STUDIES ON HYDROBIOLOGICAL PARAMETERS OF RIVER CAUVERY AND ITS TRIBUTARY ARASALAR IN KUMBAKONAM AREA, TAMIL NADU, INDIA

Thesis submitted to
Bharathidasan University, Tiruchirappalli
For the award of the Degree of
DOCTOR OF PHILOSOPHY IN ZOOLOGY

By
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Under the guidance of
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CERTIFICATE

This is to certify that the thesis entitled "**STUDIES ON HYDROBIOLOGICAL PARAMETERS OF RIVER CAUVERY AND ITS TRIBUTARY ARASALAR IN KUMBAKONAM AREA, TAMIL NADU, INDIA** " submitted to Bharathidasan University, Tiruchirappalli, for the award of the degree of **Doctor of Philosophy In Zoology,** embodies the result of the bonafide research work carried out during the year 2010-2013 by **Mrs. G. ANNALAKSHMI,** under my guidance and supervision in the P.G. and Research Department of Zoology, Khadir Mohideen College, Adirampattinam, Thanjavur District, Tamil Nadu, India.

I further certify that no part of this thesis has been submitted anywhere else for the award of any degree, diploma, associateship, fellowship or other similar titles to any candidate.

DECLARATION

I do hereby declare that this thesis work has been originally carried out during the year 2010-2013 by me under the guidance and supervision of **Dr. A. AMSATH, M.Sc., M.Phil., Ph.D.,** Research Advisor and Associate Professor, P.G. and Research Department of Zoology, Khadir Mohideen College, Adirampattinam, affiliated to Bharathidasan University, Tiruchirapalli – 620 024 and this work has not been submitted elsewhere for any other degree.

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CHAPTER 1

1. GENERAL INTRODUCTION

1.1 Background of the study

Rivers are the most important water resource in the world in general and in India in particular. Great civilizations developed along the bank of the river and even today most of the development has taken place in the cities or in the areas located near the rivers. The river provides water for the industry, agriculture, commercial, aquaculture and domestic purpose. Unfortunately the same rivers are being polluted by indiscriminate disposal of sewage and industrial waste and a plethora of human activities. River pollution has already acquired a serious dimension in India, with most its India's fourteen major, 55 minor and several hundred small rivers are facing acute water pollution problem. The fluctuating physical and chemical characteristic of water and their interaction alter the biological community of aquatic ecosystems of rivers. Anthropogenic activities in the river basin affect the physico-chemical properties of river which have indirect effect on the biological resources interacting with each other, apart from degrading the environment.

Pollution of a river first affects its chemical quality and then systematically destroys the community disrupting the delicate food web. Evidence related to impact caused due to industrialization and increased population on the aquatic environmental conditions has been noted from different rivers around the globe (Tiwary and Dhar, 1994; Chang, 2008). Water resources of highly industrialized cities in India have been chronically polluted. Major Indian rivers, such as Ganga, Yamuna, Tapti, Narmada, Sone, Chambal Damodar, Krishna, Cauvery, Brahmaputra, Mahi and other rivers are severely polluted. According to CPCB, 90% of the water supplied in India to the towns and cities is polluted, out of which only 1.6% get treated. According to the Ministry of Environment and Forest (MEF), most of rivers in India are polluted, mainly because of district inflow of untreated sewage resulting in unacceptable levels in them of BOD, SS. Even high microbial growths are noted with the aquatic systems that gradually increases eutrophication of water bodies (Penningtonet al., 2001; Kistemann et al., 2002). Rapid urbanization and industrialization, intensive agriculture and growing demand for energy during the last few decades has affected the physico-chemical parameter and biological attributes of ground and surface water (Jain et al., 2007) evidence from the studies on the rivers like Mahanadi, Narmada, Uppanar, Gola and the Gangas supports the view.

Diverse uses of the rivers are seriously impaired due to pollution and even the polluters like industry suffer due to increased pollution of the rivers. River pollution has several dimensions and effective monitoring and control of river pollution requires the expertise from various disciplines. Pollution of river is a global problem. In India it is reported that about 70% of the available water is polluted. The chief source of pollution is identified as sewage constituting 84 to 92 percent of the waste water. Industrial waste water comprised 8 to 16 percent. Rivers are considered to be the life line for most of the developing countries as they meet drinking water needs. Due to improper and inadequate treatment facilities in a country like India, huge source volume of waste water is being discharged into the river and lakes from various towns and cities. (Prakash *et al*, 2005).

Urbanization in India is taking place at a faster rate than rest of the world (United Nations Population Fund 2007). The growing population, increased economic activity, and industrialization always result in increased water demand. Ultimately, rivers play a major role in catering the water needs of growing industrial, agricultural, and domestic activity. Ironically, almost all

Indian rivers also act as carrier of untreated/partially sewage, industrial effluent, and runoff from agricultural and urban land (Chakrapani 2005; Jameel and Hussain 2005, 2007; Singh et al. 2005; Rani and Sherine 2007). The contamination by hazardous substance can pose risk to human health in particular via the food chain. However, it becomes more and more difficult to meet such water quality standards because of continuous economic expansion, urban development and growing population pressure. One such resource is the Cauvery River, the major river system of south India and Arasalar is tributary to the river Cauvery.

The Cauvery River and its tributaries are the major source of water for drinking, agriculture, and industrial needs of two states of India (Karnataka and Tamilnadu). The River covers a drainage area of nearly 90,000 km2 in the southern part of the Indian subcontinent. It flows through a densely populated area, from Coorg (Karnataka) in the Western Ghats to Bay of Bengal. Rivers Noyyal, Bhavani, and Amaravathi are the major contributories to Cauvery in the Tamilnadu state. Before emptying into Bay of Bengal, Cauvery River divides into 36 distributaries forming a wide delta. Water flow in Cauvery basin is highly dependent on monsoon. The period of June to December is characterized by southwest monsoon, post-monsoon season, and northeast monsoon during June to August, mid-August to September, and October to November, respectively. During southwest and northeast monsoon, water flow is highest in Cauvery River.

The primary uses of Cauvery and its tributaries Arasalar were providing water for irrigation and household consumption. The Cauvery, like many major rivers in general, in India faces many problems, including dry summers, wetland filling, large dams, and pollution (Manivasakam, 1996). The degree of pollution is generally assessed by studying physical and chemical characteristics of the water bodies (Duran and Suicnz, 2007). Several studies have been conducted so far to understand the physicochemical properties of rivers in India. Water pollution due to anthropogenic activities in Cauvery River and many of its tributaries, namely, rivers Noyyal, Bhavani, and Amaravathi, has been reported in earlier studies (Senthilnathan 2004, Jameel and Hussain 2005, 2007, K.L.Prakash *etal*, 2007, GovindarajSolaraj *et al*, 2009, Varunprasath 2010). According to their report, effluents from pulp and paper manufacturing, chemical industries, dyeing and bleaching units, and sewage are the major anthropogenic sources of water pollution in Cauvery River.

The Cauvery River is one of the most contentious water supplies in Southern India. The Cauvery watershed is divided between Karnataka and Tamil Nadu (both Southern Indian States)**.** While temples are the main attraction to Tamil Nadu, agriculture is the primary means of sustenance. Tamil Nadu relies on the Cauvery River to sustain its agricultural needs. Beyond the Cauvery, Tamil Nadu has very few resources for complex irrigation systems to maintain its water supply. Cauvery is the lifeblood of Tamil Nadu's agriculture and agriculture is the lifeblood of Tamil Nadu.

In this era of decreasing natural diversity, increasing floods, decreasing potable water supply, weakening natural barriers and inefficient water structures, Kumbakonam represents a sustainable model of an organized human settlement set within the Cauvery delta region in Tamilnadu. The morphology of the settlement has been, to a large extent, shaped by the way the water runs through its landscape and historically how man has dealt with it. Kumbakonam is known as the "temple town" due to the prevalence of a number of temples here and is noted for its Mahamaham festival which attracts people from all over the globe. Kumbakonam, in Thanjavur district, is located at 10° 57’ north latitude & 79° 23’ longitude. It is about 313kms from Chennai on the north, 40kms from Mayiladuthurai on the east, 40kms from Thiruvarur on the south & 40kms from Thanjavur on the west Kumbakonam, known as Kashi on Cauvery, is an ancient South Indian City located in

Cauvery River Basin, with the Cauvery in the north and river Araslar in the south.

