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Seasonal Variation in Water Quality of Four Stations in the Periyar River Basins

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Abstract

Studies were conducted to evaluate the quality of water from four stations of the river Periyar at Kanakkankadavu, Purappallikavu, Pathalam and Manjummal in Ernakulam District, Kerala, India with view to utilise them for drinking purposes. Nutrient elements like Fe, Mn, Cu, and Zn were detected occasionally and were well below the maximum admissible limit. Mercury and lead were detected in January and March samples of Kanakkankadavu. Trace levels of As, Se, Cr and Cd were detected in some samples during certain months of the study period. Significantly higher levels of Magnesium and calcium were detected during summer seasons. The hydrographic data revealed that all the sources are acidic pH, turbid, low salinity during monsoon and nitrate, sulphate and hardness were higher during summer months. Among the stations Kanakkankadavu and Purappallikavu had extreme salinity and the presence of certain toxic metals during summer months and the same for other stations were well below the limit. Results revealed that these water sources could be utilized for meeting the growing demands of drinking water for Cochin City after introducing certain water quality management measures.

Introduction

About 80% of the World's population is concentrated on coastal zones and the water availability in these areas is insufficient for the basic needs. Ernakulam is the economic capital of the state of Kerala (India) and has a population of

3,098,378 (2001 senses), which is growing day by day. The Ernakulam City has been experiencing acute water scarcity even though she is blessed with 12,700 ha of inland water area (anonymous 2003. www.kerala.gov.in). The dynamics of Cochin estuary show seasonal variation in its characteristics as the circulation is mainly attributed to the interaction between the enhanced fresh water runoff from the main rivers, Periyar with annual flow of 5180Mm³ and Muvattupuzha river with annual flow of 4780Mm³ during the south west monsoon (June – September) and high dense saline water from the Arabian sea resulting in salt wedge to highly stratified condition which exists during post monsoon period (October January). Partial to well mixed condition occurs during pre monsoon period (February – May) as the proportion of fresh water drops down (Ajith Joseph and Balchand 2001). The characteristics of nutrients in riverine environment depend mainly on spatial and temporal variations of rainfall, quantum of fresh water inflow, tidal intrusion from sea and on some biological activities like phytoplankton uptake and regeneration. The study was conducted as per the requests of Greater Cochin Development Authority to evaluate water quality with seasonal variations and to identify potential sources of natural water for drinking purposes.

Materials and Methods.

Water samples from four stations of the river Periyar basins were collected bimonthly at Kanakkankadavu (station 1), Purappallikavu (station 2), Pathalam (station 3) and Manjummal (station 4), in Ernakulam District during June 1999 to April 2000 (Fig 1). Surface and bottom water from upstream and down stream were collected from each sampling site except at station 3 where upstream surface and bottom water only were collected. The samples were brought to the laboratory and kept in chilled storage (0°C) until the analysis. The dates of collection of samples are 14-June-1999, 16-August-1999, 21-October-1999, 5- January-2000, 8-March-2000 and 15-April-2000. The physico chemical characteristics like, pH, turbidity, total hardness, chlorides, sulphate, nitrate and detergents were analysed as per the standard methods (APHA (1980)). The nutrient, toxic and trace elements viz. As, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Pb, Se, and Zn in water were analysed by ICP-AES Labtam 8410 and mercury analysed by cold vapour absorption technique using mercury analyser (ECIL 5838). The four samples

collected from each station at a sampling time were upstream surface, upstream bottom, down stream surface and down stream bottom, and were analysed for all parameters and their averages used for the evaluation. Kerala receives an annual rainfall of 3500 – 4000mm and have three distinct seasons viz. monsoon (June – September), post monsoon (October - January) and summer or pre monsoon (February – May). There is no distinct winter except slight cool nights (20 ± 3 °C) during December and January months. The data were tabulated and analysed statistically by two-way ANOVA available in Excel of MS Office software (Microsoft Corporation).

