.4
	0.01	–	< 2.0	> 12.0	–	–	> 3.0
Public water supplies	1.0	–	> 8.0	< 1.0	–	–	–
	0.8	–	5.8	3.0	–	–	–
	0.5	–	4.0	6.5	–	–	–
	0.2	–	2.5	10.0	–	–	–
	0.01	–	< 2.0	> 12.5	–	–	–
Agriculture	1.0	–	–	–	< 4.0	–	–
	0.8	–	–	–	20.0	–	–
	0.5	–	–	–	50.0	–	–
	0.2	–	–	–	80.0	–	–
	0.01	–	–	–	> 100.0	–	–
Industry	1.0	–	–	–	–	< 20	–
	0.8	–	–	–	–	100	–
	0.5	–	–	–	–	200	–
	0.2	–	–	–	–	320	–
	0.01	–	–	–	–	> 400	–
Non-contact recreation	1.0	15	> 8.0	< 1.0	< 20.0	–	–
	0.8	20	6.0	3.5	100.0	–	–
	0.5	28	4.2	8.0	250.0	–	–
	0.2	35	3.0	12.0	400.0	–	–
	0.01	> 40	< 2.5	> 15.0	> 500.0	–	–

Table 5. Computed seasonal values of Bhargava's water quality index for the study period

Station	For beneficial uses																	
	Bathing, swimming			Public water supply			Agriculture			Industrial			Non-recreation			Overall WQI		
	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S
1	85†	95*	88†	96*	96*	89†	92*	90*	80†	89†	85†	86†	81†	85†	76†	89†	90*	84†
2	6**	10**	4**	16§	11§	4**	10**	10**	10**	62‡	54‡	57‡	15§	13§	10**	22§	20§	17§
3	4**	15§	5**	10**	16§	5**	10**	10**	10**	59‡	53‡	51‡	15§	22§	8**	20§	23§	19§
4	11§	12§	17§	23§	14§	18§	10**	10**	10**	67†	61‡	57‡	37‡	23§	21§	30§	24§	25§
5	77†	57‡	57‡	84†	77†	59‡	51‡	50‡	49‡	76†	77†	81†	75†	73†	58‡	73†	67†	61‡
6	72†	75†	89†	82†	71†	80†	10**	25§	10**	59‡	61‡	61‡	73†	68†	73†	59‡	60‡	63‡
7	70†	70†	66†	86†	88†	63‡	10**	26§	10**	65†	69†	74†	73†	66†	57‡	61‡	60‡	54‡
8	85†	92*	87†	93*	92*	88†	75†	62‡	82†	85†	80†	84†	80†	81†	75†	84†	84†	83†
9	88†	92*	86†	94*	93*	87†	78†	84†	84†	86†	82†	85†	80†	80†	70†	85†	86†	82†

Rating: *Class I (Excellent) > 90
†Class II (Good) 65–89
‡Class III (Satisfactory) 35–64
§Class IV (Poor) 11–34
**Class V (Acceptable) < 10.

M, Monsoon; W, Winter; S, Summer.

coincided with significant increase and decrease in algal density. Higher monsoon averages at several stations are perhaps due to greater turbulence[17]. Vrishabhavathi registered nil DO during several months as a result of enormous input of organic wastes. In this case DO and BOD were below and above the prescribed standard limits respectively[18].

Chlorides were the second major anions after bicarbonates. Mitra[19] reported similar trend in Mahanadi and attributed the variations in the concentration of chloride to differences in the flow. Comparison of the background concentration of chlorides in Arkavathi (Ramnagar) showed an increase by 33% after the confluence of Vrishabhavathi with Arkavathi near Ganalu. A significant correlation between chlorides and ammoniacal nitrogen (0.475 and 0.455 at $P > 0.05$) was observed at Ramnagar and Harobale.

