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Seasonal study on the Physical, Chemical and Biological characteristics of River Cauvery, Tiruchirappalli District, Tamilnadu, India

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Abstract: The present investigation was carried out to determine the seasonal variations of physico-chemical parameters of certain important man made reservoirs of River Cauvery at Tiruchirappalli District, Tamilnadu during August 2012 to July 2013. The study was made during three seasons namely Monsoon (M) [August to November], Postmonsoon (PM) [December to March] and Premonsoon (PRM) [April to July]. The study revealed the status of physical and chemical parameters of River Cauvery at five different stations (from Mayanur to Grand Anicut). The physical parameters examined were temperature, turbidity, electrical conductivity and pH. The chemical parameters studied were carbonate, bicarbonate, nitrate, phosphate, silicate, salinity, chloride, sulphate, magnesium, sodium, potassium, calcium, ammonia, dissolved oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand and the Total Dissolved Solids. The biological parameters involved were phytoplankton and zooplankton density. The results obtained for the water parameters were subjected to statistical analysis which revealed that most of the parameters showed significant changes in the concentration. The models produced by different statistical analysis have shown that the limnological variables such as Temperature, Turbidity, pH, Bicarbonate, Nitrate, Phosphate, Salinity, Chloride, Sulphate, Ammonia, DO, BOD, COD and TDS were the prime factors that determined the quality of water in all five different stations. The physico-chemical characteristics of water largely determined the faunal life of these five study stations of River Cauvery.

Key words: River Cauvery, Water pollution, Tiruchirappalli, Water quality, Physical and Chemical parameters, Seasonal variations.

1 INTRODUCTION

AROUND the world the human populations including the organisms which live in it centre around rivers and water bodies and man uses these aquatic systems for different purposes but the understanding of the basic properties of these vital systems are inadequate (Ravichandran, 1987). Life in water is influenced directly or indirectly by physical, chemical and biological factors (Jerald, 1994). Planktons and fishes form an important constituent of aquatic ecosystems (Kartha and Rao, 1992). Rivers in general, are said to be one of the largest fresh water resources for human activities. India is covered with fourteen major rivers including River Cauvery and contributes 85 per cent of total water flow, and more than fifty medium and minor rivers with remaining 15 per cent of water flow (Goel, 2000). The rivers are exploited for almost every use. They are also commonly used for waste water disposal and have made the rivers highly polluted in several areas (Goel and Trivedy, 1984). Hydrobiological studies are carried out in relation to pollution in the perennial stream Khala by Verma and Shukla (1969). Goldman (1972) studied the role of micronutrients in limiting the productivity of aquatic ecosystems. Bhora (1975) made a study on the relationship between temperature, pH and dissolved organic content in Padmasagar and Ranisagar in Rajasthan. Limnological studies on Parambikulam Aliyar project was studied by Sreenivasan (1977). Sharma *et al*., (1981) found that acute changes in water quality of river Yamuna at Agra was due to the mixture of sewage water. Shahul Hameed (1981) studied the hydrobiological condition of the River Cauvery and the industrial effluents in and around Erode. Recent investigations were made on the determination of water quality of River Narmada with reference to the physico-chemical parameters (Shraddha *et al*., 2011) and the seasonal variations in physico-chemical parameters of Kedilam river, Visoor, Tamilnadu (Muniyan and Ambedkar, 2011).

After a careful perusal of the literature available on semilentic systems and seeing the rarity of information on hydrobiology of the three reservoirs (Mayanur, Mukkombu and Grand Anicut) of River Cauvery, the present study was planned and designed with the following objectives; to observe seasonal variations of physico-chemical variables of the three reservoirs with other two (Kulithalai and Melachinthamani) critical stations located between the reservoirs, to determine the seasonal variations in the phytoplankton and zooplankton density of all the five study stations.

2. MATERIALS AND METHODS

Study area : River Cauvery is one of the major rivers of South India which originates from the Brahmagiri Hills of Western Ghats and covers Karnataka and Tamilnadu states. In

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Tamilnadu it flows via Mayanur, Kulithalai, Mukkombu, Tricuhirappalli town and reaches Grand Anicut and finally confluences with the Bay of Bengal near Pumpuhar.

