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Study of Cauvery River Water Pollution and its Impact on Socio-economic Status around KRS Dam, Karnataka, India

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Abstract

It is important to make an assessment of quality for the best use of water resources distribution and utilization. It becomes necessary to have an idea of the present and future demand of water for various use e.g. irrigation, industries, public health and river conservation. In the present study an attempt has been made to evaluate water quality of Cauvery River around Krishna Raja Sagar (KRS) Dam for a period of one year. In order to evaluate the quality of Cauvery River, water samples were collected from different locations in various seasons during 2011 -12. Analysis of sediment reveals that the Cauvery River water is contaminated by certain Heavy metals with organic load. Concentrations of all metals increase in the downstream. Concentration of Heavy metals in sediments was in the order of Fe>Ni>Zn>Pb>Cu>Cr. Cr concentration exceeded the upper limit of standards. Increase of metal concentration indicate an increase in the pollution load due to application of fertilizers in the agricultural fields, ashes generated by the agricultural land and industries, industrial effluents and anthropogenic activities and discharge of wastes to the River. It was observed that the impact of human activity was severe on most of the parameters. It was observed that the main cause of deterioration in water quality was due to the lack of proper sanitation, unprotected river sites and high anthropogenic activities.

Keyword: Cauvery River; KRS Dam; Water and sediment Quality; socio-economic status

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1 Introduction

Water has an intrinsic value and it is important to make it available to various uses. In addition, due to increasing growth of urbanization and industrialization, it has been deteriorating the water quality of the reservoir resources as discharge of sewage and municipal wastes into water bodies have negative impacts. In a broad term, water quality has always refers to the physical, biological, and chemical status of the water body of the particular period. Morris and Fan (1998) noted that impoundment of water in the reservoirs changes the concentration and the relation between discharge and concentration for many water-quality constituents. Human activities such as industrial and municipal effluents, land fill leaching, non point source such as run-off and atmospheric deposition have increased the flux of heavy metals in rivers (Salonons and Forstner, 1984; Tessier and Hare, 1996; Klavins *et al*., 2000).

Heavy metal gain access into aquatic bodies and soil through the natural geochemical processes and the discharge of treated, untreated wastewater into river water. The metal toxicity, mobility and bioavailability depend on speciation pattern rather than the total metal concentration.

Chemical leaching of bedrocks, water drainage basins and runoff from river banks are the primary natural sources of heavy metals accumulation. Compare to the natural sources of heavy metal pollution, anthropogenic discharges such as urban discharges and industrial waste water, combustion of fossil fuels, mining and smelting operations, processing and manufacturing industries, waste disposal including dumping, etc., are considered as major polluting sources (Klavins et *al*., 2000; Pardo *et al*., 1990; Yu *et al.* 2001; Upadhyay *et al*., 2006). Sediments are mixture of several components of mineral species as well as organic debris, represent as an ultimate sink for heavy metals discharged into environment (Luoma and Bryan 1981; Bettinetti *et al*., 2003; Abbas *et al*., 2009). Sediment plays a major role in identifying the pollution load of the river systems by heavy metals (Lietz and Galling1989; Huang *et al*. 1994; Lapaquellerie *et al*., 1995; Wardas *et al.*, 1996).

KRS dam is located across Cauvery River in Mandya District, Karnataka State, India (Figure 1). Similar to other resources, this river is also under environmental stress due to siltation, human encroachment, high macrophytic population and sewage input from various sources. There are number of drains discharging loads of sewage, domestic waste water and industrial effluents directly into the river. This Dam has influence of various anthropogenic activities and rapid pace of industrialization in the catchment areas upstream. In this manner, the river has received silt containing fertilizers, insecticides, pesticides which are used for agriculture upstream. There are many research studies about effluents of industrial spills cause serious problems of water pollution, especially the impact of distillery effluents and the ecology of Cauvery River was investigated. (Paramasivam & Sreenivasam, 1981).

The Cauvery river act as a source of drinking water, fishing and other domestic uses for the inhabitants. It is of immense importance that a periodical research and timely monitoring of the river water and sediments around KRS dam are very much needed. In the present study, water and sediment quality analysis of Cauvery River around KRS Dam has been carried out in order to determine the sources responsible for deterioration of water quality.

2 Materials and Methods

Cauvery River originates at Talakavery in the Western Ghats in the State of Karnataka and flows generally south and east through Karnataka. The river has many tributaries. Before the dam, there is confluence of three main rivers namely, Cauvery, Hemavathi and Laxmanatheertha.

The study area (Figure 1) is situated at elevation about 600 meters above mean sea level (MSL) and lies between latitude 12°25′30"N and longitudes 76°34′34" W. River traverses through south of Karnataka and Tamil Nadu and its length is about 750 Km. It serves as a major source of domestic, irrigation and industrial water supply. Subsequently, it receives untreated domestic waste water. This research work is focused on the KRS dam and it's downstream. The major land uses in the basin are agriculture (36%) and forests (38%), with the remaining areas being developed areas, wetlands. Samples were collected in different seasons, monsoon, post monsoon and pre monsoon. The sampling locations are spread throughout the study area and divided into as upstream of KRS Dam (two sampling station) and in the downstream (eight sampling stations) were selected. Sampling locations are given in Figure 2 and Table 1.

Water samples were collected as per standard method of sampling techniques. Some of the sensitive parameters such as temperature, pH and electrical conductivity, were determined directly in the field and for DO the samples were preserved for the subsequent laboratory analyses like electrical conductivity, pH, turbidity, BOD, total alkalinity, total solids, TDS, nitrate, phosphate and sulphate, These were analyzed within twenty four hours and subsequently total hardness, calcium, magnesium, sodium, potassium, were analyzed. The water analyses were carried out as per the methods described by APHA (2006).