Kumbakonam city today occupies an area of 12.58 sq km with a population of 1.4 lakhs inhabitants with firmly established urban social space, building typology and landscape. The site interpretation echoes environmental aspects related to very specific waterscape. The urban tissue explains the integrated appropriations at the social, economic and environmental levels thus bridging the stratified urban conditions in cities. The structuring of social institutions, housing, urban agricultural lands, natural and manmade water tanks, and parks maintain the identity of the site's historical layers and the strong connection with water. Unlike other religious centers, organized around a single core, kumbakonam is unique being one of the very few multi core temple cities. The urban fabric includes temples, matams, chattrams, agraharams, paditorais (ghats), making it one among the best surviving of ancient Tamil cities. Its strategic location along the Cauvery delta region renders it as an ecologically sensitive zone and its continuous habitation since ninth century adds to its strong socio religious significance.

The Arasalar is one of those 5 tributaries that River Cauvery splits into in the Thanjavur District, thus forming the Cauvery Delta area. The separation actually happens in the town of Thiruvaiyaru (literally, 5 rivers) and this region leading up to the eastern coast where these rivers flow into the Bay of Bengal has historically been one of the most fertile pieces of land mass in the whole of the Indian Subcontinent. This region has served as the Rice bowl of India during its heyday and was predominantly irrigated by the channels dug from these rivers. The present study is an effort to monitor, assess and model the water quality of the Cauvery, a southern part of the Indian subcontinent. The river traverses through a number of densely populated and industrial cities and receive effluents through a network of surface drains.

1.2 Statement of the problem

Water quality is at present a global issue, especially when considering its implications to humanity in terms of water borne diseases. The deterioration of water quality has led to the destruction of ecosystem balance, contamination and pollution of ground and surface water resources. Water quality degradation world-wide is due mainly anthropogenic activities which release pollutants into the environment thereby having an adverse effect upon aquatic ecosystems. Water quality can be regard as a net work of variables (pH, oxygen concentration, temperature etc.,) that are linked and co linked; any changes in these physical and chemical variables can affect aquatic biota in a variety of ways.

Water quality problems have intensified through the ages in response to the increased growth and concentration of populations and industrial centers. Polluted water is an important vehicle for the spread of diseases. In developing countries 1.8 million people, mostly children, die every year as a result of water-related diseases (WHO, 2004). Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties. Other factors being the same, aquaculture species will be healthier, production will be more, environmental impacts will be less and quality better in culture systems with “good” water quality than in those with “poor” water quality (Chhatawal, 1998).

Water resources and aquatic biodiversity are intimately interrelated and interdependent. Both provide a wide range of functions and have intrinsic value as well as provide for the sustenance of human populations. Degradation of water quality, depletion of water resources and loss of aquatic biodiversity are prominent features of the environmental landscape requiring urgent attention at global and national scales. A major threat to aquatic ecosystems which can be lead to severe pollution problem is nutrient enrichment.

Nutrients are important building blocks for healthy aquatic ecosystems and are generally non – toxic even in high concentrations; however this can change with alterations in environmental parameters such as pH and temperature. Increased nutrient levels (especially nitrogen and phosphorus) can result in over stimulated growth of aquatic weeds and algae and can ultimately lead to oxygen depletion resulting in a eutrophic system. The occurrence of nutrients in aquatic ecosystems is closely linked to activities in the catchment, such as natural weathering, agricultural runoff and disposal of untreated or partially treated wastes (Madikizela et al, 2001; Nhaphi and Tirivarombo, 2004).

The indiscriminate and large scale deforestation and over grazing in the watershed areas of river basins have caused soil erosion resulting in considerable silting of dams and shrinkage of river flows. This leads to the flooding of the rivers at the time of excessive rains (Goel, 2006). The disposal of waste leads to contamination of river and lakes chronically affecting the flora and fauna. According to surveys carried out on selected stretches of important rivers, it has been found that most of the rivers are grossly polluted. The domestic sewage discharged from a population of about 2 millions gives rise to numerous water-borne diseases like typhoid, cholera, dysentery, poliomyelitis and cysticercoids, thereby affecting the human health and deterioration of the water quality (Sharma, 1996).

Sediments act as carriers or sinks of pollution. They are composed of numerous individual layers. Each of these layers corresponds to a distinct condition of water flow. Sediments have been used widely as environmental indicators due to their ability to store contaminants as well as trace contamination sources. Soils and sediments receive potentially toxic elements from both natural as well as anthropogenic sources. These include weathering of natural minerals, mining, industries, agriculture and waste disposal.

Rivers and streams are important component of natural environment. They have many values such as economic (fishing, electricity generation, transport and irrigation), aesthetic (recreation), ecological (biodiversity), water for consumption (water supply for domestic and industrial uses) and conveying wastewater discharges (treated or untreated). To maintain these values and their sustainable use, given water quality standard must be met. For every use of the river water different set of contaminants or water quality parameters play deterministic role for water quality assessment.

For irrigation use dissolved solids (TDS), pH, sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) are the most important. For other uses dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), carbonaceous oxygen demand (COD), inorganic nitrogen (ammonia and nitrite), phosphorus, suspended solids, hazardous substances, organic pollutants (e.g. petroleum and hydrocarbons) and heavy metals (e.g. mercury and cadmium) are also considered. The contamination by hazardous substance can pose risk to human health in particular via the food chain. However, it becomes more and more difficult to meet such water quality standards because of continuous economic expansion, urban development and growing population pressure.

1.3 Significance of the research work

This study will provide baseline information on the trophic status of the rivers for further studies in the Cauvery River and its tributaries Arasalar. The knowledge acquired will be useful in the management of these important ecosystem and natural resources of the river for the survival and continued economic benefits to the community. This study will cover a gap in knowledge of biotic (fauna and flora) and abiotic (water and sediment) components, with special regard to physical and chemical monitoring, biomonitoring and biodiversity in the two rivers.

The study serves to determine the water quality of River Cauvery and its tributaries Arasalar. It provides the physicochemical and biological characteristics of the water and, finally, contributes towards the limnological knowledge of the river.

1.4 Objectives of the research work

The research aim to be carried out during this two year study is to determine and integrate the physicochemical parameters, sediment characters, nutrient concentration, plankton community structure and bio diversity at river Cauvery and its tributaries Arasalar thereby determining the quality of waters. Water quality investigations are carried out to provide information on the health of water bodies and for developing strategies that help in better management of catchment and water resources.

The objectives of the studies:

1. To determine physic-chemical parameters and nutrient characters of river Cauvery and Arasalar.

2. To determine sediment characters of river Cauvery and Arasalar.

3. To identify plankton community structure as an indirect assessment of the water quality.

4. To identify the plankton (zooplankton and phytoplankton) in selected sites and estimate their abundance and diversity in relation to water quality parameters.

5. To determine biodiversity of river Cauvery and Arasalar.

CHAPTER 2

PHYSICO-CHEMICAL AND NUTRIENT ANALYSIS OF THE RIVER CAUVERY AND ITS TRIBUTARY ARASALAR

2.1 INTRODUCTION

The water quality assessment is carried out by physical, chemical and biological investigations. Each fresh water body has an individual pattern of physical and chemical characteristics, which are largely determined by the climatic, geomorphological and geochemical conditions prevailing in the drainage basin (Rajeshwari 2009). If the surface waters were totally unaffected by human activities, up to 90-99 % of global fresh waters, depending on the variable of interest, would have natural chemical concentrations suitable for aquatic life and most human uses. Natural events and anthropogenic influences can affect the aquatic environment in many ways, like synthetic substances may get added to water, the hydrological regime may be altered or physical or chemical nature of the water may be altered.

The term water quality was coined with reference to the quality of water required for human use (i.e. drinking, agricultural and industrial purposes). This term entirely human prospective does not hold true for all aquatic organisms or ecosystems (Dollars, *et al* 1994). A more modern approach is to consider water quality as the combined effect of the physical attributes and chemical constituents not only in the water but upon all aspects of the aquatic environment (King *et al* 2003). Water quality provides current information about the concentration of various solutes at a given place and time. Water quality parameters provide the basis for judging the suitability of water for its designated uses and to improve existing conditions. For optimum development and management for the beneficial uses, current information is needed which is provided by water quality programmers (Lloyd, 1992). Unequal distribution of water on the surface of the earth and fast declining availability of useable freshwater are the major concerns in terms of water quantity and quality (Boyd & Tucker, 1998).

Rivers are the most important freshwater resource for man. Social, economic and political development has been largely related to the availability and distribution of freshwaters contained in riverine systems. River systems can be considered as arteries of the land supplying life giving water to an abundance of organisms whilst at the same time supporting modern civilizations (King *et al* 2003). In recent years both the Anthropogenic influences such as urban, industrial and agricultural activities have increased exploitation of water resources as well as natural processes such as precipitation inputs, erosion, weathering of crustal materials, degradation of surface waters and rendering the water bodies unsuitable for both primary and secondary use (Agbaire, 2009 and Najafpour, 2008).

