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Heavy Metal Pollution and Chemical Profile of Cauvery River Water

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Abstract: Analysis of water, plankton, fish and sediment reveals that the Cauvery River water in the downstream is contaminated by certain heavy metals. Water samples have high carbonate hardness. Concentrations of all elements and ions increase in the downstream. Main ions are in the following order: Na > HCO_3 >Mg > K > Ca> Cl > SO_4. Heavy metal concentration in water was Cr >Cu ≈ Mn > Co > Ni > Pb > Zn, in fish muscles Cr > Mn > Cu > Ni > Co > Pb ≈ Zn, in phytoplanktens Co > Zn > Pb > Mn > Cr and in the sediments the heavy metal concentration was Co > Cr > Ni ≈ Cu > Mn > Zn > Pb. Although, the quality of Cauvery River may be classified as very good based on the salt and sodium for irrigation, Zn, Pb and Cr concentration exceeded the upper limit of standards. Metal concentrations in the downstream indicate an increase in the pollution load due to movement of fertilizers, agricultural ashes, industrial effluents and anthropogenic wastes. An immediate attention from the concerned authorities is required in order to protect the river from further pollution.

Introduction

The natural elements which cause water pollution is gases, soil, minerals, humus materials, waste created by animals and other living organisms present in water[1,2]. During rain, surface water with soil, mud and humus enter into the river, tanks and other water bodies. The inorganic minerals like sodium, potassium, calcium, magnesium and heavy metals like iron, manganese, lead, mercury, chromium, cadmium, nickel, cobalt, beryllium copper *etc*., when present above the permissible limit are harmful. Agricultural water pollution is caused by fertilizers, insecticides, pesticides, farm animal wastes and sediments. Research findings indicate that application and heavy doses of fertilizers pollute ground water through leaching of nitrate from nitrogenous fertilizers and of cadmium from single super phosphate and of fluoride from rock phosphates. The use of various types of pesticides and insecticides in agriculture cause water pollution. Careless deposit of animal waste closed to the wells and ponds situated in the backyards cause pollution of water through leaching. The pathogenic organisms of these wastes transmit to the water and pose serious problems. There are agencies to monitor routinely the major ion chemistry of the river. However, toxic metals are not considered in many studies. There are several times increase in heavy metals in Cauvery River in recent years[3-5].

Cauvery River is one of the major rivers of India, which is considered sacred. The river is considered to rise at Talakaveri in the Brahmagiri hills in Kodagu, though there is not a flow at this point all year round. It forms the principal drainage of this district and is already a major river when it leaves the Western Ghats near Kushalnagar. After the river leaves the Kodagu hills and flows onto the Deccan plateau, it forms two islands, *i.e*. Srirangapatna and Shivanasamudra. It also drops into the Hoganekal Falls just before it arrives in the towns of Hoganekal and Srirangam in Tamil Nadu. At Sivasamudra Island the river drops 320 ft (98 m), forming the famous Sivasamudarm Falls known separately as Gagana Chukki and Bhara Chukki. The river enters Tamil Nadu in all splendour after leaving the great falls in Hogenakal. From there it meanders into the southern plains. It is in the composite district of Thanjavur that the rich, Silt-laden river delta region is formed before it empties into the Bay of Bengal through its two mouths.

This study was performed in eight stations starting from upstream A (Hanagadu near Lakshmanatirtha in Kodagu district) Station B (Marchinahalli near Krishnarajasagara) Station C(Kamenahalli near Krishnarajasagara) Stations D (Sangama in Srirangapatanam considered a sacred place, people visit this place to take holy bath and through ashes in the river) Station E and F (Bannur and Sosale, here agricultural activities are present in almost four seasons). Station G and H (Bilagale and Nanjangud is a holy place and industrial area).

Experimental

Fish, sediment and plankton samples were collected and digested according to standard methods. Water samples were collected in polyethylene bottles from 8 stations along waterway. The samples were preserved according to standard methods. pH, salinity and electrical conductivity were measured with a YSI 33 model portable conductivity meter. Samples were filtered through 0.45 mm millipore filter paper. They were concentrated 5 times by evaporation method for heavy-metal analyses. All samples were preserved at 4 ^{o}C. Heavy-metals (Cr, Co, Cu, Mn, Ni, Zn and Pb), Ca and Mg were detected by atomic absorption spectrometer. Na and K have been analyzed by flame photometer, SO_4 by gravimetric, HCO_3 and Cl by volumetric methods[6,7]. To check the accuracy and precision of the measurements Merc standard solutions with known concentrations were analyzed.