2.1 Socio-Economic Assessment

Fishing communities and major markets of fishes are spread along the Cauvery river basin. However, the number of households within the communities varies. Small-scale fishermen are more vulnerable and are forced to migrate across the basin. Data were collected from both the primary and secondary sources. Primary data were collected from key informants—direct and indirect dependents. Household survey of fishermen households, labourers hired by fishermen (direct dependents) and middleman—traders (indirect dependents) were carried out. Secondary data sources include State Fisheries Department, and Karnataka State Fisheries Development Corporation and Fisheries co-operative societies. The study was conducted in Cauvery river basin from January 2011 to June 2011. The data were gathered through household survey. The survey was based on two criteria like water sources and socio-economic status. Interviews also carried out with traders. The sampling ensured representation of informants from different fishing sources like Reservoirs. In order to understand livelihoods, both men and women were interviewed due to women and men together contributed to the household economy through fishing.

3 Results

3.1 Water Quality Parameters

The results are summarized in Tables 2- 4. All parameters are based on changeable water quality, like anthropogenic activities and natural phenomena. Therefore, DO, and BOD are determined to check the organic and inorganic pollution in water. In order to determine the accuracy of analysis of all parameters in each sample station, the total anions and cations are calculated based on the principle of electro-neutrality (Table 5).

The water temperature of a river is very important, as many of the physical, biological, and chemical characteristics of the river are directly affected by temperature. Most waterborne animal and plant life survives within a certain range of water temperatures, and few of them can tolerate extreme changes in this parameter. The water temperature is checked with a thermometer at the sample site Average of water temperature in summer was highest, 29.6 ^{o}C during April and 26 ^{o}C during August.

pH is ranged from a minimum of 6.82 at R_2 in (downstream) in monsoon, to a maximum 8.62 at D_1 station (upstream) in Pre monsoon. Higher pH always favors the fish production in reservoir. As per the WHO standards pH for aquatic life is in the range of 6.5-9.0 and for drinking purpose the standard is 6.5-8.5. The pH observed in the present study is similar with Kataria, et, al (1996).

Electrical conductivity (EC) is used as a basic index to select the suitability of water for agricultural purposes.. In the present study EC was minimum, 83 μmhos/cm at R_1 and maximum, (290 μmhos/cm) at $R_{8.}$

Turbidity is caused due to presence of suspended matter, clay silt, colloidal organic particles, plankton and other microscopic organisms. In the present study turbidity found to be a minimum of 1 NTU at R_1 and to a maximum of 6.72 NTU in downstream in monsoon; the minimum of 5.6 NTU at $R_{5,}$ to a maximum 15.2 NTU at R_3 station in post monsoon, and the minimum of 1 NTU at $R_{2,}$ to a maximum 4.5 NTU at D_1 station (upstream) in pre monsoon.

Total Dissolved solids (TDS) is a measure of the solid materials dissolved in the river water. This includes salts, some organic materials, and a wide range of other materials from nutrients to toxic materials. In the present study TDS ranged from minimum of 25 mg/l at R_1 to a maximum of 100 mg/l in R_7 during monsoon; and the minimum of 50 mg/l at $D_{2,}$ to a maximum 320 mg/l at $R_{6,}$ it ranged R_7 stations during post monsoon, from a minimum of 100 mg/l at $D_{1,}$ to a maximum 220 mg/l at R_6 station in pre monsoon.

Alkalinity in this study ranged from 60-180 mg/l which was attributed to bicarbonate. Alkalinity was lowest during monsoon and during other times it was approximately constant and more than140 mg/l.

Total hardness is determined as $CaCO_3$ mg/l. Mainly TH causes from cations of calcium, magnesium, iron and strontium. In the present study, minimum of 34 mg/l at R_8 station to a maximum of 44 mg/l at D_1 during monsoon; the minimum of 80 mg/l at $D_{2,}$ to a maximum 102 mg/l at D_1 stations during post monsoon, and the minimum of 116 mg/l at $D_{1,}$ R_3 to a maximum 160 mg/l at R_8 station in pre monsoon. Average hardness was lowest (37 mg/l) in monsoon.

Chloride level of water indicates the pollution degrading of water (Hasalam S. M., 1991). It is found in the form of Na^+, K^+ and Ca^{++} salts. Higher concentration of chloride is hazardous to human consumption and creates health problems. Desirable limit of chloride by ISI (1991) for drinking purpose is 250 mg/l. In the present study it varied from 26.58

mg/l at R_5 station to a maximum of 51.4 mg/l in D_2 during monsoon, the minimum of 27 mg/l at $R_{8,}$ to a maximum 56.8 mg/l at D_1 stations during post monsoon, and the minimum of 56.8 mg/l at R_1 to a maximum 124.96 mg/l at R_3 station in pre monsoon.

Phosphate (PO_4^{3-}) is readily taken by phytoplankton and it is necessary for plant and animal growth. It can be present in water in many forms. Higher value of phosphate in reservoir water is due to agricultural wastes and use of fertilizers. It may enter into surface water from man-generated wastes and run-off. In this study phosphate was noted a minimum of 0.07 mg/l at R_6 station to a maximum of 0.184 mg/l at D_2 during monsoon; the minimum of 0.02 mg/l at $R_{5,}$ to a maximum 0.04 mg/l at most stations during post monsoon, and the minimum of 0.0048mg/l at R_5 to a maximum 0.0097mg/l at R_8 station in pre monsoon.

Nitrate is added by common sources such as fertilizers, animal wastes, septic tanks, municipal sewage treatment systems, and decaying plant debris. During monsoon, soil loss contributes to the increase of nitrogen concentration in river water, (Jingsheng Chen et, al, 2000). In the present study nitrate ranged from a minimum of 0.037 mg/l at R_1 station to a maximum of 4.04 mg/l at D_2 during monsoon; and the minimum of 0.02 mg/l at $R_{5,}$ to a *maximum* of *0.04* mg/l at most stations during post monsoon, and the minimum of 0.0035 mg/l at R_1 to a maximum of 0.088 mg/l at D_2 station in pre monsoon.