Mayanur (Latitude 10o57’33.29”N, Longitude 78o14’2.94”E) is an important place in the History of Tamilnadu. Kulithalai (Latitude 10o56’45.00”N, Longitude 78o24’50.02”E) station is located 15 Km away from Mayanur reservoir is also subjected to the analysis. Mukkombu (Latitude 10o53’32.90”N, Longitude 78o34’57.97”E) reservoir lies 15 Kms away from Kulithalai station and considered as an area of importance. From this small reservoir the River Cauvery trifurcates into Cauvery proper, Coolroon and the Ayyan Vaikaal (stream), hence the name Mukkombu (three parts). This is other wise called the Upper Anicut. Melachinthamani (Latitude 10o50’8.43”N, Longitude 78o41’42.11”E) station is situated 15 Kms away from Mukkombu at the heart of Tiruchirappali town. Grand Anicut (Latitude 10o49’48.23”N, Longitude 78o49’7.81”E) reservoir is situated 15 Kms away from Melachinthamani station. From this reservoir, four branches of rivers originates, all headed to various parts of Eastern Tamilnadu. The four branches are Grand Anicut canal (Puthaar), Vennar, Cauvery, Colroon. The map of the sampling stations was shown in Figure 1.

The water samples were collected at five stations. Mayanur Reservoir (S1), Kulithalai (S2), Mukkombu Reservoir (S3), Melachinthamani (S4) and Grand Anicut Reservoir (S5). For the analysis of physico-chemical parameters, the surface water samples were collected in sterilized 250ml reagent bottles. Samples were protected from direct sun light and immediately transported to the laboratory for analyses. The collected samples were analysed within three days during which samples were kept in cold storage (Kulshrestha et al., 1991) according to methods suggested by Golterman (1975), American Public Health Association (APHA, 1976) and National Environmental Engineering Research Institute (NEERI, 1986).

A) Physical Factors

i. Water Temperature

Water temperature was recorded by a sensitive 0-50oC mercury thermometer graduated to 0.02oC. It was measured 0.2m below the water surface (Sjoberg and Danell, 1982, Michael, 1986).

ii. Turbidity: The turbidity was estimated with a Systronics 131 Nephelo turbidity meter.

iii. Electrical conductivity (EC): The conductivity was measured using a Systronics 303 direct reading conductivity meter. The conductivity readings were taken at the ambient temperature and were corrected uniformly using the correction factor as given by Golterman (1969).

B) Chemical Factors

i. pH: The pH of water is determined using SYSTRONICS Digital pH meter, model 335 which gives direct value of pH.

ii. Carbonate and Bicarbonate: The acid-base titration of phenolphthalein and methyl orange alkalinity was determined following volumetric principle (Welch, 1948). Phenolphthalein alkalinity value represented the carbonate content (Trivedy et al., 1987). The value of bicarbonate alkalinity was obtained by subtracting the value of phenolphthalein alkalinity from that of the methyl orange alkalinity.

iii. Nitrate: Nitrate content was estimated by Phenate photometric method (Mc Kee and Wolf, 1963; Jenkins and Mesker, 1964).

iv. Phosphate: The phosphate content was estimated following persulphate digestion method. The liberated orthophosphate after digestion was colorimetrically estimated (APHA, 1976; Sawyer and McCarty, 1978).

v. Silicate : The Silicate content was estimated based on molybdo-silicate method. Ammonium molybdate reacts with silica to form a coloured heteropoly acid. The intensity of the colour is proportional to the concentration of silica, which was then measured colorimetrically (Schwertz, 1942; ASTM, 1972).

vi. Salinity: Chlorinity of the water sample was estimated using Mohr’s Method and the salinity was calculated using Knudsen’s formula (Strickland and Parsons, 1972).

vii. Chloride: Chloride content was determined following argentometric titration. Silver nitrate reacts with chloride ions to form silver chloride. The completion of reaction is indicated by the red colour produced by the reaction of silver nitrate with potassium chromate indicator solution (Kolthoff and Stenger, 1947; Vogel, 1964).

viii. Sulphate: Sulphate estimation was based on turbidimetric method (Trivedy et al., 1987). Sulphate ions were precipitated as barium sulphate in acid medium by using conditioning reagent. Light absorbed by the precipitate was then measured at 420 nm with a spectrophotometer.