Results and Discussion

The pH value of water is an important indication of its quality and it is dependent on the carbon dioxide, carbonate–bicarbonate equilibrium. Acid-base reactions are important in groundwater because of their influence on pH and the ion Chemistry. The pH value in the study area varies between 6.5 and 9.4. pH of water in stations E & F was low this may be attributed to discharge of acidic water by agricultural and domestic activities. The pH value of 7.5 to 8.0 usually indicates the presence of carbonates of calcium and magnesium, and a pH of 8.5 or above shows appreciable exchangeable sodium. Therefore, the results clearly indicate the dominance of bicarbonate, sodium and chloride towards downstream as compared to upstream.

The electrical conductivity is a useful parameter of water quality for indicating salinity hazards. Electrical conductivity of ground water of Cauvery River varies from 3.2 to 45.4 mV. It indicates that salinity is more prevalent than sodicity in the study area. It is observed that water of high electrical conductivity values are predominant with sodium and chloride ions. This is evident at places like Sangama, Sosale, Bannur, Bilagalae and Nanjangud. Further it is observed that saline water also have relatively more calcium, magnesium and bicarbonate ions. This is observed especially at Honagadu and Bilagale. Potassium and carbonate ions are mostly confined up to a range of 5% of the total salt concentration. It is rather difficult to draw a general conclusion on the ionic composition of the water in relation to geographical conditions. In general, water in areas of high rainfall, *i.e.* above 1000 mm per annum and with good drainage is of good quality. This is clear from the present study that, in the upstream where the rainfall is more (above 1000 mm) the quality of water is good whereas in the downstream area various parameters exceeds the acceptable limits (Tables 1& 2)

Table 1. Physicochemical parameters of water in various sampling stations

Physiochemical parameters	Sampling stations							
	Upstream A	B	C	D	E	F	G	Downstream H
PH	7.0	7.3	7.7	7.9	6.5	6.7	8.6	8.9
EC, mV	3.2	3.7	4.2	15.4	9.7	10.4	22.8	45.4

Table 2. Major constituents load (kg/day) in various sampling stations

Major constituents load, kg/day	Sampling stations							
	Upstream A	B	C	D	E	F	G	Downstream H
Na	589.70	59.60	345.60	1208.50	803.50	905.60	1012.50	6023.80
K	157.25	72.50	691.20	403.70	180.20	187.90	530.45	21926.40
Ca	808.70	82.90	236.25	691.20	103.70	130.50	425.27	37479.10
Mg	274.56	33.45	245.67	420.78	76.88	86.98	335.10	14512.20
Cl	936.53	153.70	453.45	2543.61	1424.54	2177.65	2688.34	50586.33
SO_4	5840.23	492.50	1226.65	207.66	1231.34	1345.52	1523.28	55036.43
HCO_3	9536.55	672.75	489.89	345.89	550.15	516.35	634.55	11247.45

The diagrammatic representation (Figures 1) showing percentage distribution of anions and cations with total ion concentration, indicate that bicarbonates ions are the dominating anions in the upstream, whereas towards downstream, concentration of chloride increases over bicarbonates indicating salinity problems in irrigated soil. Similarly among cations calcium and magnesium are the predominant ones. It is also observed that potassium shows a significant increase in its concentration in Marchinahalli area[11].