The Dissolved Oxygen (DO) test measures the amount of life-sustaining oxygen dissolved in the water. This oxygen is available for fish, invertebrates, and all other aquatic animals. Most aquatic plants and animals need oxygen to survive. Depletion of DO in water is due to high temperature or added materials would increase microbial activity, (Kataria,et, al.,1996). In the present study, it varied from 3.8 mg/l at R_3 station to a maximum of 6.3mg/l at R_8 during monsoon; and the minimum of 2.42mg/l at $R_{5,}$ to a *maximum* 3.6 mg/l at D_1, R_1, R_2 stations during post monsoon, and the minimum of 6.1mg/l at R_3 to a maximum 11.7mg/l at R_8 station in pre monsoon.

The Biochemical Oxygen Demand (BOD) is a measure of the amount of biological pollutions. Naturally, Bacteria utilize organic matter in their respiration and remove oxygen from the water. Here, BOD varied from 0.3 mg/l at R_1, $R_{2,}$ R_3 and R_4 stations to a maximum of 1.05 mg/l in R_7, R_8 during monsoon; and the minimum of 1 mg/l at all station in downstream, to a *maximum* 1.5 mg/l at upstream stations during post monsoon, and the minimum of 1.8 mg/l at D_1 to a maximum 3.5 mg/l at R_3 station in pre monsoon.

3.2 Sediment Quality Analysis

The variation of pH during the three seasons is shown in Figure 2**.** The pH analysis of sediment samples during Pre-monsoon varies from 6.9-8.9, during Monsoon 6.4-8.5, and during Post monsoon it ranges between 6.9-8.1. From the result obtained the pH of the river sediment shows slightly turning into alkaline.

pH is having negative correlation among all the parameters except Calcium and Magnesium. Electrical conductivity (EC) is a measure of ions present in the sample. The conductivity of a solution increases with the increases amount of ions.

Electrical conductivity indicates the presence of soluble salts in the sediments. In the present work, EC of sediment samples shows a range 65-85dS/cm during pre monsoon, 71-88 dS/cm in Monsoon and for Post Monsoon it ranges from 63.4-86 dS/cm. Due to the more concentration of dissolved solids in the river sediments, EC values goes on increasing. Electrical Conductivity values of sediment samples were found to be in unsafe range. This indicates the release of wastes into the river through anthropogenic activities.

EC variations for Pre-monsoon, Monsoon and Post-monsoon seasons are shown in Figure 4.

Sodium is a component of Sodium Chloride (NaCl) and very important compound found everywhere in the living environment. Sodium is a compound of many foodstuffs for instance of common salt. It is necessary for humans to maintain the balance of the physical fluids system. The Sodium contents of Cauvery River sediments ranges from 11.10-12.95 mg/kg during Pre-monsoon, 7.13-8.42 mg/kg in Monsoon and 9.10-11.32 mg/kg for Post-monsoon. The correlation between Sodium and Magnesium is positive and negative with all the remaining parameters. The variations in Sodium concentrations are shown in Figure 5.

Potassium is not an integral part of any major plant component but it plays a key role in a vast array of physiological process vital to plant growth from protein synthesis to maintenance of plant and water balance. It ranges between 1.38-7.54 mg/kg during Pre-monsoon, 1.10-2.65 mg/kg during Monsoon and 1.38-2.68 mg/kg during Post monsoon. Figure 6 represents the variations in potassium concentration in sediments. High concentration of available Potassium is due to the weathering of minerals and release potassium ions, these ions are adsorbed onto the cation exchange sites. The lower concentration of available Potassium at station P_2 may be due to less mineral weathering in the river sediment.

Calcium promotes the activity of soil bacteria concerned with the fixation of the free nitrogen or the formation of nitrates from organic forms of nitrogen. Calcium deficiency is commonly associated with the acidity, which will lead to the accumulation of toxic salts of iron, aluminium and manganese in the sediments. Magnesium is essential for all organisms and is not toxic under normal circumstances. Deficiencies of magnesium are much more common than problems concerned with toxicity. Magnesium is a key plant nutrient and is essential for photosynthesis in plants, where it forms the active site in the chlorophyll enzyme molecule.

In the present study the concentration of calcium in the sediments ranges from 4.93-6.78 mg/kg during Pre-monsoon, 2.45-4.125 mg/kg during Monsoon and 3.15-4.843 mg/kg during Post- Monsoon. Magnesium values varied between 0.69-1.42 mg/kg during Pre-Monsoon, 0.64-1.21 mg/kg during Monsoon and0.69-1.42 mg/kg during Post-Monsoon. In the statistical analysis Calcium and Magnesium content are positively correlated with the organic carbon, pH, EC and Sodium. The variations in concentrations of Calcium and Magnesium are shown in Figure 7 and Figure 8 respectively.

The organic carbon represents the organic matter in the sediment. The dead organic matter gets deposited in the bottom and undergoes chemical and bacterial decomposition. Estimation of organic carbon can serve as an important tool in determining the status of food available to the benthic fauna and also indicates the extent to which the bottom sediment is fertile for the subsistence of benthic fauna. The organic carbon also exerts an influence on the available phosphorus level in the soil. Jhingran (1991) described that, the carbon is the common constituent of all organic matter and is a measure of bacterial activity. The % Organic carbon of the sediments in the Cauvery River ranged from 0.2-0.93 % during Pre-Monsoon, 0.19-0.63 % Monsoon and 0.20-0.93 % during Post Monsoon. The results of organic carbon of study area, shows a highest range of 0.93% in Pre-Monsoon season. From the organic carbon result the sediment quality of the Cauvery River has increases their fertility due to the influx of the contaminants from anthropogenic activities and discharge of domestic wastes directly to the river. Graphical representation of Percentage of Organic carbon is shown in Figure 9.