ix. Calcium and Magnesium: Hardness was estimated by compleximetric titration. The major cations imparting hardness to water are calcium and magnesium (Trivedy et al., 1987). These ions react with EDTA to form soluble complexes and the completion of reaction is indicated by colour change with Eriochrome Black T and Murexide indicators for total hardness and calcium hardness respectively (Taylor, 1949; APHA, 1976). The value of magnesium hardness was obtained by subtracting the value of calcium hardness from the total hardness value (Trivedi and Goel, 1984; Manivasakam, 1985).

x. Sodium and Potassium: Sodium and Potassium were determined following Flame photometric method using Elico Flame Photometer (Digital Type Model CL22-D (Dean, 1960).

xi. Ammonia: The ammonia content was estimated following Phenate Photometric Method (Abbasi, 1998).

xii. Dissolved Oxygen (DO): The DO was estimated by Alsterberg (Azide) modification of Winkler’s Method following volumetric principle (Micheal, 1986).

xiii. Biochemical Oxygen Demand (BOD): The five day BOD was calculated following direct method as per APHA (1976). The difference in dissolved oxygen values before the start of incubation and after five days of incubation at 20oC was the five day BOD.

xiv. Chemical Oxygen Demand (COD): The reflux-dichromate oxidation technique was followed for the volumetric estimation of COD. Here organic matter of the sample was completely oxidised by reflux ion with a known excess of potassium dichromate solution under acidic condition. The untreated dichromate was back titrated with a standard solution of ferrous ammonium sulphate (APHA, 1976; Sawyer and Mc Carty, 1978).

xv. Total Dissolved Solids (TDS): The TDS was estimated following gravimetric method (APHA, 1976; Sawyer and Mc Carty, 1978). 50 ml of water sample is filtered through ordinary filter paper and water is collected in the evaporating dish of known weight. The total water is evaporated. Whatever solid matter is present gets accumulated at the bottom of the dish. After the water gets dried totally it is again weighed. By weight difference method the Total dissolved solid is determined.

C. Biological factors

i. Phytoplankton and Zooplankton: Phytoplankton and zooplankton were sampled by filtering 100 litre of water through a conical shaped (mouth diameter 15 cm, length 45 cm) net of bolting silk of 20 micron and 32 micron mesh size respectively. The filtrate was concentrated to 100 ml and preserved in 4 per cent formaldehyde solution. 1 per cent Lugol solution was added to phytoplankton sample (Trivedy et al., 1987). Planktons were quantified as number of organisms per litre in a Sedgewick-Rafter counting cell (Micheal, 1986).

3. RESULTS AND DISCUSSION

The results on the water parameters obtained from the water samples collected between S1 to S5 sampling stations during monsoon, postmonsoon and premonsoon are presented in Tables 1, 2 and 3 respectively. The temperature was found to be high during premonsoon and low during the monsoon in all sampling stations. From S1 to S3 a decreasing trend in the turbidity value was noticed seasonally from monsoon to postmonsoon and to premonsoon. On the contrary S4 and S5 showed a highest turbidity during monsoon and premonsoon.

Hydrology can play a fundamental role in controlling the physical, chemical and the biological characteristics of aquatic systems (Gosselink and Turner, 1978). Devaraj *et al*., (1988) were also of the view that the physico-chemical properties of water determined the quality and quantity of the fauna in a reservoir.

In the present study, water temperature and pH have been entered as significant factors in influencing plankton population. Graham *et al*., (1982) have shown that water temperature regulated the role of photosynthesis in aquatic ecosystems.