Rivers are subjected to various natural processes taking place in the environment, such as the hydrological cycle. As a consequence of unprecedented development, human beings are responsible for choking several lakes to death. Storm water runoff and discharge of sewage into rivers are two common ways that various nutrients enter the aquatic ecosystems resulting in the pollution of those systems (Sudhira and Kumar, 2000; Adeyemo, 2003).

A continuous monitoring of water quality is very essential to determine the state of pollution in our rivers. This information is important to be communicated to the general public and the Government in order to develop policies for the conservation of the precious fresh water resources (Ali *et al*., 2000). Water is the universal solvent required for all the living beings. Without the knowledge of water quality, it is difficult to understand the biological phenomenon fully because the chemistry of water reveals much about the metabolism of the ecosystem and explains the general hydro biological inter-relationship. The physico-chemical parameters of water and the dependence of all life process of these factors make it desirable to take water as an environment.

Nutrients are essential elements for the primary productivity of any aquatic ecosystem (Wetzel 1983), and include nitrogen, phosphorus and silicon among others. The nutrient dynamics are influenced by different factors such as the weather, geology and soil type, drainage pattern and weathering processes. Nutrients occur in various sources and forms. Within the aquatic ecosystems, phosphorus and nitrogen roles can vary (McCarthy 1981, Howarth 1980) In marine ecosystems nitrogen is the liming nutrient for phytoplankton growth (Smith 1984, Ryther & Dustan 1971) while phosphorus frequently is a limiting nutrient in fresh water systems (Hecky & Kilman 1988).

A number of factors influence water chemistry. Gibbs (1970) proposed that rock weathering, atmospheric precipitation, evaporation and crystallization control the chemistry of surface water. The influence of geology on chemical water quality is widely recognized (Gibbs, 1970; Langmuir, 1997). The influence of soils on water quality is very complex and can be ascribed to the processes controlling the exchange of chemicals between the soil and water (Lester & Birkett, 1999). Apart from natural factors influencing water quality, human activities such as domestic and agricultural practices impact negatively on river water quality. It is, therefore, important to carry out water quality assessments for sustainable management of water bodies.

In India, river waters are mainly used to meet potable water needs of urban population and a number of studies on physic-chemical and biological quality of these waters have been extensively carried out (Chakraborty *et al.*, 1977 and Srivastava *et al.*, 1996). Husain and Ahmed (2002) identified the variability of physico-chemical parameters of River Pachin, Itanagar. The variability in the physico-chemical parameters for different flow periods maybe assigned to dilution of river water by dilution runoff, runoff, human activities and organic load. The present investigation will be therefore a contribution to the understanding of the physico chemical and nutrient status of these two rivers as well and will provide a starting point to future researchers in their management.

2.2 MATERIALS AND METHODS

2.2.1 Description of study area

Cauvery originates in Karnataka at Talakaveri, in Kodagu and flows down through Kushal Nagar, Srirangapatna, and Shivanasamudram before reaching Hogennikal and Srirangam in Tamilnadu. In Erode in Tamilnadu two more tributaries join it – Noyyal and Amaravathi. In Trichirapalli, it branches out in to Coleroon and Cauvery. Cauvery again divides in to Arasalar and Cauvery at Papanasam, near Kumbakonam. Kumbakonam in Tanjore district is located at 10º 59' north latitude and 79º 23' longitudes.

India, along the certain holy river-edge settlements have grown into religious centers or holy cities. Kumbakonam is one such city in Tamilnadu, along the Cauvery River; located in the delta between the Cauvery and its tributary Arasalar. The city has developed in the delta between the Cauvery River to the north and the Arasalar River, to the south and has a gentle slope from north-west to south-east. In the present context, there are vast agricultural wetlands to the north and south of planning area; with the rivers Cauvery and Arasalar as the main source of irrigation.

The Arasalar is tributary of the river Cauvery, having a total run of 24 km. It enters Karaikal region, a little east of Akalanganni. It forms the natural boundary line separating Niravi Commune from Tirunallar on the north-west and Karaikal on the north east. The Nattar, branching off from Arasalar at Sakkotai in Thanjavur District, runs a distance of 11.2km in a south-easterly direction across Nedungadu and Kottucheri Communes before emptying itself into the sea. The Vanjiar fed by the Arasalar, takes its course along the northern boundary of Tirunallar Commune, drops on a south-easterly curve towards Karaikal Commune and merges with the Arasalar, south-east of Karaikal town after covering a distance of about 9 km. The Nular, also fed by the Arasalar, runs a distance of 13.77 km. before it joins Vanjiar northeast of Karaikal town. The mighty Cauvery River in Tamil Nadu is reduced to a number of unused channels and falls into the Bay of Bengal at the historical place of Poompuhar or Kaveripoompatinam about 13kms north of Tharangampadi.

2.2.2 Sampling and analysis of water

Three sampling stations were selected for river Cauvery such as station 1. Melakaveri (upstream of the river) station 2. Palakarai (midstream of the river) and station 3. Manajerry (downstream of the river) and similarly for river Arasalar such as station 1. Women’s College Bridge (upstream of the river) 2. Patthadi palam (midstream of the river) and station 3. Sakkottai (downstream of the river) for sampling purpose.

The physico-chemical water quality parameters were analyzed using standard methods. Water samples were collected from six stations on monthly basis using a standard water sampler for a period of one year (from Jan 2010 to Dec 2010). At the time of sampling, the air and water temperature were recorded by using alcoholic bulb and digital thermometer. Light penetration was recorded with the help of sacchi disk. Determination of pH and conductance were all so performed on site using portable meters (Henna pen type, Portugal). For other parameters samples were preserved by adding an appropriate reagent and brought to the laboratory in sampling kids maintained at 4 ºC for detailed chemical analysis by the methods as described by APHA, 1998 and Trivedy et al.,1986. Table 1 describes the methods adopted for analysis of water samples.

Table 1. Methods adopted for analysis of water samples studied.

S. No.	Parameters	Method/Instrument
1.	Temperature	Celsius thermometer
3.	Transparency	Sacchi disc
4.	Conductivity	Conductivity meter (Henna pen type) made in Portugal
5.	Total Solis	Gravimetric method (Muffle furnace drying)
6.	Dissolved solids	Gravimetric method (Muffle furnace drying)
7.	Suspended solids	Gravimetric method (Muffle furnace drying)
8.	pH	pH meter (Henna pen type) made in Portugal
9.	Free Co2	Titrimetric method
10.	Alkalinity TA	Titrimetric method
11.	DO	Winkler's iodometric method
12.	BOD	Winkler's method after incubation for 5 days
13.	COD	Titrimetric method
14.	Total Hardness	Titrimetric method
15.	Calcium	Titrimetric method
16.	Magnesium	Calculation from hardness and calcium
17.	Chloride	Titrimetric method
18.	Sodium	Flame Spectrometry
19.	Potassium	Flame Spectrometry
20.	Ammonia	Colorimetric (Nesslerisation)
21.	Nitrite	Colorimetric (EDTA disulphonilic acid method)
22.	Nitrate	Colorimetric (Phenol disulphonic acid method)
23.	Phosphate	Colorimetric (Molybdophosphoric acid method)
24.	Sulfate	Turbidimetric at 420nm
25.	Silicate	Colorimetric (Molybosilicate method)
26.	Iron	Colorimetric (110 phenonthroline method)