Nitrate is a necessary primary macro nutrient for plants that stimulates plant growth and is usually added as a fertilizer but can also be found in sediments as nitrate, ammonia, organic nitrogen or nitrite. Nitrate is a useful form of nitrogen because it is biologically available to plants and is therefore a valuable fertilizer. However, excessive levels of nitrate in soils and sediments can produce negative health impacts on humans and animals. The Nitrate content in sediments of the Cauvery River ranged from 2.8-3.3 mg/kg during Pre- Monsoon, 1.0-2.9 mg/kg during Monsoon and 1.9-4.6 mg/kg during Post-Monsoon. Increase of Nitrate concentration indicates the pollution level of the river. Increase of Nitrate level is due the domestic waste discharge into the river. The presence of significant quantities of Nitrates in sediment samples indicated that, the river water is getting polluted day to day due to discharging of industrial effluent along with the sewage and agricultural runoff to the river system. Contamination primarily occurs because many chemicals bind to organic or inorganic particles that eventually settle to the bottom of rivers and reservoirs. Once contaminants are bound to a particle surface into its interior matrix, they become less likely to be bio-transformed and desorption is usually very slow; therefore, sorbed contaminants will reside for long periods in the sediment. This is promoted largely by the very high surface area of these particles and the tendency for higher concentrations of organic matter in the fine particles that absorb organic contaminants. Variations in Nitrate concentrations are shown in Figure 10.

3.3 Socio-Economic Status

Local communities have observed negative impacts from the Cauvery River, when large amounts of water released from the KRS dam, causing massive downstream flooding. In the rainy season, floods caused by water releases from the dam, has damaged agricultural crops and flooded village’s property along the Cauvery river stretch. Communities present in the downstream have been impacted by water level fluctuations. Massive surges of water over 2 m high have caused large amounts of riverbank erosion. During the dry season activities like fishing has been severely disturbed since lesser quantity of water. However, local communities opined that the water quality problems originated with the entering of toxic elements river system. Irregular fluctuation of water level in the Cauvery River has seriously affected the vegetation, birds, reptiles and various aquatic life forms.