From the present investigation it is inferred that the plankton density in these water bodies depended greatly on parameters that influenced habitat quality (such as temperature, turbidity, pH, DO, carbonates and TDS), nutrient levels and planktonic resources. The levels of DO of River Bhavani (Varunprasath and Daniel, 2010) was found to be similar with our present investigation. The drastic decline in the levels of DO in Melachinthamani station and Grand Anicut reservoir may be due to the local anthropogenic activities, agricultural runoff and by industrial effluent as evidenced from the reports of River Narmadha (Shraddha et al., 2011). The cations that are responsible for hardness are calcium and magnesium and the anions were mainly carbonate, bicarbonate, chloride, silicate, nitrate and sulphate (Trivedy and Goel, 1984). Low chloride indicated relative absence of pollution (Sreenivasan, 1969). Klein (1957) found a direct correlation between chloride concentration and pollution level. Munawar (1970) has suggested that higher levels of chlorides in water are an index of pollution of animal origin. In Tawa reservoir of Madya Pradesh, the chloride concentration was below 40mg/lit and hence the system was termed oligotrophic (Singhai et al.,1990). In the present study, the mean chloride concentration was below the prescribed limits in Mayanur, Kulithalai and Mukkombu and was found higher in Melachinthamani and Grand Anicut stations and hence an identical conclusion could also be arrived at for these study stations.

Nutrients such as nitrate, phosphate and silicate in these reservoirs and other two stations have also been correlated with the plankton density. It has been noted that these nutrients have an influence over the plankton density. It is well documented that these nutrients play a vital role in the productivity of many aquatic ecosystems (Moyle, 1949; Hutchinson, 1957; Wetzel, 1975; Richardson *et al*., 1978; Stauffer, 1991). Nutrient conditions of water played an important role in phytoplankton production (Singh and Desai, 1980). Holmgren (1983) was of the view that enrichment with both nitrates and phosphates made phytoplankton increase 50 to 60 times in the Scandinavian sub-arctic lakes. Hassan et al. (2008) was of the view that low levels of nitrate would be the limiting phytoplankton growth in Shatt Al-Hilla river water.

The level of ammonia are found to be very high in S4 and S5 than S1, S2 and S3 stations, the possible reason might be the mix up of heavy domestic sewage and agricultural wastes into these stations, thereby a decrease in the densities of planktons. Plankton which play a key role in the ecosystem of an environment is directly related to the fish potential of a lake (Sugunan, 1980) and Stanley reservoir (Sreenivasan, 1969). In the present study also it was observed that DO values were high and pH levels slightly in alkaline range in Mayanur reservoir, Kulithalai station and Mukkombu reservoir where the phytoplankton and zooplankton densities were high. Whereas in Melachinthamani station and Grand Anicut reservoir a drastic decline in the phytoplankton and zooplankton densities may be due to the low DO values and high alkaline range in pH.

The Dendrogram of monsoon, S2-S3 and S4-S5 showed similarities and varied from S1 (Chart 1). The

Dendrogram of postmonsoon showed similarities between S1-S2 and S4-S5 (Chart 2). During premonsoon of 2012-2013, S2-S3 and S4-S5 showed similarities of the physico-chemical parameters (Chart 3). The Dendrogram of annual and seasons showed common resemblance between S4 and S5 than the other stations. In certain cases S1 and S2 showed resemblances.

Chi Square analysis of water parameters and plankton density from S1 to S5 showed significant changes (at 0.05 level) in bicarbonate (X2 182.43), phosphate (X2 23.62), salinity(X2 612.28), chloride(X2 36.32), sulphate(X2 11.71), ammonia(X2 16.02), COD(X2 40.68) and TDS (X2 2221.00) concentrations, phytoplankton(X2 1684.6) and zooplankton(X2 42.17) densities.

The Analysis of Variance (F- values) of physical, chemical and biological parameters from S1 to S5 study stations of River Cauvery are presented in Table 4. The parameters which are significant at 5% level 'between' stations are turbidity, pH, nitrate, salinity, ammonia, DO, BOD, COD, TDS, phytoplankton and zooplankton. Whereas the factors which are significant at 5% level 'within' the stations are temperature, turbidity, EC, pH, carbonate, bicarbonate, nitrate, phosphate, silicate, salinity, chloride, sulphate, magnesium, sodium, potassium, ammonia, DO, BOD, COD, phytoplankton and zooplankton.

The models produced by different statistical analysis have shown that the limnological variables such as Temperature, Turbidity, pH, Bicarbonate, Nitrate, Phosphate, Salinity, Chloride, Sulphate, Ammonia, DO, BOD, COD and TDS were the prime factors that determined the quality of water in all five different stations. Also from the foregoing discussion, it is clear that the physico-chemical characteristics of water largely determined the faunal life of these five study stations of River Cauvery. In conclusion, this study suggests that the parameters that influenced habitat quality (such as turbidity, pH, DO, conductivity, BOD, COD, solids, chloride and ammonia), nutrient status and planktonic resources were significant in determining the planktonic population in these study stations.