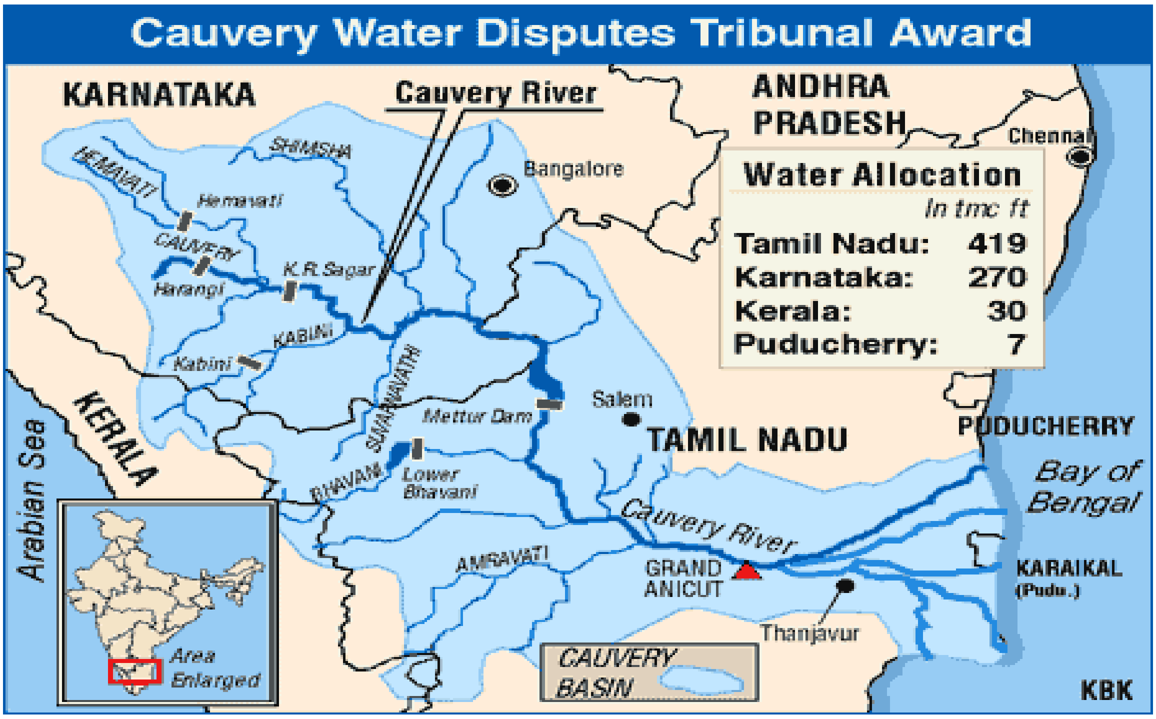


Figure 1. Cauvery River basin.

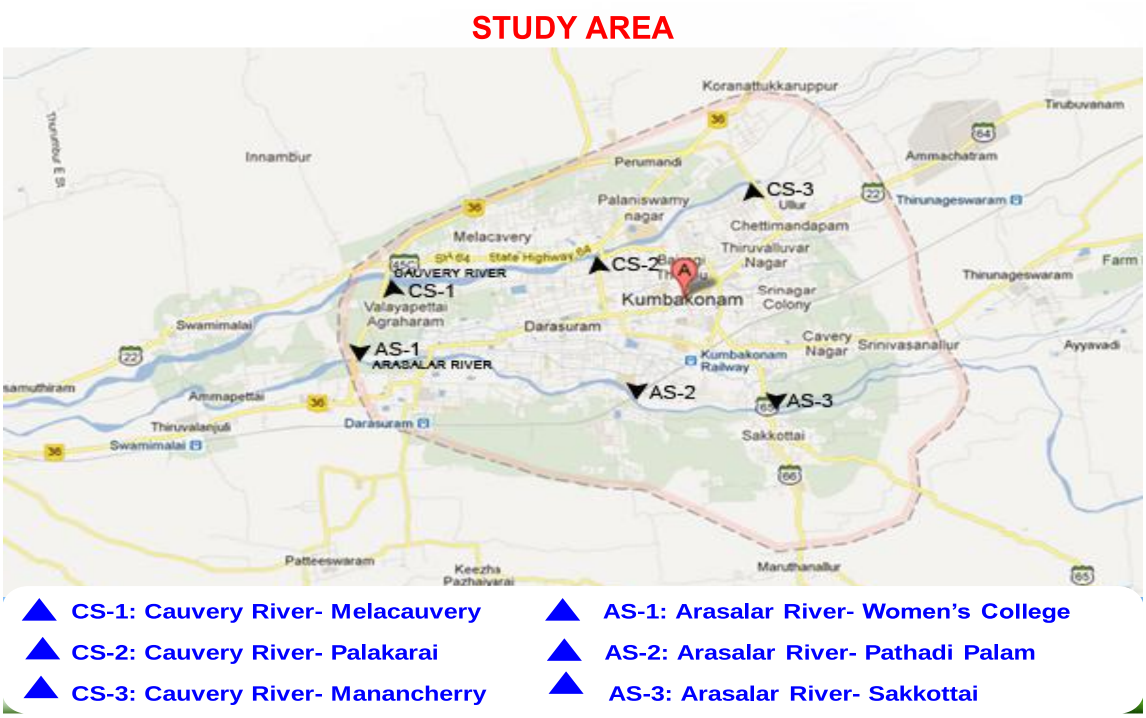


Figure 2. Study area.

Figure 3. River Cauvery, Station 1- Upstream (Melakaveri).

Figure 4. River Cauvery, Station 2 – Midstream (Palakarai)

Figure 5. River Cauvery, Station 3 – Downstream (Manajerry)

Figure 6. River Arasalar, Station 1- Upstream (Womens College)

Figure 7. River Arasalar, Station 2- Midstream (Patthadi palam)

Figure 8. River Arasalar, Station 3- Downstream (Sakkottai)

2.3 RESULTS

2.3.1 Physicochemical Analysis

Monthly variations of physico-chemical parameters (Air temperature, Water temperature, Transparency, Conductivity, Total solids, Total dissolved solids, Total suspended solids, pH, Free Co2, Dissolved oxygen, BOD, and COD) of the river Cauvery and its tributary Arasalar for a period of one year (Jan 2010 to Dec 2010) are presented in Table 2, 3, 4, 9, 10, 11 and Fig1 and Fig 2. While the range and mean values of physico-chemical parameters of the river Cauvery and its tributary Arasalar are listed in table 5 and 12. The Pearson's correlation analysis was used to assess the relationship between physico-chemical parameters and their significance was presented in the table 6, 7, 8, 13, 14, and 15.

2.3.1.1 Air temperature

The air temperature of Cauvery River and Arasalar River was observed to be in the ranges of from 26°C to 33°C and 27ºC to 32ºC. The minimum and maximum (26°C and 33°C) air temperature was recorded in the river Cauvery. The mean value of air temperature was found to be 30.84±3.43ºC, 30±2.85ºC and 30.30±1.43ºC for S1, S2, and S3 in the river Cauvery and 29.92±1.75ºC, 29.53±1.66ºC and 29.46±1.19ºC for S1, S2, and S3 in the river Arasalar respectively. The result showed that there is no significant difference in the air temperature between the two rivers.

Table 2. Physical and chemical properties of River Cauvery S1.

Parameters / Months	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
Air temperature(ºC)	32	31	30	36	32	33	34	36	28	26	27	26
Water temperature(ºC)	28	27	29	31	30	31	30	27	28	25	26	26
Transparency (cm)	26	35	48	89	115	61	50	45	69	67	90	50
Conductivity (µ Sie)	950	980	790	1220	1140	1330	1010	1200	930	910	900	780
Total Solis (mg/L)	420	440	470	650	670	600	580	540	480	440	680	520
Dissolved solids (mg/L)	253	158	229	258	357	401	298	305	325	227	399	328
Suspended solids mg/L	167	288	241	392	313	199	282	235	155	213	281	192
pH	7.7	7.8	7.5	7.8	7.9	7.9	8.0	8.1	7.6	7.4	7.5	7.8
Free Co2(mg/L)	1.2	1.4	1.6	1.8	2.0	1.9	1.7	1.5	1.3	1.1	0.9	1
Alkalinity TA (caco3)	170	210	180	220	230	250	310	250	210	190	220	170
DO (mg/L)	7.8	8	7.2	5.4	5.2	5.1	5.3	5.9	6.5	6.7	6.9	7.2
BOD*(mg/L)	11.2	10.4	9.2	8.2	9.1	9.2	8.2	7.2	11.5	12.1	12.5	13.5
COD(mg/L)	35	36	40	32	27	36	34	30	33	34	37	25
Total Hardness (mg/L)	72	92	120	160	162	170	93	125	235	150	184	135

Table 3. Physical and chemical properties of River Cauvery S2.