4 Figures and Tables

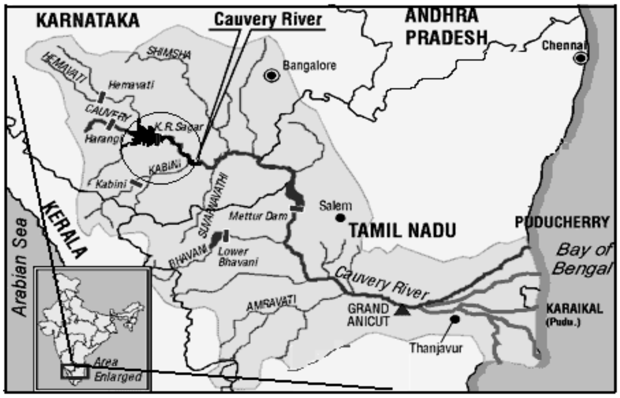

Figure 1: Map of Cauvery River basin in India

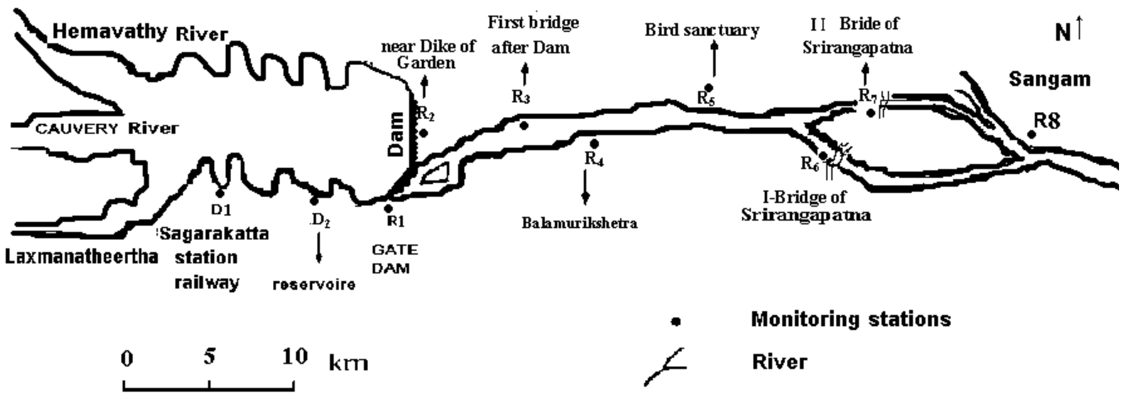

Figure 2: Map of sample location sites around K.R.S. dam of cauvery River Basin

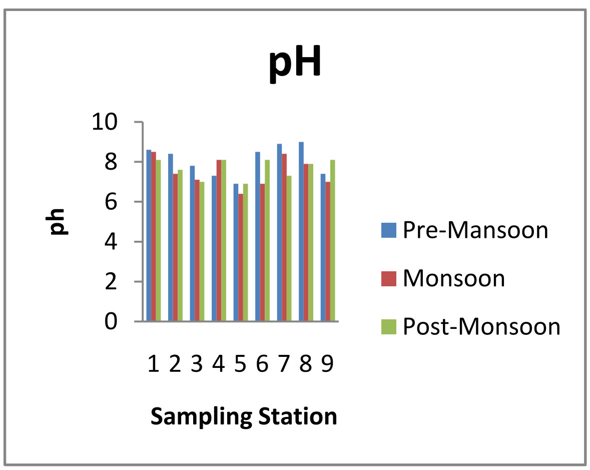

Figure 3: Variations in pH of Sediments

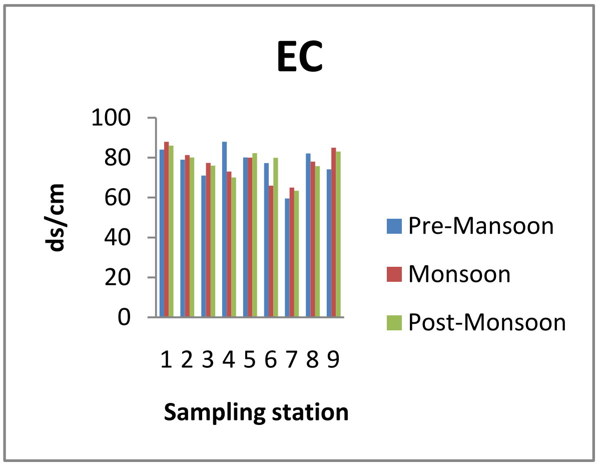

Figure 4: Variations of EC

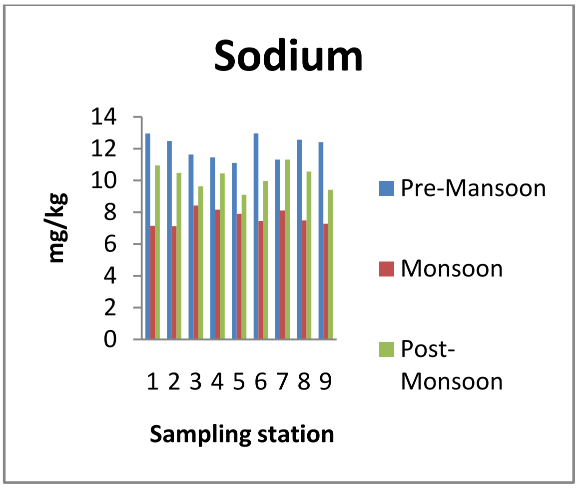

Figure 5: Variations of Sodium

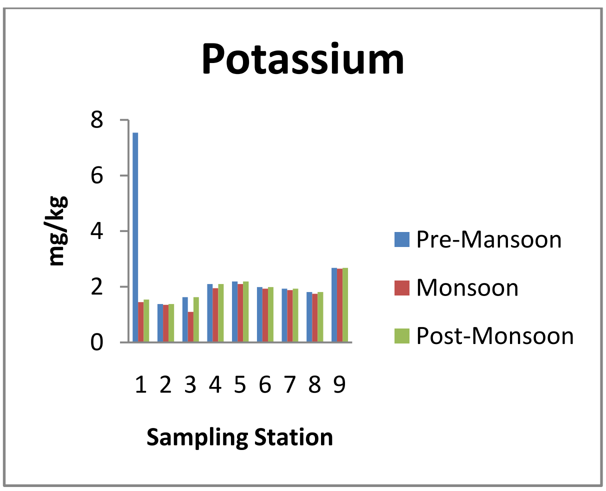

Figure 6: Variations of Potassium

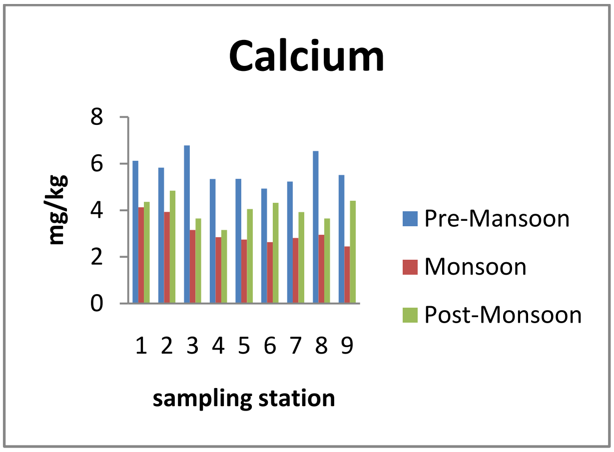

Figure 7: Variations of Calcium

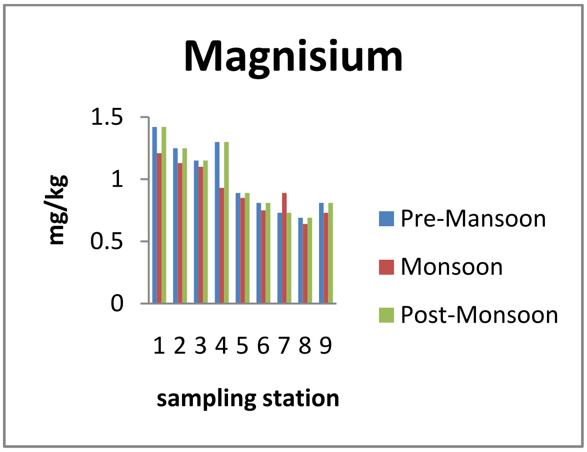

Figure 8: Variations of Magnesium

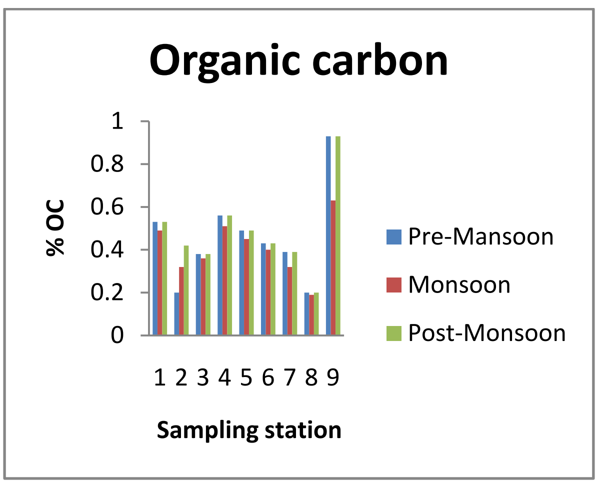

Figure 9: Variations of Organic Carbon

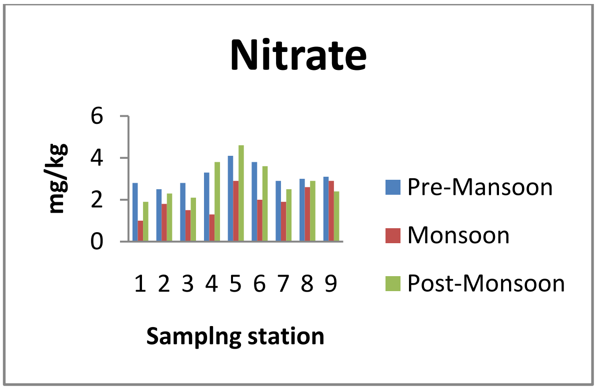

Figure 10: Variations of Nitrate

Table 1: Location of sampling stations

No	Station No.	Location
1.	**D_1**	**Upstream of dam** -North bank
2.	**D_2**	**Upstream of dam-** Chikkarahalli
3.	**R_1**	Downstream-KRS Dam
4.	**R_2**	Downstream- Balmuri
5.	**R_3**	Downstream- Yedmuri
6.	**R_4**	Downstream-Belagola
7.	**R_5**	Downstream-Pump house
8.	**R_6**	Downstream-Birds sanctuary
9.	**R_7**	Downstream-Temple
10.	**R_8**	Downstream-Nimishambha temple

Table 2: Physico-Chemical analysis of Upstream & Downstream CAUVERY River water of KRS Dam during pre monsoon

Number	Parameters	Stations									
		D_1	D_2	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
1	Turbidity	4.5	1.5	2	1	2.5	2	2	3	3	1
2	pH	8.62	8.5	7.61	7.48	8.05	7.81	7.61	7.51	8.12	8.15
3	DO	7.2	7	7.2	7	6.1	10.8	7.8	8.9	9.2	11.7
4	BOD	1.8	2.7	2.5	2.5	3.5	2.5	2.5	2.5	2.6	2.6
5	TS	310	260	320	360	340	350	360	370	380	340
6	NO_3^-	0.035	0.088	0.0035	0.047	0.047	0.0054	0.037	0.028	0.028	0.028
7	Cl^-	96.6	76.67	56.8	113.6	124.96	85.2	99.4	93.72	133.5	105.08
8	PO_4^{-3}	0.008	0.007	0.0089	0.0089	0.00778	0.0065	0.0048	0.0058	0.00778	0.0097
9	Alkalinity	129.7	121.1	138.4	138.4	103	147.05	155.7	164.35	155.7	155.7
10	TH	116	128	116	124	116	140	132	140	152	160
11	TDS	100	110	140	100	150	140	140	220	180	200