Results and Discussion

The turbidity of water samples collected during monsoon was very high while the same in other seasons was well below the limit prescribed (10NTU). Station 3 and 4 are significantly turbid between June to October compared to the other stations and the maximum admissible limit for prospective drinking water source is 10NTU (Fig 2). The heavy inflow of water in the river sources due to rain is the main reason for the turbidity during monsoon. The pH (Fig 3) varied from 5.32 to 6.70 during June to October and the remaining periods it was neutral to alkaline (6.92 to 7.65). The average pH in all the stations during June was 5.73, significantly low, especially at stations 2 to 4 and it was 6.50 and 6.55 in August and October respectively. The pH in samples collected during January to April varied from 7.18 to 7.28. Among the stations, station 4 recorded near neutral pH (7.0 ± 0.2) compared to the other stations. A slight decrease of pH in bottom water was observed, which may be attributed to detritus decomposition of organic matter in the bottom sediments leading to the production of organic acid.

Chloride, an indicator of salinity in the samples collected from June to October was found to vary between 8.15 - 31.91ppm (Fig 4) and the concentrations during June, August and October respectively were 12.27-31.91, 12.40 – 21.27 and 8.10 – 31.55ppm. The sample collected from station 2 during June and October recorded significantly higher concentrations (28.36-35.46 and 24.11 to 35.46 ppm respectively) and station 3 revealed higher level of chlorides during August (21.27ppm) whereas upstream water showed slightly higher

salinity than downstream. The samples collected during January - April had recorded significantly higher concentration of chlorides in station 1 probably due to heavy salt incursion during high tides as well as due to the relatively reduced flow of fresh water from upstream areas. The chloride concentration varied in station 1 from 2747 to 10017 during January to April. Similarly station 2 also recorded higher levels of chlorides (51 – 1693ppm) during this period. This indicates that station 1 and 2 are more prone to salt incursion during summer months suggesting some control measures to use this water for drinking purpose. The chloride varied in station 3 and 4 between 12.05 – 17.73 ppm during this period. Salinity beyond 1000 ppm not advisable for drinking water sources as it is difficult to rectify and desalination is very costly. In this situation the water sources from Kanakkankadavu and Purappalli kavu could not be utilised during summer months for drinking water purposes. However, possibility of constructing a barrier to prevent extreme tidal variation (varied 0.5 to 2m heights) during summer months can be an effective solution to keep these stations as active source for drinking water. Recording high salinity/chlorides during the summer season was due to the low amount of rainfall and resultant reduction in fresh water flow (Lakshmanan et al 1992) coupled with high rates of evaporation in the shallow coastal areas owing to atmospheric temperature and wind condition.

The permitted level of total hardness in drinking water was 600 ppm and it was much higher in samples from stations 1 and 2 during January to April (Fig 5). In all other stations it exceeded only in the month of January. This property is interrelated with the concentration of Mg, Ca, sulphate and chlorides. Sulphate concentration varied between 1.8 to 9.11, 0.60 to 2.03 and 0 to 3.69 ppm respectively during June, August and October (Fig 6). Surface water of station 2 had comparatively higher sulphate concentration among stations. Sulphate concentrations were higher during January to April and station 1 and 2 recorded higher values viz. 233 -390, 31 -275 and 26 - 296ppm respectively in January, March and April. Sulphate in station 3 and 4 was significantly low through out the sampling period. According to the Bureau of Indian Standard (BIS) specification the admissible sulphate concentration in drinking water is 150 ppm whereas it in Canada and US is 500 and 250 ppm respectively (Moore 1991). The sulfate levels

were far below in station 3 and 4. However in station 1 and 2 it is higher during summer months.