Parameters / Months	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
Air temperature(ºC)	31	30	30	32	32	33	33	34	29	27	25	26
Water temperature(ºC)	28	28	29	31	32	31	29	27	28	26	26.5	27
Transparency (cm)	29	38	45	92	121	118	55	40	65	62	99	65
Conductivity(µ Sie)	850	880	890	1220	1160	1320	1110	1250	830	810	900	880
Total Solis*(mg/L)	520	480	370	660	670	620	480	440	380	340	580	420
Dissolved solids (mg/L)	153	170	239	158	257	301	398	295	220	130	300	210
Suspended solids (mg/L)	367	310	131	502	413	319	82	145	160	210	200	210
pH	7.9	8.2	7.8	7.8	7.9	8.0	8.3	7.9	7.8	7.6	7.5	7.8
Free Co2(mg/L)	1.3	1.5	1.7	1.9	2.1	1.8	1.5	1.6	1.5	1.4	1.1	1.2
Alkalinity TA (caco3)	250	150	280	240	170	150	210	170	110	90	230	180
DO (mg/L)	6.8	7.5	7.2	6.4	6.2	5.5	4.3	4.9	5.5	6.7	6.8	7.2
BOD*(mg/L)	9.2	12.2	10.2	8.5	7.3	9.5	11.2	12.2	14.5	12.2	9.3	10.5
COD (mg/L)	38	36	48	36	28	46	44	40	32	36	38	28
Total Hardness (mg/L)	83	62	140	155	168	178	193	145	135	170	164	155

Table 4. Physical and chemical properties of River Cauvery S3.

Parameters / Months	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**Jun** 2010	**Jul** 2010	**Aug** 2010	**Sep** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
Air temperature(°C)	30	30	29	32	31	33	32	30	29	31	28	29
Water temperature(0	28	27	29	31	30	31	30	27	28	25	26	26
Transparency (cm)	30	39	45	60	88	92	120	60	140	160	202	180
Conductivity(m Sie)	770	840	880	950	1100	1220	980	1260	850	900	980	1100
Total Solis*(mg/L)	470	380	420	520	630	660	580	440	370	320	390	450
Dissolved solids	180	167	220	240	325	425	280	185	150	167	222	325
Suspended solids (mg/L)	290	213	200	280	305	235	300	255	220	153	168	125
pH	7.7	7.8	7.5	7.8	7.9	7.9	8.0	8.1	7.6	7.4	7.5	7.8
Free Co2(mg/L)	1.2	1.4	1.6	1.8	2.0	1.9	1.7	1.5	1.3	1.1	0.9	1
Alkalinity TA (caco3)	190	160	180	140	270	250	150	175	180	190	130	145
DO (mg/L)	7.8	8	7.2	5.4	5.2	5.1	5.3	5.9	6.5	6.7	6.9	7.2
BOD*(mg/L)	10.2	11.5	10.2	9.5	8.4	9.6	11.5	12.2	13.1	12.5	10.2	9.7
COD(mg/L)	34	37	43	45	36	28	44	40	30	32	27	26
Total Hardness (mg/L)	183	162	135	175	158	180	203	155	165	160	154	175

Table 5. Range value Mean value and Standard Deviation of Physico-Chemical Parameters of River Cauvery.

Water quality Parameters	**Range value**			**Mean value ± Standard Deviation**			**WHO Guide lines**
	S1	**S2**	**S3**	**Station 1**	**Station 2**	**Station 3**	
Air Temperature (ºC)	26-36	26-33	28-33	30.84±3.43	30±2.85	30.30±1.43	25
Water Temperature (ºC)	25-31	26-32	26-31	28.23±1.96	28.65±1.88	28.23±1.96	40
Transparency (cm)	40-28	42-160	45-140	111 ± 54.76	96.53 ± 43.03	91.61 ± 34.07	-
Electrical Conductivity (µ Sie)	780-1330	710-1320	770-1260	1003.84 ±169.14	985.38±198.05	1000.76 ±157.34	1500
Total Solis (mg/L)	420 -680	370 -670	320 -660	536.15±91.51	487.69±113.95	472.30±103.53	600
Dissolved Solids (mg/L)	158 -401	120 -398	167 -425	294.46±70.80	227±81.85	245.84±82.07	-
Suspended Solids (mg/L)	167 -392	131 -502	213 -305	247.53±65.27	254.53±122.19	226.46±57.80	-
pH	7.5 -8.1	7.6 -8.3	7.4 -8.1	7.74±0.20	7.85±0.22	7.74±0.20	6.5-8.5
Free Co2(mg/L)	0.9 -2.0	1.1 -2.1	0.9 -1.9	1.43±0.35	1.53±0.28	1.43±0.35	0.5-2.0
Alkalinity TA (caco3)	170-310	90-280	130-270	217.5±40.02	185.83±57.59	180±42.47	30
Dissolved Oxygen (mg/L)	5.1 -8.0	4.3 -7.6	5.1 -7.8	6.51±1.03	6.35±1.02	6.51±1.03	5.0-6.0
BOD (mg/L)	7.2 -14.1	9.2 -14.5	8.4 -13.1	10.46±2.17	10.61±1.91	10.56±1.46	<2
COD (mg/L)	25 - 40	28 - 48	26 - 45	33.07±4.11	36.92±6.46	34.76±6.63	50
Total Hardness (mg/L)	72-184	62-193	135-203	141.5±45.33	145.66±38.09	167.08±17.43	200

Table 6. Correlation matrix among various Physico-chemical parameters in river Cauvery at S1.

	AT	WT	Trans	EC	TS	TDS	TSS	pH	Co2	Alkali	DO	BOD	COD	Hard
AT	1													
WT	0.700161**	1												
Trans	-0.05454	0.249182	1											
EC	0.767221**	0.626691*	0.279125	1										
TS	0.294908	0.445622	0.77786**	0.493195	1									
TDS	-0.05526	0.200238	0.509976*	0.30413	0.697449*	1								
TSS	0.466605	0.395243	0.517001*	0.352375	0.62199*	-0.12715	1							
pH	0.749044**	0.455867	-0.10318	0.639878	0.31682	0.197943	0.226389	1						
Co2	0.736151**	0.890974**	0.293296	0.713604**	0.395852	0.08547	0.453378	0.562067*	1					
Alkali	0.575839*	0.473723	0.170722	0.574328*	0.510671*	0.327972	0.350826	0.638125*	0.53226*	1				
DO	-0.53546*	-0.66404*	-0.57092*	-0.73933	-0.70694**	-0.54546	-0.37731	-0.51932*	-0.72283**	-0.73027**	1			
BOD	-0.91767**	-0.68555*	-0.0366	-0.68976*	-0.28717	0.074575	-0.47565	-0.648*	-0.82195**	-0.64328*	0.613517*	1		
COD	-0.01645	0.078823	-0.29075	-0.1297	-0.24673	-0.26826	-0.04703	-0.47239	-0.04454	-0.00134	0.284136	-0.07687	1	
Hard	-0.31741	0.031495	0.668427*	0.13136	0.40311	0.571498*	-0.06661	-0.29058	-0.0178	0.008266	-0.35796	0.218305	-0.124	1

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 7. Correlation matrix among various Physico-chemical parameters in river Cauvery at S2.

S2	AT	WT	Trans	EC	TS	TDS	TSS	pH	Co2	Alkali	DO	BOD	COD	Hard
AT	1													
WT	0.621977*	1												
Trans	-0.01011	0.584498*	1											
EC	0.76304**	0.65503*	0.495954	1										
TS	0.345778	0.716868**	0.704137**	0.635891*	1									
TDS	0.332128	0.176395	0.244719	0.48725	0.176871	1								
TSS	0.205516	0.592891*	0.424502	0.301339	0.74372**	-0.50437*	1							
pH	0.666348*	0.374953	-0.24802	0.343042	0.107609	0.36122	-0.03007	1						
Co2	0.696433*	0.873342**	0.45174	0.670395*	0.482168	0.067008	0.478123	0.288611	1					
Alkali	0.112686	0.210875	-0.13133	0.069842	0.281215	0.155905	0.111739	-0.00178	-0.00271	1				
DO	-0.62137*	-0.2048	-0.11769	-0.5967* 9	-0.08463	-0.70411**	0.326696	-0.39593	-0.25069	0.19379	1			
BOD	-0.14141	-0.59665*	-0.5513*	-0.39754	-0.78706**	-0.0515	-0.63587*	0.104904	-0.3739	-0.57394*	-0.22068	1		
COD	0.385222	0.068402	-0.18878	0.262708	-0.09226	0.413644	-0.34181	0.246682	0.063618	0.39404	-0.2724	0.01573	1	
Hard	0.037349	0.212296	0.604944*	0.448415	0.1574	0.567645*	-0.23639	-0.19129	0.210123	-0.09019	-0.53079	-0.20726	0.124019	1

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 8. Correlation matrix among various Physico-chemical parameters in river Cauvery at S3