12	Ca^{+2}	25.7	17.62	22.42	28.83	25.7	24.03	32.06	25.7	33.64	38.5
13	Mg^{+2}	12.64	20.5	14.64	12.69	12.64	19.51	12.67	18.5	16.6	15.58
14	Na^+	80.7	78.7	54.6	41.6	168.5	147.5	159	152.5	163	231
15	K^+	3.5	4.4	2.5	1.6	4.4	4.6	5.6	5.6	6.7	1.4
16	HCO_3^-	129.7	121.1	138.4	138.4	173	147.05	155.7	164.35	155.7	155.7

17	SO_4^{-2}	0.5646	1.132	1.0607	1.15	1.205	0.4084	1.388	1.535	0.899	3.0952
Accuracy Calculation -	∑cations(meq)	5.920	6.100	4.760994	4.331	9.760	9.334	9.698	9.578	10.302	13.281
	∑anions(meq)	4.859	4.170	3.891	5.493	6.382	4.819	5.382	5.366	6.332	5.577
	percent difference %	0.098	0.187	0.100	-0.118	0.209	0.319	0.286	0.281	0.238	0.408

(All parameters are expressed in mg/l except pH, Turbidity)

Table 3: Physico-Chemical analysis of Upstream & Downstream CAUVERY River water of KRS Dam during post monsoon

Number	Parameters	Stations									
		D_1	D_2	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
1	Turbidity	8.4	7.2	7.2	9	15.2	11.2	5.6	8.8	9.6	21.2
2	pH	8.58	8.31	8.38	8.39	8.51	8.54	8.24	8.46	8.46	8.46
3	DO	3.2	3.6	3.6	3.6	3.02	2.57	2.42	2.99	2.99	2.49
4	BOD	1.5	1.5	1	1	1	1.5	1.5	1	1	1
5	TS	250	210	290	245	250	340	300	340	340	230
6	NO_3^-	0.04	0.04	0.03	0.03	0.04	0.03	0.02	0.04	0.04	0.04
7	Cl^-	56.8	42.6	34.1	3.4	34.1	34.1	34.1	39.8	39.8	27
8	PO_4^{-3}	0.04	0.04	0.03	0.03	0.04	0.03	0.02	0.04	0.04	0.04
9	Alkalinity	180	140	160	160	100	160	160	160	160	160
10	TH	102	80	84	84	84	84	84	84	84	84
11	TDS	190	50	270	205	200	300	230	320	320	162.5
12	Ca^{+2}	21.6	22.5	20.05	20.05	20.05	20.05	25.7	22.5	22.5	26.5
13	Mg^{+2}	7.3	3.9	7.3	7.3	7.3	7.3	5	5	5	8.3
14	Na^+	149.5	142.5	157	250	248.5	242.5	245.5	150.5	207	157
15	K^+	11.5	12.7	12	11.8	11.6	11.6	13.1	12.3	12.2	13.7
16	HCO_3^-	180	140	160	160	100	160	160	160	160	160
17	SO_4^{-2}	0.19	0.19	0.12	0.13	0.19	0.15	0.12	0.15	0.15	0.145
Accuracy Calculation -	∑cations(meq)	8.472	7.9636	8.733	12.77	12.701	12.440	12.702	8.391	10.845	9.181
	∑anions(meq)	4.556682	3.500	3.587	3.584	2.605	3.588	3.586	3.749	3.749	3.388
	percent difference %	0.300	0.389	0.417	0.561	0.659	0.552	0.559	0.382	0.486	0.460