The nitrate concentration was found to vary between 0 to 28 ppm during the study period (Fig 7). Among these results lowest level of nitrate was detected during June, March and April and the station 1 had higher nitrate level compared to other stations during the above period. The bottom water showed lower level of nitrate than surface. Nitrate varied from 14.90 – 22.55, 9.10 - 16.22 and 7.50 - 13.95 ppm respectively during August, October and January. Station 2 had comparatively higher nitrate content during August –January and followed by station 1. The high concentration of nitrate at farthest station during the post monsoon season showed a significant impact of fresh water run off from Periyar River.

Detergent contamination is a common phenomenon wherever there is human habitation. Trace levels of detergents were detected in most of the stations during June to January and after March it was not detected in any stations except at station 1 (Fig 8). The concentration varied between 0 to 0.017ppm and the permitted level is 0.2-1.0ppm. The detergent concentration during monsoon and post monsoon may be attributed to the excess and fast drainage of rainwater from land to reach the river.

Among nutrient elements studied magnesium concentration was significantly higher in all the stations especially in samples collected during January to April. The Mg detected at station 1 was significantly higher viz.93, 438 and 463 ppm respectively during January, March and April respectively (table 1). The Mg levels were 0.68-1.16 ppm during June to October. Station 2 recorded next highest level of Mg during January (95.62ppm) and it reduced slowly to 3.94 ppm in April. In station 3 and 4 the variation through out the year was between 0.83 to1.26and 0.54 to 1.17 ppm respectively. Similar trend was detected in the case of calcium and it was maximum in station 1 especially during March - April. In station 2 the Ca was maximum during January (35.15 ppm), which decreased to 3.28 ppm in April. Calcium levels recorded in station 3 and 4 respectively were 1.34 – 3.47ppm and 2.11 – 3.77 ppm in the whole year and the same is

significantly low compared to other stations. The higher levels of calcium and magnesium in station during January to April can be attributed to saline ingression that also contributes to higher salinity and hardness. Except this, all stations through out the year showed calcium and magnesium level within tolerance limits.

Iron was detected in samples collected from station 1 which ranged from 0- 0.03 ppm through out the year and in other stations it varied irregularly. Even then the iron detected was well below the prescribed levels. According to Moor (1991) the oxidation reduction cycle is important in controlling the fate of iron in most surface waters. The cycle varies seasonally, particularly in lakes that develop an anoxic hypolimnion during the summer. Oxygen concentration at the water sediment interface often approaches zero. This causes the reduction of Fe^{3+} to soluble Fe^{2+} , which is then transported upward in water column. The oxygenated water results in reoxidation to the insoluble Fe^{2+} , which settles to the bottom to repeat the cycle. Manganese was not detected in any station and season except at station 1 where 0.02 ppm each in June and January months. Copper was detected during June in station 1, 3 and 4 in trace levels (0.01ppm). Other sampling periods it was well below the detection limit. Zinc was detected in June and August samples and the concentration varied respectively between 0 to 0.02 ppm and 0 to 0.01 ppm. Ajmal and Uddin (1986a b) detected zinc levels in municipal, standing and running waters of Aligarh was 0.02 to 0.27ppm, 0.029 to 0.36ppm and 0.01 to 0.18 ppm respectively.

Chromium was not detected in any samples of except in downstream bottom waters of station 2 (0.01ppm) during August (Table 2). Cadmium concentration was detected mainly in station 1 during June and October samples (0.002ppm). Traces of Hg was detected only in samples collected from station 1 during March and April respectively at a concentration of 0.21 and 0.24 ppm indicating toxic levels and some kind of industrial pollution. Downstream water was having little higher concentration than upstream. Inorganic and methyl mercury are soft acids and form sulphide complex in presence sulphides. These complexes remain largely intact upon transport to estuarine waters, even though chloride is in excess Moore (1991). Mercury had a strong positive correlation between Ca, Mg, Pb, Se, total hardness and chloride. Arsenic was detected in only

at station 1 especially during March, April and June and their mean concentration was 0.395, 0.390 and 0.008 ppm respectively. Generally arsenic residues are very low in drinking water and have little toxicological significance at these concentrations. Recently As toxicity was reported from West Bengal and Bangladesh region. (Tom Clarke, 2003). The samples from station 1 exceeded the maximum contaminant limit (AWWA 1985) 0.05ppm during summer months it may be a contaminant / pollutant from nearby factories.