S3	AT	WT	Trans	EC	TS	TDS	TSS	pH	Co2	Alkali	DO	BOD	COD	Hard
AT	1													
WT	0.665424 *	1												
Trans	-0.30213	-0.48081	1											
EC	0.309274	0.178661	0.15023	1										
TS	0.69657*	0.82256**	-0.2398	0.52119	1									
TDS	0.514354	0.533837 *	0.135189	0.64805*	0.832938**	1								
TSS	0.535315 *	0.73463**	-0.61953*	0.033799	0.636781*	0.103729	1							
pH	0.479301	0.455867	-0.34955	0.63569*	0.653989*	0.422565	0.586672*	1						
Co2	0.724011**	0.890974**	-0.55321*	0.351874	0.784638**	0.495026	0.720532**	0.562067	1					
Alkali	0.435877	0.393869	-0.26486	0.32014	0.548508*	0.455346	0.351407	0.183868	0.578704*	1				
DO	-0.69577*	-0.66404 *	-0.06087	-0.6313*	-0.72875**	-0.57893*	-0.50318*	-0.5193*	-0.72283**	-0.39692	1			
BOD	-0.19508	-0.47511	0.139074	-0.25608	-0.64917*	-0.6843*	-0.21332	-0.16934	-0.38322	-0.31698	0.22696	1		
COD	0.325971	0.479142	-0.64175*	-0.13326	0.170193	-0.21347	0.603337*	0.31821	0.558923*	-0.14548	-0.24679	0.016701	1	
Hard	0.566305*	0.339872	0.057341	0.025461	0.481653	0.337185	0.395886	0.463651	0.142422	-0.08345	-0.30968	-0.02684	0.019132	1

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 9. Physical and chemical properties of River Arasalar S1.

Parameters / Months	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010
Air temperature(°C)	30	31	29	32	30	32	33	30	28	29	28	27
Water temperature(0	29	28	29	30	31	31	29	29	30	27	28	26
Transparency (cm)	40	49	45	65	88	98	130	110	120	130	208	190
Conductivity(m Sie)	910	1040	980	1050	1100	1220	980	1160	950	950	980	1025
Total Solis*(mg/L)	570	480	620	520	630	660	580	740	570	520	690	750
Dissolved solids	320	267	320	240	325	425	280	385	250	267	322	325
Suspended solids (mg/L)	250	213	300	280	305	235	300	355	320	253	368	425
pH	7.6	7.9	7.6	7.7	8	7.9	8.1	8.2	7.6	7.7	7.5	7.8
Free Co2(mg/L)	1.6	1.5	1.7	1.8	1.7	2	2.1	1.8	1.4	1.6	1.1	1.9
Alkalinity TA (caco3)	200	200	190	210	270	350	400	230	220	180	190	165
DO (mg/L)*	6.8	6.4	6.8	5.4	5.6	6.1	6.3	6	6.4	6.7	6.8	7.3
BOD*(mg/L)	14.2	12.5	13.2	11.8	13.7	10.5	11.2	12.4	13.3	12.5	10.8	9.9
COD(mg/L)	52	47	55	48	46	38	44	42	31	34	29	36
Total Hardness (mg/L)	283	182	165	155	178	280	233	165	145	205	144	165

Table 10. Physical and chemical properties of River Arasalar S2.

Parameters / Months	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010
Air temperature(°C)	29	30	30	31	32	31	32	29	27	29	28	27
Water temperature(0	28	29	29	31	30	31	28	29	30	28	27	27
Transparency (cm)	42	45	35	55	78	88	110	130	140	112	108	160
Conductivity(m Sie)	810	940	1080	1050	850	1120	960	1260	1150	1050	1280	1050
Total Solis*(mg/L)	670	580	720	620	530	560	780	640	670	590	690	760
Dissolved solids	350	213	300	280	305	235	300	355	320	253	368	425
Suspended solids (mg/L)	320	367	400	340	225	325	480	285	350	337	322	335
pH	7.7	7.9	7.8	7.7	8.1	7.9	8.1	8.2	7.6	7.6	8.4	7.8
Free Co2(mg/L)	1.8	1.6	2	1.6	1.7	2	2.1	1.8	1.3	1.6	1.3	1.9
Alkalinity TA (caco3)	220	180	290	230	170	250	300	140	210	150	130	195
DO (mg/L)	6.6	6.2	6.7	5.2	6.6	5.1	5.3	6.5	6.2	6.9	6.6	7.5
BOD (mg/L)	12.5	14.4	13.6	10.8	14.7	11.5	12.2	11.4	14.3	11.5	13.8	10.9
COD(mg/L)	62	58	64	58	36	40	44	46	41	51	32	38
Total Hardness (mg/L)	183	163	205	195	168	180	202	155	175	225	164	185

Table 11. Physical and chemical properties of River Arasalar S3.

Parameters / Months	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010
Air temperature(°C)	28	29	30	29	32	31	30	30	28	29	29	28
Water temperature(0	29	30	28	32	31	30	29	28	29	27	28	27
Transparency (cm)	51	55	45	56	68	79	101	128	140	132	108	106
Conductivity(m Sie)	960	840	980	1060	950	1020	990	1060	1150	1050	1180	1060
Total Solis*(mg/L)	570	680	620	520	640	665	775	640	570	690	780	660
Dissolved solids	320	367	400	330	225	335	480	285	350	335	322	335
Suspended solids (mg/L)	250	313	200	190	415	330	295	355	220	355	458	325
pH	7.8	7.7	7.9	7.6	8.0	7.6	8.2	8.1	7.7	7.5	8.2	7.9
Free Co2(mg/L)	1.7	1.5	2.1	1.7	1.8	2.0	2.0	1.7	1.9	1.7	1.6	1.8
Alkalinity TA (caco3)	210	170	220	173	184	150	200	190	213	162	174	205
DO (mg/L)	6.5	5.2	6.2	5.3	6.4	7.1	7.3	7.7	6.3	5.9	5.6	6.5
BOD*(mg/L)	12.0	14	13	10	14	11	12	11	14	11	13	10
COD(mg/L)*	52	48	54	68	46	50	34	56	51	41	42	39
Total Hardness (mg/L)	164	202	275	145	178	190	175	215	255	155	144	135

Table 12. Range value Mean value and Standard Deviation of Physico-Chemical Parameters of River Arasalar.

Water quality Parameters	Range value			Mean value ± Standard Deviation			WHO Guide line
	S1	S2	S3	Station 1	Station 2	Station 3	
Air Temperature (ºC)	27-33	27-32	28-32	29.92 ± 1.75	29.53 ± 1.66	29.46 ± 1.19	25
Water Temperature (ºC)	26-31	27-31	27-32	29 ± 1.58	28.84 ± 1.62	29 ± 1.47	40
Transparency (cm)	26 -115	29 - 121	30-160	62.61±24.56	70.61±30.48	105.84±58.17	-
Electrical Conductivity (μ Sie)	910-1220	810-1280	840-1180	1036.53±92.45	1056.92±140.8	1018.46±90.35	1500
Total Solis (mg/L)	480-750	580-780	570-775	610.76±83.21	655.38 ± 77.20	646 ± 75.56	600
Dissolved Solids (mg/L)	240-425	213-425	320-480	310.46±52.23	308 ± 57.56	347.23 ± 61.64	-
Suspended Solids (mg/L)	213-425	320-410	190-458	300.30±58.16	345.84 ± 61.72	299.69 ± 86.14	-
pH	7.5-8.2	7.6-8.4	7.6-8.3	7.79 ± 0.21	7.93 ± 0.26	7.88 ± 0.26	6.5-8.5
Free Co2(mg/L)	1.1-2.1	1.3-2.2	1.5-2.1	1.71 ± 0.28	1.76 ± 0.28	1.81 ± 0.19	0.5-2.0
Alkalinity TA (caco3)	170-310	90-280	130-270	217.5±40.028	185.83±57.59	180±42.47	30
Dissolved Oxygen (mg/L)	5.4-7.4	5.1-7.5	5.2-7.7	6.46 ± 0.59	6.36 ± 0.76	6.42 ± 0.80	5.0-6.0
BOD (mg/L)	8.7-14.2	9.7-14.4	9-14	11.9 ± 1.60	12.40 ± 1.60	11.84 ± 1.67	2
COD (mg/L)	30-55	31-64	34-68	40.92 ± 8.58	46.23 ±11.33	47.92 ± 8.80	50
Total Hardness (mg/L)	72-184	62-193	135-203	141.5± 45.33	145.66 ±38.09	167.08 ±17.43	200

Table 13. Correlation matrix among various physico-chemical parameters in river Arasalar at S1