FIGURE 1: THE MAP OF STUDY AREA

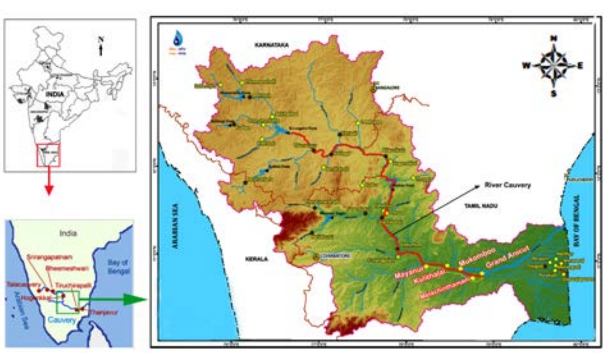


Chart 1: The Dendrogram analysis showing the similarities of the physical, chemical and biological parameters of Mayanur (S1), Kulithalai (S2), Mukkombu (S3), Melachinthamani (S4) and Grand Anicut (S5) stations of River Cauvery during monsoon.

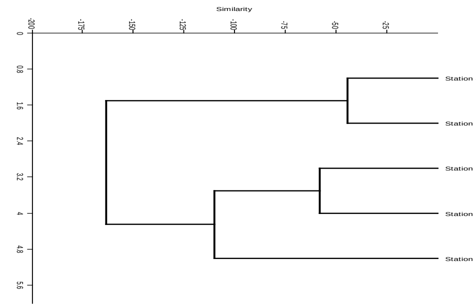


Chart 2: The Dendrogram analysis showing the similarities of the physical, chemical and biological parameters of Mayanur (S1), Kulithalai (S2), Mukkombu (S3), Melachinthamani (S4) and Grand Anicut (S5) stations of River Cauvery during postmonsoon.

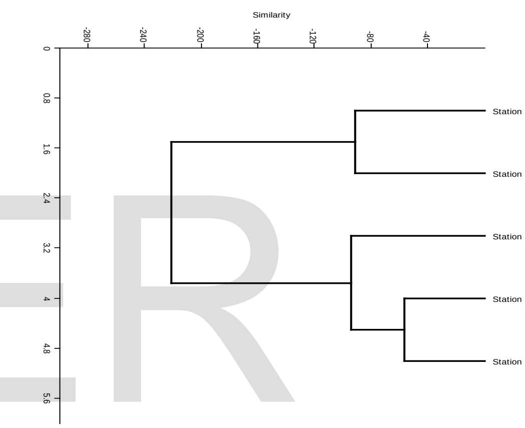
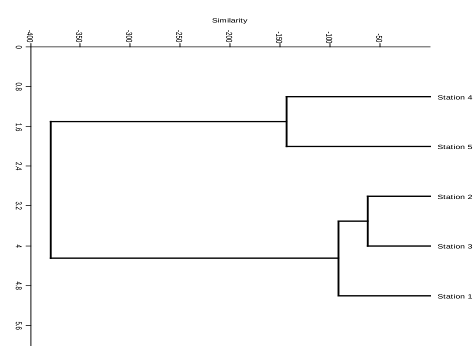


Chart 3: The Dendrogram analysis showing the similarities of the physical, chemical and biological parameters of Mayanur (S1), Kulithalai (S2), Mukkombu (S3), Melachinthamani (S4) and Grand Anicut (S5) stations of River Cauvery during premonsoon.



4. CONCLUSION

In conclusion, this study suggests that the parameters that influenced habitat quality (such as turbidity, pH, DO, conductivity, BOD, COD, solids, chloride and ammonia), nutrient status and planktonic resources were significant in determining the planktonic population in these study stations.

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Table 1: Variations in the physical, chemical and biological parameters of sampling stations during monsoon (n=4).