The water quality of Cauvery is in the excellent to good range mainly due to lower input of industrial and/or municipal wastes. The polluted waters of the tributaries are diluted to a great extent by Cauvery as the inflow from them is comparatively less and variable. Further, the observed values of DO, BOD and ammoniacal nitrogen both during monsoon and summer indicated optimum self-purification occurring in the system. Therefore, it can be said that the present built-in purifying capacity of Cauvery is sufficient to tolerate the existing pollution load. In general the quality oscillated between poor to satisfactory range for Arkavathi after confluence with Vrishabhavathi, while before it tends to remain in good to satisfactory range (Ramnagar). Vrishabhavathi water was of poor or unacceptable quality because of the enormous amount of urban wastes discharged into it.

The uniqueness of water quality of Byramangala is mainly due to its morphometry, being situated on the outlet of a tank. The tank acts as a sink facilitating sedimentation of most components. As a consequence, in contrast to Shanumangala and Hanchipura of Vrishabhavathi, the outlet point at Byramangala showed lower hardness, chlorides and conductance. Similarly, Ramnagar differed from Ganalu and Harobale as it is the point before the confluence of the tributaries.

Therefore, it is inferred that Vrishabhavathi brings about considerable lowering of the water quality of Arkavathi but had no significant impact on Cauvery. The Duncan's test helped in strengthening the conclusion drawn by the use of water quality index. A comparison of DO and BOD values indicated that Cauvery is not largely affected by the inflow from the tributaries while water quality of Arkavathi deteriorates considerably after its confluence with Vrishabhavathi.

1. Paramasivam, M. and Sreenivasan, A., *Indian J. Environ. Hlth.*, 1981, **23**, 222–238.
2. Somashekar, R. K., *Int. J. Environ. Studies*, 1984, **23**, 209–215.
3. Somashekar, R. K., *Int. J. Environ. Studies*, 1985, **24**, 115–125.
4. Annapoorani, K. and Lakshamanaperumalsamy, *Indian J. Environ. Protect.*, 1989, **9**, 725–730.
5. Bhargava, D. S., *Environ Pollut.*, 1983, **B6**, 51–67.
6. Lohani, B. N. and Todino, G., *J. Environ. Engg.*, 1984, **110**, 1163–1176.
7. Tiwari, T. N. and Ali, M., *Indian J. Environ. Protect.*, 1987, **7**, 347–351.
8. Tiwari, T. N. and Ali, M., *Indian J. Environ. Protect.*, 1988, **8**, 269–274.
9. Viet, N. T. and Bhargava, D. S., *Indian J. Environ. Hlth.*, 1989, **31**, 321–330.
10. Bilgrami, K. S., Sheokumar and Sahay, S. S., *Proc. Indian Natn. Sci. Acad.*, 1993, **B59**, 59–66.
11. APHA-AWWA-WPCF, *Standard Methods for the Examination of Water and Waste Water*, APHA Inc., New York, 1985, 16th ed., pp. 76–537.
12. Trivedi, R. K. and Goel, P. K., *General Chemical and Biological Methods for Water Pollution Studies*, Environ. Publications, Karad, 1986.
13. Zafar, A. R., *Hydrobiologia*, 1986, **138** 177–187.
14. Hynes, H. B. N., *The Ecology of Running Waters*, Liverpool University Press, Liverpool, 1970.
15. Srivastava, U. S. and Kulshrestha, A. K., *Recent Trends in Limnology*, 1990, 351–363.
16. Hegde, G. R. and Kale, Y. S., *Indian J. Environ. Hlth.*, 1995, **37**, 52–56.
17. Pophali, S., Siddiqui, S. and Dhan, L. H., *Indian J. Environ. Protect.*, 1990, **10**, 203–207.
18. *Tolerance Limits for Inland Surface Water when used as Water for Public Water Supplies and Bathing Ghat*, ISI: 2296, Indian Standard Institution, New Delhi, 1974.
19. Mitra, A. K., *Indian J. Environ. Hlth.*, 1995, **37**, 26–36.

ACKNOWLEDGEMENTS. Financial assistance provided by the Department of Environment and Forest, New Delhi to A.C.S. is gratefully acknowledged.

Received 9 April 1996; revised accepted 5 March 1997