S1	AT	WT	Trans	EC	TS	TDS	TSS	pH	Co2	Alkal	DO	BOD	COD	Hard
AT	1													
WT	0.54088*	1												
Trans	-0.48589	-0.43941	1											
EC	0.368805	0.517566*	-0.04453	1										
TS	-0.41062	-0.08234	0.56762*	0.411709	1									
TDS	0.037749	0.319864	0.093987	0.691761*	0.72119**	1								
TSS	-0.62132	-0.40502	0.727627**	-0.0322	0.782967**	0.133741	1							
pH	0.515133*	0.198762	-0.05762	0.633289*	0.221882	0.352731	0.000675	1						
Co2	0.561548	0.222234	-0.18176	0.445153	0.146515	0.298445	-0.0584	0.647514	1					
Alkal	0.737045**	0.592885*	-0.0358	0.400723	0.011084	0.290919	-0.24538	0.587313*	0.606246*	1				
DO	-0.64707*	-0.7262**	0.38969	-0.53726*	0.247546	0.030532	0.326717	-0.44355	-0.24656	-0.42071	1			
BOD	-0.02701	0.245153	-0.67784*	-0.34324	-0.44771	-0.26332	-0.40402	-0.13704	-0.29139	-0.21943	-0.19987	1		
COD	0.454029	0.219174	-0.84143**	-0.00745	-0.29762	-0.02131	-0.40663	0.158412	0.356922	0.054493	-0.24183	0.491179	1	
Hard	0.506848*	0.298166	-0.32242	0.100189	-0.14596	0.395151	-0.56364*	0.166051	0.445936	0.51266	0.049848	0.044387	0.261045	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 14. Correlation matrix among various physico-chemical parameters in river Arasalar at S2.

S1	AT	WT	Trans	EC	TS	TDS	TSS	pH	Co2	Alkal	DO	BOD	COD	Hard
AT	1													
WT	0.519837*	1												
Trans	-0.53441*	-0.36126	1											
EC	-0.45007	-0.00749	0.497259	1										
TS	-0.34405	-0.6394*6	0.314352	0.160171	1									
TDS	-0.57793*	-0.64567*	0.519454*	0.221673	0.614436*	1								
TSS	0.117129	-0.19081	-0.06435	-0.01753	0.657762*	-0.18615	1							
pH	0.258677	-0.16322	0.13509	0.298827	0.05434	0.226133	-0.14035	1						
Co2	0.490519	0.026089	-0.15093	-0.31417	0.269783	-0.03728	0.352229	0.078063	1					
Alkal	0.436964	0.273616	-0.33689	-0.30618	0.408907	-0.2167	0.693459*	-0.26386	0.65088*	1				
DO	-0.62832*	-0.71722**	0.272878	-0.00171	0.188725	0.572905*	-0.33602	-0.05872	-0.17385	-0.50528*	1			
BOD	0.024163	0.046124	-0.27924	-0.17797	-0.18805	-0.16517	-0.09971	0.195379	-0.41507	-0.10567	0.151628	1		
COD	0.17221	0.127638	-0.73151**	-0.38136	0.000533	-0.36136	0.309935	-0.51527*	0.227708	0.374852	-0.07082	-0.08681	1	
Hard	0.155929	-0.09724	-0.10404	-0.21834	0.235684	-0.2317	0.499039	-0.56996*	0.311464	0.459096	-0.03107	-0.38003	0.379221	1

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 15. Correlation matrix among various Physico-chemical parameters in river Arasalar at S3.

S2	AT	WT	Trans	EC	TS	TDS	TSS	pH	Co2	Alkal	DO	BOD	COD	Hard
AT	1													
WT	0.381457	1												
Trans	-0.22753	-0.55016 *	1											
EC	-0.30174	-0.32452	0.673608 *	1										
TS	0.218225	-0.42322	0.310452	0.050187	1									
TDS	-0.23564	-0.19813	-0.02602	-0.11025	0.338047	1								
TSS	0.366685	-0.23472	0.336844	0.138757	0.692664 *	-0.44198	1							
pH	0.229738	-0.22237	0.123535	0.145936	0.54132 *	0.095615	0.429982	1						
Co2	0.346311	-0.06638	-0.03559	0.07001	-0.03893	0.42144	-0.38433	0.074624	1					
Alkal	-0.34227	-0.2949	-0.03224	0.043713	-0.26579	0.261211	-0.47202	0.372929	0.384202	1				
DO	0.347997	-0.24744	0.317774	0.059268	0.162741	0.08491	0.092752	0.394841	0.552178	0.238653	1			
BOD	0.174536	0.157155	-0.12875	-0.23537	0.13567	-0.01909	0.127273	0.214538	-0.03108	0.223674	-0.22966	1		
COD	-0.01695	0.538173 *	-0.39006	0.003876	-0.81642**	-0.31065	-0.54645 *	-0.38579	-0.08825	-0.02263	-0.24086	-0.15699	1	
Hard	0.156939	-0.04149	-0.03739	-0.12275	-0.24827	0.209952	-0.43011	-0.01849	0.488635	0.439096	0.188556	0.523521 *	0.267345	1

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 16. Nutrient concentration of River Cauvery at station 1.

Parameters/Months	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010
Calcium (mg/L)	12.8	11.5	11.2	12.7	11.6	13.2	14.5	14.9	15.1	13.5	13.1	12.4
Magnesium (mg/L)	41.5	39	42	40	43	39.5	41.6	45	42.3	46.1	43.6	44.2
Chloride(mg/L)	55.2	69.4	80.7	103	89.4	73.7	46.8	33.3	57.2	61.1	46.8	35.2
Sodium (mg/L)	50.1	53.5	48	42.5	39.5	44	48	52	54	56	58	52
Potassium (mg/L)	7.5	5.4	7.8	8.1	6.6	6.3	7.2	8.4	7.8	6.9	7.4	7.8
Ammonia (mg/L)	0.34	0.32	0.36	0.38	0.37	0.39	0.41	0.33	0.35	0.39	0.32	0.37
Nitrite (mg/L)	3.5	3.8	4.5	4.2	4	3.5	3.2	2.9	2.5	3.8	4.2	4.6
Nitrate (mg/L)	43	42	48	50	52	38	47	45	42	40	47	53
Phosphate (mg/L)	1.2	1.5	1.1	1.3	1.4	1.5	1.7	1.6	0.9	1	1.5	1.6
Sulfate (mg/L)	13.5	12.9	12.5	14.2	12.7	13.2	12.5	12.9	13.5	13.9	14.1	12.8
Silicate (mg/L)	7.2	6.8	6.5	6.9	7.8	5.1	4.5	3.2	7.5	6.9	5.9	6.2
Iron (mg/L)	0.36	0.53	0.42	1	0.62	0.6	1.1	0.85	0.90	0.33	0.43	0.52

Table17. Nutrient concentration of River Cauvery at station 2.

Parameters/ Months	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010
Calcium (mg/L)	13.5	12.4	13.2	12.8	13.5	14.6	13.7	12.6	12	12.7	13	14.2
Magnesium (mg/L)	40	42	44	46	43	45	40	41.5	39	38.5	41	46
Chloride(mg/L)	40.3	52.4	30.7	93	64.4	53.7	76.8	63.3	47.2	71.1	36.8	45.2
Sodium (mg/L)	48	52	54	56	58	45	50.5	44	42	43	40	38
Potassium (mg/L)	6.4	6	5.4	7.2	5.1	6.7	7.1	7.4	6.9	7.2	6.5	6.4
Ammonia (mg/L)	0.33	0.32	0.34	0.29	0.25	0.4	0.35	0.34	0.42	0.44	0.46	0.38
Nitrite (mg/L)	3.5	3.8	4	4.5	4.2	4.2	3.4	3.2	4.4	3.8	4.7	3.7
Nitrate (mg/L)	41	45	38	46	53	45	51	50	49	54	45	35
Phosphate (mg/L)	0.9	0.95	0.89	1.1	0.85	1.2	1.3	1.5	1.6	1.8	1.7	0.9
Sulfate (mg/L)	13.9	12.8	11.9	12.5	12.8	13.2	13.5	12.4	12.6	11.8	13.1	12.9
Silicate (mg/L)	7.2	6.5	3.8	3.3	4.6	2.7	5.1	6.2	4.5	2.7	1.9	3.2
Iron (mg/L)	1.2	1.3	0.5	0.64	1.2	0.99	0.29	0.68	0.79	0.43	0.23	0.42

Table 18. Nutrient concentration of River Cauvery at station 3.