Parameter	Unit	S1		S2		S3		S4		S5	
		Mean	± S.E.	Mean	± S.E.	Mean	± S.E.	Mean	± S.E.	Mean	± S.E.
Water Temp	°C	21.38	1.03	22.13	0.92	22.38	1.40	24.00	1.08	23.75	1.11
Turbidity	NTU	7.25	0.64	7.50	0.58	8.98	0.58	13.73	1.38	13.00	0.63
EC	ds/m	0.53	0.03	0.61	0.09	0.52	0.04	0.61	0.01	0.65	0.03
pH		7.05	0.10	7.07	0.13	7.31	0.04	7.50	0.09	7.63	0.06
Carbonate	mg/lit	15.83	4.73	12.23	1.21	14.85	2.77	16.13	1.97	15.60	1.36
Bicarbonate	mg/lit	181.52	5.78	213.40	28.78	192.20	1.76	222.71	1.76	228.81	3.94
Nitrate	mg/lit	4.00	2.30	3.83	2.11	4.32	2.59	4.26	2.25	5.14	2.82
Phosphate	mg/lit	37.43	27.53	39.96	28.37	47.64	34.18	49.38	36.91	50.23	36.60
Silicate	mg/lit	1.66	0.13	1.94	0.17	2.28	0.38	4.48	1.92	4.46	1.75
Salinity	mg/lit	159.25	8.20	186.00	4.20	225.00	15.67	237.50	24.87	255.00	33.29
Chloride	mg/lit	124.08	27.99	157.76	44.13	140.04	24.28	143.58	31.09	180.81	31.38
Sulphate	mg/lit	35.79	9.12	32.42	14.98	38.43	17.09	36.63	18.59	48.03	19.51
Magnesium	mg/lit	12.15	1.72	16.71	3.95	14.13	1.74	16.71	3.76	20.51	5.23
Sodium	mg/lit	46.54	7.64	52.57	9.82	55.15	8.44	58.60	10.47	60.90	10.38
Potassium	mg/lit	9.29	3.74	9.97	3.33	9.19	2.44	17.40	4.94	21.41	5.92
Calcium	mg/lit	43.09	2.65	45.09	3.71	39.33	4.43	38.08	4.33	41.08	1.92
Ammonia	mg/lit	0.35	0.13	0.36	0.12	0.48	0.17	11.10	3.61	7.85	1.79
DO	mg/lit	9.13	0.14	8.98	0.22	7.70	0.37	4.97	0.28	5.65	0.12
BOD	mg/lit	0.49	0.08	0.54	0.09	0.56	0.01	0.78	0.05	0.62	0.06
COD	mg/lit	19.70	3.98	22.57	4.51	25.07	2.45	33.67	3.12	28.66	3.36
TDS	mg/lit	287.50	41.31	362.75	6.52	393.75	6.25	495.00	39.42	488.75	37.33
Phytoplankton	nos/lit	382.75	40.89	341.75	52.58	496.50	43.80	112.00	10.80	276.00	38.90
Zooplankton	nos/lit	42.25	4.48	33.25	3.68	50.25	2.17	10.75	2.56	19.00	2.74

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Table 2: Variations in the physical, chemical and biological parameters of sampling stations during postmonsoon (n=4).