The lead in water sample was detected mainly during January to April and June. The concentration rang was 0 – 0.035, 0.04 – 0.05, 0.01 –0.38 and 0 – 0.01 ppm respectively in January, March, April and June. The Pb was significantly higher in samples collected during March and among stations, station 1 recorded higher levels of Pb. The mean Pb concentrations were 0.352, 0.053, 0.040 and 0.040 in station 1, 2, 3 and 4 respectively. Lead is mainly mobilised through anthropogenic sources, especially from fuel combustion. Ajmal and Uddin (1986a,b) reported 0.0008 - 0.0055, 0.005 - 0.0025 and upto 0.025 ppm respectively from standing water, running water and borewell sources of Aligarh. Selenium was detected during summer only in station 1. The concentration was 1.212 and 0.672 ppm in March and April respectively. All other stations free from selenium through out the seasons.

The study gave the information on the physico chemical characteristics of water of four river sources of Cochin. The sources from Kanakkankadavu and Purappallikavu had recorded the presence of toxic metal residues and extreme salinity during summer months. These water sources can be utilized for meeting the growing demands of drinking water after introducing some management measures.

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Table 2 . Concentration of metals in different seasons and stations in ppm

Element	Station	Concentration in ppm					
		June	August	October	January	March	April
As	1	0.007	0	0	0	0.395	0.390
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0.005	0	0	0	0
Cd	1	0.002	0	0.002	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0.002	0	0	0
Cr	1	0	0	0	0	0	0
	2	0	0.005	0	0	0	0
	3	0	0.005	0	0	0	0
	4	0	0	0	0	0	0
Hg	1	0	0	0	0	0.210	0.245
	2	0	0	0	0	0	0.005
	3	0	0	0	0	0	0
	4	0	0	0	0	0.210	0.245
Pb	1	0.005	0	0	0.030	0.352	0.382
	2	0	0	0	0.035	0.052	0.017
	3	0.015	0	0	0	0.040	0.015
	4	0.012	0	0.002	0	0.040	0.015
Se	1	0	0	0	0	1.212	0.672
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0

Table 1 . Concentration of metals in different seasons and stations in ppm

Element	Station	Concentration in ppm					
		June	August	October	January	March	April
Cu	1	0.007	0	0	0	0	0
	2	0	0.002	0	0	0	0
	3	0.005	0.005	0	0	0	0
	4	0.007	0.005	0	0.002	0	0
Zn	1	0.017	0.005	0	0	0	0
	2	0.017	0.005	0	0	0	0
	3	0.005	0.01	0	0	0	0.010
	4	0.012	0.007	0.005	0	0	0
Fe	1	0.025	0.007	0.002	0.007	0.030	0.032
	2	0	0.005	0	0.012	0	0.002
	3	0	0	0.015	0.02	0	0
	4	0	0.015	0	0.027	0	0.002
Mn	1	0.020	0	0	0.015	0	0
	2	0.002	0.002	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
Ca	1	2.420	5.895	1.725	44.827	135.250	140.500
	2	3.435	4.580	2.640	35.150	6.395	3.287
	3	1.865	3.475	1.300	2.665	2.575	2.385
	4	3.775	2.862	2.110	3.187	2.920	2.945
Mg	1	0.960	1.162	0.680	93.04	438	463
	2	2.192	1.065	2.182	95.625	13.275	3.947
	3	0.835	0.790	0.540	1.020	1.260	0.950
	4	0.927	0.785	0.542	0.987	1.175	0.792

Fig 1. Map of the sampling stations 1. Kanakkankadavu, 2. Purappally kavu 3. Pathalam 4. Manjummal.