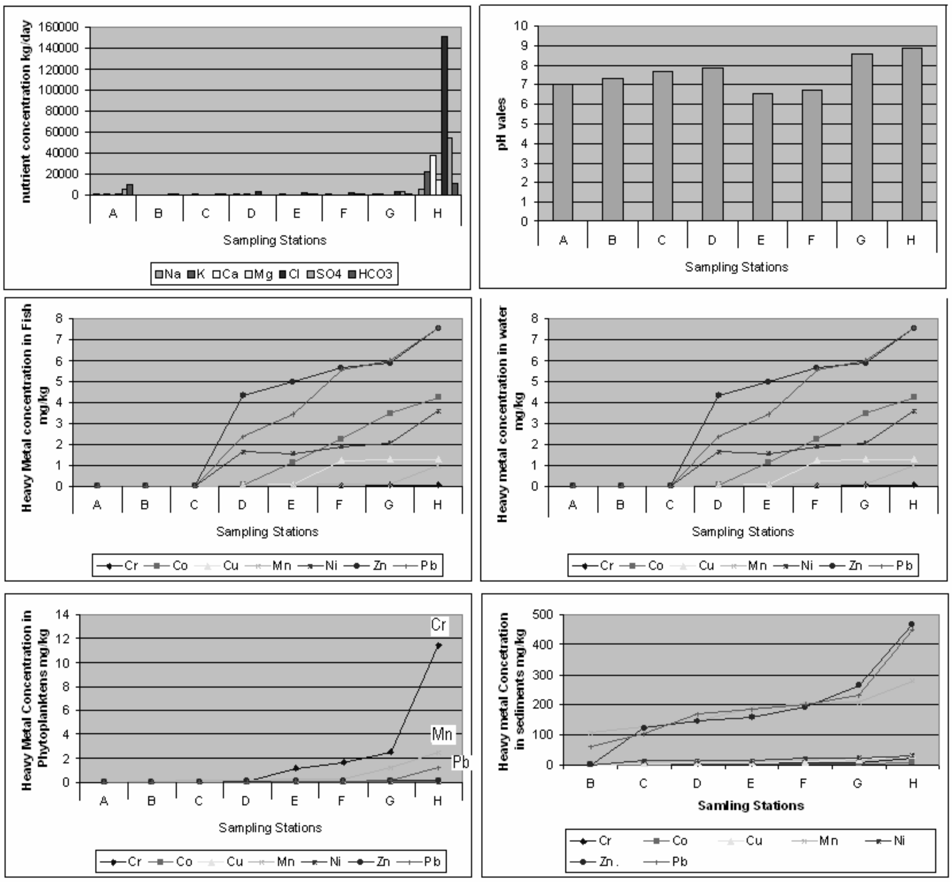

Figure 1. Chemical profile of Cauvery River water.

Focusing on the quality of the surface water through measurement of dissolved heavy-metal (Cr, Co, Cu, Mn, Ni, Zn and Pb) concentration at the various station, the results of water analysis are summarized in Table 3. The water from eight places differed slightly in the concentrations of a particular metal. Water samples from stations E, F and G contained the highest amounts of each metal. Concentration of Ni, Zn and Pb is considerably higher in downstream (Station H) than in the other sampling locations.

Table 3. Heavy metal concentrations of water (mg/kg) in various sampling stations

Heavy metal load in water, mg\kg	Sampling stations							
	Upstream A	B	C	D	E	F	G	Downstream H
Cr	BDL	BDL	BDL	0.05	0.17	0.22	0.25	0.32
Co	BDL	0.07	0.09	1.20	1.35	1.56	1.75	2.23
Cu	0.03	0.06	0.08	0.09	1.02	1.02	1.05	1.12
Mn	BDL	BD	BDL	BDL	0.08	0.06	0.06	1.25
Ni	0.05	0.08	0.15	0.24	0.26	1.32	2.45	5.25
Zn	BDL	1.23	1.86	1.95	2.35	3.67	4.45	10.70
Pb	0.08	1.12	1.45	1.89	2.25	3.00	3.56	9.95

Phytoplanktons are the bioindicators of the presence of metals in an aquatic ecosystem. Because it eliminates metals from the water, accumulates and stores them over a long period, even when the concentrations of metals in the water is low. High water temperature, oxygen concentration, basic pH and hardness of river water increase heavy metal toxicity. The observed concentrations of metals in the plankton are Co > Zn > Pb > Mn > Cr (Table 5). The occurrence of higher concentrations of Pb, Mn and Cr in phytoplankton is attributed to their higher concentrations in the river water and sediment.

Table 4. Heavy metal concentration in fish muscles (mg/kg) in various sampling stations.