Parameter	Unit	S1		S2		S3		S4		S5	
		Mean	± S.E.	Mean	± S.E.	Mean	± S.E.	Mean	± S.E.	Mean	± S.E.
Water Temp	°C	26.00	1.08	26.75	1.65	27.13	1.64	27.25	1.25	28.00	1.73
Turbidity	NTU	6.08	0.21	6.18	0.15	6.93	0.29	7.48	0.21	9.10	0.50
EC	ds/m	0.56	0.07	0.65	0.02	0.65	0.02	0.74	0.03	0.83	0.02
pH		7.37	0.06	7.95	0.23	7.79	0.17	8.11	0.11	8.21	0.22
Carbonate	mg/lit	9.83	0.83	10.80	1.21	16.28	1.64	16.80	1.21	14.85	3.07
Bicarbonate	mg/lit	262.37	28.51	259.32	23.17	241.01	24.47	282.20	22.47	335.59	20.54
Nitrate	mg/lit	4.39	1.91	4.72	1.51	5.41	2.05	6.11	2.04	7.70	2.44
Phosphate	mg/lit	6.53	0.86	49.71	41.66	44.16	27.48	76.51	31.69	51.62	20.29
Silicate	mg/lit	1.95	0.08	1.87	0.11	2.07	0.11	5.82	1.98	4.23	0.39
Salinity	mg/lit	187.75	19.67	215.75	20.36	229.25	11.93	378.75	49.03	335.25	35.11
Chloride	mg/lit	161.31	13.69	157.76	4.46	161.31	8.86	176.02	13.35	168.40	13.38
Sulphate	mg/lit	9.13	0.65	15.25	2.62	10.21	3.16	16.69	1.32	18.61	1.80
Magnesium	mg/lit	20.96	5.98	22.18	3.79	21.57	2.60	24.61	5.58	27.98	4.88
Sodium	mg/lit	65.72	1.56	66.70	4.05	68.83	0.95	74.69	5.51	85.66	4.76
Potassium	mg/lit	10.95	0.48	10.66	0.49	10.95	0.28	12.41	0.46	15.25	0.58
Calcium	mg/lit	34.42	2.08	38.83	4.51	39.83	5.49	49.60	5.13	47.65	3.76
Ammonia	mg/lit	1.19	0.42	0.88	0.39	2.16	1.62	25.51	4.59	17.39	4.36
DO	mg/lit	8.30	0.34	8.53	0.15	7.78	0.20	2.86	0.93	4.17	0.53
BOD	mg/lit	0.45	0.03	0.51	0.05	0.67	0.11	1.36	0.34	0.86	0.15
COD	mg/lit	21.85	2.70	24.36	1.85	31.52	3.36	44.05	4.35	35.46	2.71
TDS	mg/lit	255.00	27.23	276.25	22.30	348.75	13.90	460.00	7.36	408.75	10.48
Phytoplankton	nos/lit	88.00	7.70	98.50	7.77	94.00	11.47	47.00	6.98	125.25	14.02
Zooplankton	nos/lit	39.00	6.42	39.75	6.29	34.25	3.57	5.25	0.85	15.75	3.68

Table 3: Variations in the physical, chemical and biological parameters of sampling stations during premonsoon (n=4).

Parameter	Unit	S1		S2		S3		S4		S5	
		Mean	± S.E.	Mean	± S.E.	Mean	± S.E.	Mean	± S.E.	Mean	± S.E.
Water Temp	°C	28.00	1.29	28.50	0.96	30.00	1.15	29.75	0.95	30.25	0.63
Turbidity	NTU	4.88	0.09	4.20	0.80	5.45	0.09	14.00	2.65	15.58	2.99
EC	ds/m	0.56	0.00	0.68	0.07	0.70	0.11	0.92	0.26	0.90	0.16
pH		7.30	0.09	7.45	0.09	7.70	0.09	7.98	0.11	8.05	0.05
Carbonate	mg/lit	9.60	0.81	12.75	1.32	12.38	0.94	15.00	1.22	15.38	0.94
Bicarbonate	mg/lit	192.20	1.76	239.48	20.29	260.23	53.01	252.91	9.97	343.21	36.72
Nitrate	mg/lit	2.08	0.12	2.49	0.36	2.98	0.36	3.43	0.34	5.35	0.81
Phosphate	mg/lit	4.18	0.64	8.75	0.93	10.70	0.74	19.80	4.76	25.90	1.17
Silicate	mg/lit	1.48	0.16	1.48	0.19	1.98	0.22	3.43	0.68	3.95	0.46
Salinity	mg/lit	182.25	22.61	209.00	17.18	224.00	25.43	324.00	56.70	340.50	43.44
Chloride	mg/lit	145.36	8.44	180.81	29.59	168.40	5.32	167.16	13.20	207.39	21.73
Sulphate	mg/lit	8.29	1.32	8.65	1.30	10.21	3.59	13.81	3.45	17.41	3.00
Magnesium	mg/lit	10.33	1.75	15.19	4.61	15.19	0.78	20.05	3.23	27.07	2.63
Sodium	mg/lit	48.26	3.11	60.04	3.20	69.52	8.67	67.22	4.91	79.28	5.67
Potassium	mg/lit	9.39	0.70	10.07	0.19	11.54	1.07	11.44	0.37	15.54	2.17
Calcium	mg/lit	28.06	5.96	32.06	5.49	34.57	3.60	49.10	4.37	68.13	14.82
Ammonia	mg/lit	0.13	0.03	0.65	0.31	2.98	2.34	27.50	3.57	26.50	3.20
DO	mg/lit	7.90	0.30	7.75	0.21	6.46	0.75	2.60	0.40	3.89	0.37
BOD	mg/lit	0.28	0.05	0.42	0.06	1.18	0.16	1.47	0.07	1.18	0.07
COD	mg/lit	10.03	1.17	11.46	1.76	20.06	0.83	40.48	4.58	31.52	1.65
TDS	mg/lit	196.25	19.51	216.25	23.22	270.00	28.28	521.25	72.98	621.25	60.08
Phytoplankton	nos/lit	465.50	37.37	360.25	26.23	397.75	50.63	64.25	6.30	184.75	33.68
Zooplankton	nos/lit	61.50	6.61	53.50	4.99	34.25	4.71	12.50	0.96	20.75	1.49