(All parameters are expressed in mg/l except pH, Turbidity)

Table 4: Physico-Chemical analysis of Upstream & Downstream CAUVERY River water of KRS Dam during Monsoon

Number	Parameters	Stations									
		D_1	D_2	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
1	Turbidity	6.32	4.24	2.72	1	2.88	4.44	6.72	4.88	4.12	4.24
2	pH	7.38	7.46	7.18	6.82	7.15	7.2	7.5	7.1	7.4	7.23
3	DO	4.4	5.2	5.5	4.8	3.8	5.8	6.3	5.8	6.2	6.3
4	BOD	0.9	0.8	0.3	0.3	0.3	0.3	0.6	0.6	1.05	1.05
5	TS	125	100	50	50	100	100	100	100	125	100
6	NO_3^-	4.04	1.19	0.37	0.38	0.38	0.39	0.404	0.45	0.46	0.66
7	Cl^-	35.45	51.4	30.13	33.67	31.9	30.13	26.58	37.22	49.63	24.815
8	PO_4^{-3}	0.184	0.16	0.16	0.1	0.1	0.091	0.051	0.07	0.083	0.131
9	Alkalinity	60	60	60	60	60	60	60	60	60	60
10	TH	44	37	36	36	36	36	36	37	38	34
11	TDS	75	50	25	50	50	50	25	50	100	50
12	Ca^{+2}	8	7.5	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
13	Mg^{+2}	5.832	5.5	4.86	4.5	4.5	4.4	4.26	4.4	5.346	4.374
14	Na^+	26.6	12.8	11.3	14.7	11.2	11	15.2	11.4	13.1	11.7
15	K^+	6.4	4.2	3.5	4.3	3.2	3.1	3.5	3.3	3.4	3.2
16	HCO_3^-	60	60	60	60	60	60	60	60	60	60
17	SO_4^{-2}	2.4	2.8	3.6	0.4	0.4	0.91	0.68	1.52	2.72	2.08
Accuracy Calculation -	∑cations(meq)	2.199	1.490	1.300	1.438	1.258	1.2388	1.420	1.261	1.415	1.269
	∑anions(meq)	2.103	2.514	1.918	1.949	1.899	1.860	1.754	2.073	2.448	1.740
	percent difference %	0.022	-0.255	-0.192	-0.150	-0.203	-0.200	-0.105	-0.243	-0.267	-0.156

(All parameters are expressed in mg/l except pH, Turbidity)

Table 5: Physico-Chemical parameters of sediment samples during Monsoon

Sampling station	pH	EC (µs/cm)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	K (mg/kg)	%Organic carbon	Nitrate (mg/kg)
D_1	8.5	84	4.125	1.21	7.15	1.45	0.49	1.0
D_2	7.4	79	3.926	1.13	7.13	1.35	0.32	1.8
R_1	7.1	71	3.152	1.10	8.42	1.10	0.36	1.5
R_2	8.1	88	2.843	0.93	8.16	1.95	0.51	1.3
R_3	6.4	80.1	2.74	0.85	7.90	2.10	0.45	2.9
R_4	6.9	77.32	2.63	0.75	7.45	1.93	0.40	2.0
R_5	8.4	59.55	2.81	0.89	8.11	1.88	0.32	1.9
R_6	7.9	82.13	2.95	0.64	7.49	1.75	0.19	2.6
R_7	7	74.13	2.45	0.73	7.28	2.65	0.63	2.9

Table 6: Physico-Chemical parameters of sediment samples in Pre Monsoon

Sampling stations	pH	EC (µs/cm)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	K (mg/kg)	%Organic carbon	Nitrate (mg/kg)
P1	8.6	88	6.12	1.42	12.95	7.54	0.53	2.8
P2	8.4	81.3	5.83	1.25	12.48	1.38	0.2	2.5
P3	7.8	77.4	6.78	1.15	11.63	1.63	0.38	2.8
P4	7.3	73	5.34	1.3	11.45	2.10	0.56	3.3
P5	6.9	80	5.35	0.89	11.10	2.19	0.49	3.1
P6	8.5	66	4.93	0.81	12.96	1.99	0.43	3.8
P7	8.9	65	5.23	0.73	11.31	1.93	0.39	2.9
P8	9	78	6.54	0.69	12.56	1.81	0.20	3.0
P9	7.4	85	5.51	0.81	12.41	2.68	0.93	3.3

Table 7: Physico -Chemical parameters of sediment samples in Post Monsoon

Sampling stations	pH	EC (µs/cm)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	K (mg/kg)	%Organic carbon	Nitrate (mg/kg)
D_1	8.1	86	4.361	1.42	10.95	1.54	0.53	1.9
D_2	7.6	80.1	4.843	1.25	10.48	1.38	0.42	2.3
R_1	7	76	3.65	1.15	9.63	1.63	0.38	2.1
R_2	8.1	70.1	3.15	1.3	10.45	2.10	0.56	3.8
R_3	6.9	82.3	4.15	0.89	9.10	2.19	0.49	4.6
R_4	8.1	79.9	4.32	0.81	9.96	1.99	0.43	3.6
R_5	7.3	63.4	3.92	0.73	11.31	1.93	0.39	2.5
R_6	7.9	75.8	3.65	0.69	10.56	1.81	0.20	2.9
R_7	8.1	83.1	4.41	0.81	9.41	2.68	0.93	2.4