Nutrients load in fish, mg/kg	Sampling stations							
	Upstream A	B	C	D	E	F	G	Downstream H
Cr	-	-	-	ND	ND	ND	0.052	0.055
Co	-	-	-	0.051	1.121	2.255	3.501	4.226
Cu	-	-	-	0.064	0.088	1.234	1.256	1.265
Mn	-	-	-	0.056	0.056	0.087	0.089	1.006
Ni	-	-	-	1.628	1.535	1.879	2.058	3.571
Zn	-	-	-	4.329	4.994	5.670	5.877	7.544
Pb	-	-	-	2.341	3.450	5.550	6.026	7.563

Table 5. Heavy metal concentrations in phytoplanktens (mg/kg) in various sampling cations.

Heavy metal load phytoplankton, Kg/day	Sampling stations							
	Upstream A	B	C	D	E	F	G	Downstream H
Cr	BDL	BDL	ND	0.091	1.121	1.674	2.543	11.452
Co	BDL	BDL	0.022	0.024	0.027	0.032	0.048	0.049
Cu	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Mn	BDL	0.06	0.141	0.190	0.251	0.255	1.257	2.459
Ni	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Zn	BDL	BDL	0.028	0.045	0.044	0.074	0.125	0.168
Pb	BDL	BDL	0.024	0.027	0.052	0.085	0.125	0.195

BDL-Below detection limit

Study of fish muscle is one of the means to investigate the amount of heavy metals entering the human body in food[11]. Concentrations of metals in fish muscles that were observed during the present study are shown in Table 4. The observed concentrations of metals in the fish muscles was Cr > Mn > Cu > Ni > Co > Pb ≈ Zn.

Metal mobilization in the sediment environment is dependent on physicochemical changes in the water at the sediment–water interface. The precipitation of lead, copper, manganese, chromium and zinc might be the result of alkaline pH in the form of insoluble hydroxides, oxides and carbonates. Metals such as chromium, copper and nickel have interacted with organic matter in the aqueous phase and settled, resulting in a high concentration of these metals in the sediment[8,9]. Mobilization of zinc and lead is also effected by higher concentrations of manganese in the sediment Concentrations of metals. Chromium, lead and zinc in the sediment are categorized as 'non-pollution', nickel is categorized as 'moderate pollution' and copper is categorized as 'heavy pollution' as per the criteria for sediment concentration of metals established by the USEPA Mineralogical studies of polluted sediments indicate that heavy metals are found to be associated with fine particles of silt clay that have large surface areas and the tendency to adsorb and accumulate metal ions due to their intermolecular forces. The heavy metal concentration in the investigated sites was found to be Co > Cr > Ni ≈ Cu > Mn > Zn > Pb (Table 6).

Table 6. Heavy metal in concentrations sediments (mg/kg) in various sampling stations.

Heavy metal load sediments mg/kg	Sampling stations							
	Upstream A	B	C	D	E	F	G	Down-stream H
Cr	BDL	1.55	1.76	2.23	2.87	5.67	6.45	18.24
Co	BDL	BDL	1.23	1.76	2.45	2.56	4.44	6.78
Cu	BDL	BDL	4.55	7.86	7.72	9.43	17.32	29.87
Mn	BDL	105.23	123.67	145.50	187.20	202.34	207.45	278.27
Ni	BDL	BDL	13.45	13.56	13.73	19.51	23.50	28.20
Zn	BDL	BDL	120.50	145.59	156.47	190.62	263.51	467.30
Pb	BDL	59.30	102.43	167.94	185.51	199.50	230.67	450.52

BDL-Below detection limit

Conclusions

The present study is an attempt to detect changes in the water quality characteristics within the river system with respect to major nutrients and heavy metals. The study reveals that there are additions of large quantities of effluents due to movement of fertilizers, agricultural ashes, industrial effluents and anthropogenic wastes particularly in the down streams of the river. Major nutrients are in the following order: Na > HCO3 >Mg > K > Ca> Cl > SO_4. Heavy metal concentration in water was Cr > Cu ≈ Mn > Co > Ni > Pb > Zn, in fish muscles Cr > Mn > Cu > Ni > Co > Pb ≈ Zn in phytoplanktens Co > Zn > Pb > Mn > Cr and in sediments the heavy metal concentration was Co > Cr > Ni ≈ Cu > Mn > Zn > Pb. In general the heavy metal concentration in Cauvery River was found to be maximum in sediments, phytoplanktens and fish.

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