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Table 4: Analysis of Variance (F- values) of physical, chemical and biological parameters from S1 to S5 study stations of River Cauvery during the year 2012-2013.

Parameter	Variance	SS	df	MS	F-cal	F-crit 5% level
Water Temp	Between	38.70	4.00	9.68	2.36	2.52
	Within	690.50	11.00	345.25	84.21	1.92
Turbidity	Between	493.00	4.00	123.25	3.09	2.52
	Within	178.40	11.00	89.20	2.24	1.92
EC	Between	0.48	4.00	0.12	1.02	2.52
	Within	0.98	11.00	0.49	4.14	1.92
pH	Between	4.00	4.00	1.00	4.21	2.52
	Within	4.70	11.00	2.35	9.89	1.92
Carbonate	Between	181.00	4.00	45.25	0.71	2.52
	Within	341.00	11.00	170.50	2.67	1.92
Bicarbonate	Between	56182.00	4.00	14045.50	1.32	2.52
	Within	85370.00	11.00	42685.00	4.01	1.92
Nitrate	Between	50.20	4.00	12.55	3.37	2.52
	Within	645.00	11.00	322.50	86.58	1.92
Phosphate	Between	7275.00	4.00	1818.75	0.59	2.52
	Within	105565.00	11.00	52782.50	17.12	1.92
Silicate	Between	95.00	4.00	23.75	2.16	2.52
	Within	67.00	11.00	33.50	3.05	1.92
Salinity	Between	188529.00	4.00	47132.25	4.87	2.52
	Within	143616.00	11.00	71808.00	7.41	1.92
Chloride	Between	11184.00	4.00	2796.00	0.82	2.52
	Within	74449.00	11.00	37224.50	10.88	1.92
Sulphate	Between	819.00	4.00	204.75	0.57	2.52
	Within	22655.00	11.00	11327.50	31.30	1.92
Magnesium	Between	790.00	4.00	197.50	1.86	2.52
	Within	2513.00	11.00	1256.50	11.85	1.92
Sodium	Between	3163.00	4.00	790.75	2.02	2.52
	Within	8544.00	11.00	4272.00	10.91	1.92
Potassium	Between	495.00	4.00	123.75	1.11	2.52
	Within	482.00	11.00	241.00	2.16	1.92
Calcium	Between	2316.00	4.00	579.00	0.68	2.52
	Within	1708.00	11.00	854.00	1.01	1.92
Ammonia	Between	4932.00	4.00	1233.00	7.82	2.52
	Within	1147.00	11.00	573.50	3.64	1.92
DO	Between	252.00	4.00	63.00	21.45	2.52
	Within	38.70	11.00	19.35	6.59	1.92
BOD	Between	4.90	4.00	1.23	2.97	2.52
	Within	2.10	11.00	1.05	2.55	1.92
COD	Between	3986.00	4.00	996.50	5.18	2.52
	Within	1434.00	11.00	717.00	3.73	1.92
TDS	Between	683887.00	4.00	170971.75	5.06	2.52
	Within	125209.00	11.00	62604.50	1.85	1.92
Phytoplankton	Between	518739.00	4.00	129684.75	2.75	2.52
	Within	687144.00	11.00	343572.00	7.28	1.92
Zooplankton	Between	13089.00	4.00	3272.25	7.03	2.52
	Within	2213.00	11.00	1106.50	2.38	1.92