Table 8: Mean values of Physico-chemical parameters of sediment samples

Sampling stations	pH	EC (µs/cm)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	K (mg/kg)	%Organic carbon	Nitrate (mg/kg)
D_1	8.4	86	4.86	1.35	10.35	3.51	0.51	1.9
D_2	7.8	80.13	4.86	1.21	10.03	1.37	0.31	2.2
R_1	7.3	74.8	4.52	1.13	9.89	1.45	0.37	2.13
R_2	7.8	77.03	3.77	1.17	10.02	2.05	0.54	2.8
R_3	6.7	80.8	4.08	0.87	9.36	2.16	0.47	3.53
R_4	7.8	74.40	3.96	0.79	10.12	1.97	0.42	3.13
R_5	8.2	62.65	3.98	0.78	10.24	1.91	0.36	2.43
R_6	8.2	78.64	4.38	0.67	10.20	1.79	0.19	2.83
R_7	7.5	80.74	4.12	0.78	9.41	2.67	0.83	2.86

Table 9: Total Heavy metal Concentration in Cauvery river Sediments (mg/kg)

Sampling Stations	**Copper**	**Chromium**	**Lead**	**Zinc**	**Nickel**	**Iron**
D_1	5.1	3.0	34.3	25.6	32.8	3384
D_2	4.2	3.6	32.5	27.1	37.3	3876
R_1	4.5	2.9	40.2	30.9	40.8	4123
R_2	7.86	3.8	29.1	37.4	45.2	3693
R_3	8.3	4.8	30.5	23.4	36.7	3742
R_4	8.5	3.3	24.3	31.5	44.5	3816
R_5	9.4	4.1	37.6	40.3	33.4	4523
R_6	8.7	3.6	35.4	38.7	36.1	3415
R_7	9.8	3.9	38.7	41.2	39.8	3964

Table 10: Correlation matrix between Physico-Chemical parameters of Monsoon season

	pH	EC	Ca	Mg	Na	K	O.C	Nitrate
pH	1							
EC	-0.00142	1						
Ca	0.428547	0.27560	1					
Mg	0.293365	0.06491	0.8302	1				
Na	-0.02671	-0.3330	-0.4012	0.01142	1			
K	-0.26593	-0.0199	-0.7295	-0.7132	-0.1554	1		
O.C	-0.19436	0.19877	-0.1922	0.08649	-0.1123	0.55787	1	
Nitrate	-0.61686	-0.1536	-0.6338	-0.7670	-0.1461	0.66913	0.00532	1

Table 11: Correlation matrix between Physico-Chemical parameters of Pre-Monsoon season

	pH	EC	Ca	Mg	Na	K	O.C	Nitrate
pH	1							
EC	-0.26018	1						
Ca	0.220713	0.491227	1					
Mg	-0.18301	0.446565	0.252335	1				
Na	0.525847	0.293776	0.143502	0.09132	1			
K	0.151145	0.537908	0.136969	0.491417	0.419139	1		
O.C	-0.57604	0.288966	-0.3524	-0.01003	-0.03257	0.29701	1	
Nitrate	-0.22422	-0.44466	-0.607	-0.41495	0.138086	-0.13338	0.438889	1

Table 12: Correlation matrix between Physico-Chemical parameters of Post-Monsoon season

	pH	EC	Ca	Mg	Na	K	O.C	Nitrate
pH	1							
EC	0.209469	1						
Ca	0.0538	0.611906	1					
Mg	0.129136	0.262181	0.024272	1				
Na	0.298495	-0.49505	-0.09681	0.173823	1			
K	0.171554	0.010546	-0.14433	-0.51231	-0.51125	1		
O.C	0.330349	0.359715	0.258472	0.112333	-0.39457	0.691305	1	
Nitrate	-0.14955	-0.05543	-0.28192	-0.26886	-0.43719	0.430645	-0.04792	1

Table 13: Correlation matrix between Heavymetals

	Copper	Chromium	Lead	Zinc	Nickel	Iron
Copper	1					
Chromium	0.591992	1				
Lead	-0.11036	-0.14137	1			
Zinc	0.647248	0.060342	0.339233	1		
Nickel	0.106049	-0.14413	-0.47724	0.176395	1	
Iron	0.171172	0.1932	0.371396	0.343809	-0.00382	1

5 Conclusion

The present study provides simple representation complex of variables (physical, biological and chemical) that govern the overall water quality of surface water that are intended for potable use. It indicates that during monsoon few of the water quality parameters like phosphate, nitrate (in upstream), EC, total hardness and TDS (in downstream) is more which is due to release of agricultural runoff, domestic waste water and industrial effluent into the river. Water is non-alkaline water and it is suitable for water pipe line, Because of total hardness was higher than alkalinity, The above data on the water quality parameters of Cauvery River clearly showed that river water is safe for drinking water supply, fishery, irrigation, and industrial purposes, as most of the parameters are found within the permissible limits. The results of the physico-chemical variables investigated from sediments of Cauvery River indicated that most of the parameters did not exceed the safe limits. The mean pH of the river was still basic. Cauvery River is a good example of a site where contributions of pollutants both from natural (lithogenic) sources and anthropogenic activities. The major sources of pollution of the Cauvery River are the industrial effluents, return flows, agricultural runoff, municipal and domestic sewage besides pedogenic background contributions. During the study period, the sediment samples during Monsoon season showed significantly lower values than Pre-Monsoon and Post-Monsoon season samples. The main reason behind the lower concentration during the Monsoon season is the dilution factor with the pollutant. The physico-chemical analysis of sediment samples of Cauvery River showed an optimum pH in the suitable range for most of the biological life because the reactions in the neutral range to slightly alkaline is most favourable. Electrical Conductivity (EC) indicates the presence of significant amounts of anions and cations and during the present study. Electrical Conductivity values of sediment samples were found to be in unsafe range. The organic carbon (%) recorded during the study period, suggested that river is getting organic loads from sewage water which is directly mixing into the river.

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