Parameters / Months	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010
Calcium (mg/L)	10.2	12.8	13.4	13.2	13.8	14.2	13.6	12.6	12.4	12.7	13.7	13.2
Magnesium (mg/L)	35.9	40.1	42	38	35	33	40.5	41.5	39	38.5	43.2	42
Chloride(mg/L)	35.5	41.1	36.2	66	54.2	43.2	46.8	53.3	37.2	60.1	46.8	35.1
Sodium (mg/L)	45	48	54	56	60	55	54	52	49	47	45	42
Potassium (mg/L)	7.1	6.5	5.9	7.3	5.5	6.9	7.1	7.4	7.2	7.4	6.8	6.4
Ammonia (mg/L)	0.43	0.36	0.34	0.33	0.35	0.4	0.25	0.36	0.42	0.44	0.45	0.38
Nitrite (mg/L)	3.9	3.6	4	4.7	4.2	4.9	3.5	3.8	4.5	3.9	4.9	3.8
Nitrate (mg/L)	38	45	44	46	35	49	50	46	54	35	47	52
Phosphate (mg/L)	1.2	1.4	0.96	1.1	1.4	1.7	0.85	0.9	1.2	1.5	1.4	1.7
Sulfate (mg/L)	14.1	13.5	12.1	12.5	12.8	13.4	13.5	11.9	12.6	13.9	14	12.9
Silicate (mg/L)	7.5	6.9	6.5	5.9	4.8	3.8	5.2	6.1	4.8	3.7	2.9	3.2
Iron (mg/L)	0.52	0.24	0.35	1.4	0.91	1.4	1.2	0.85	0.89	1.55	1.31	0.72

Table 19. Nutrient concentration of River Arasalar at station 1.

Parameters / Months	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010
Calcium (mg/L)	26.66	37.71	67.33	72.14	60.33	47.33	39.31	62.54	30.08	30.66	48	49.31
Magnesium (mg/L)	19.84	23	18.7	35.1	26.27	23.58	22.12	31.58	25.84	25.7	21.96	22.12
Chloride (mg/L)	173.24	113.6	107.92	191.7	272.2	312.4	352.1	262.1	93.72	96.56	127.8	94.4
Sodium (mg/L)	145	148	154	256	260	255	154	252	149	147	245	242
Potassium (mg/L)	23.38	21.25	12.25	16.38	14.57	13.96	14.15	15.44	11.23	12.42	13.81	11.42
Ammonia (mg/L)	0.82	0.58	0.07	0.12	0.17	0.17	0.43	0.26	0.52	0.34	0.35	0.48
Nitrite (mg/L)	3.9	3.6	4	4.7	4.2	4.9	3.5	3.8	4.5	3.9	4.9	3.8
Nitrate (mg/L)	24.61	13.91	24.22	36.11	35.2	39.22	40	26.22	34.82	35.44	27.10	32.11
Phosphate (mg/L)	1.1	1.2	0.96	1.5	1.3	1.6	0.85	1.9	1.3	1.4	1.5	1.6
Sulfate (mg/L)	114.46	99.16	65.94	59.16	76.13	99.4	48.52	62.92	52.62	55.22	38.63	33.93
Silicate (mg/L)	17.48	15.57	12.2	20.6	16.2	41.2	18.8	12.1	21.2	22.3	11.82	10.52
Iron (mg/L)	1.56	1.33	1.22	1.13	1.72	0.89	0.19	0.78	0.99	0.33	0.33	0.22

Table 20. Nutrient concentration of River Arasalar at station 2.

Parameters/ Months	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010
Calcium (mg/L)	32.06	41.68	36.87	57.71	60.12	64.12	67.33	64.12	49.69	39.69	60.92	56.11
Magnesium (mg/L)	19.5	16.67	19.3	25.93	26.81	33.25	37.73	29.25	19.59	24.47	24.17	22.9
Chloride (mg/L)	153.24	109.6	107.92	161.9	172.2	212.4	252.1	162.1	83.72	86.56	107.8	84.4
Sodium (mg/L)	125	118	124	156	160	155	164	232	249	187	225	212
Potassium (mg/L)	14.38	16.25	12.25	17.38	15.57	14.96	12.15	13.44	12.43	11.32	12.71	12.32
Ammonia (mg/L)	0.73	0.43	0.09	0.34	0.27	0.19	0.33	0.16	0.42	0.24	0.25	0.38
Nitrite (mg/L)	2.5	4.6	3.1	3.7	3.2	4.7	2.3	2.8	4.3	3.5	2.9	2.8
Nitrate (mg/L)	20.75	12.61	18.22	26.16	25.4	29.21	30	26.18	32.84	33.24	30.10	32.25
Phosphate (mg/L)	1	1.1	0.96	0.9	1.3	1.4	1.05	1.5	1.8	1.6	1.3	1.2
Sulfate (mg/L)	94.46	109.12	55.72	49.22	86.18	88.44	52.32	42.52	52.55	75.22	48.63	43.53
Silicate (mg/L)	12.84	11.51	10.1	15.3	12.4	20.2	14.4	9.1	11.3	16.4	9.74	10.45
Iron (mg/L)	1.22	0.444	0.555	1.66	2.1	1.1	1.19	1.28	0.89	2.55	2.31	1.22

Table 21. Nutrient concentration of River Arasalar at station 3.

Parameters Months	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010
Calcium (mg/L)	33.66	40.08	32.06	64.12	56.11	65.73	88.77	70.14	49.69	48.09	51.3	51.3
Magnesium (mg/L)	13.13	19.5	9.61	28.27	22.9	32.76	36.41	32.66	23.01	22.42	25.05	25.54
Chloride (mg/L)	85.2	79.4	90.72	173.24	99.4	93.72	56.8	113.6	127.8	71	56.8	85.2
Sodium (mg/L)	242	245	147	149	154	148	174	202	169	187	145	142
Potassium (mg/L)	8.5	6.5	9.1	7.3	11.1	12.5	7.9	6.9	7.8	8.5	9.3	10.8
Ammonia (mg/L)	0.21	0.48	0.37	0.6	0.15	0.06	0.38	0.19	0.55	0.14	0.16	0.19
Nitrite (mg/L)	3.5	4.8	4.2	3.3	4.0	3.2	3.1	2.2	2.8	3.7	4.5	3.9
Nitrate (mg/L)	22.62	15.82	18.22	16.1	34.2	32.44	32	28.33	32.42	28.32	29.13	22.15
Phosphate (mg/L)	1.8	2.2	1.96	1.5	0.9	1.2	1.85	1.25	1.4	1.3	1.2	1.7
Sulfate (mg/L)	128	132	95.94	89.16	76.13	99.8	78.5	42.9	52.62	75.22	58.6	63.9
Silicate (mg/L)	10.32	12.52	11.2	18.6	14.2	21.2	28.8	14.1	15.2	12.3	12.82	13.52
Iron (mg/L)	0.56	0.33	0.92	1.13	0.72	1.56	1.44	1.2	0.99	0.43	0.33	0.62

Table 22. Range value Mean value and Standard Deviation of nutrient concentration of River Cauvery.

Water quality Parameters	Range value			Mean value ± Standard Deviation			WHO Guide line
	S1	S2	S3	Station 1	Station 2	Station 3	
Calcium (mg/L)	11.5 – 15.1	12 – 14.6	10.2 – 14.2	13.041 ± 1.296	13.183 ± 0.755	12.983 ± 1.029	75
Magnesium (mg/L)	39 – 46.1	38.5 – 46	33 – 43.2	42.316 ± 2.189	42.166 ± 2.631	39.058 ± 3.135	50
Chloride (mg/L)	33.3 – 89.4	30.7 – 93	35.1 – 66	62.65 ± 21.409	56.241 ± 18.14	46.291 ± 10.242	200
Sodium (mg/L)	39.5 – 58	40 – 58	42 – 60	49.8 ± 5.610	47.541 ± 6.534	50.583 ± 5.401	200
Potassium (mg/L)	6.3 – 8.4	5.1 – 7.4	5.5 – 7.4	7.2666 ± 0.847	6.525 ± 0.725	6.7916 ± 0.608	10
Ammonia (mg/L)	0.32 – 0.41	0.25 – 0.46	0.25 – 0.45	0.3608 ± 0.029	0.36 ± 0.0620	0.3758 ± 0.0568	-
Nitrite (mg/L)	2.5 – 4.6	3.2 – 4.7	3.5 – 4.9	3.725 ± 0.636	3.95 ± 0.464	4.1416 ± 0.492	3
Nitrate (mg/L)	38 – 53	35 – 54	35 – 54	45.583 ± 4.737	45.916 ± 5.728	45.083 ± 6.229	50
Phosphate (mg/L)	0.9 – 1.7	0.85 – 1.8	0.85 – 1.7	1.3583 ± 0.257	1.2241 ± 0.348	1.275 ± 0.2893	0.1
Sulfate (mg/L)	12.5-14.2	11.8-13.9	11.9 - 11.9	13.225 ± 0.606	12.783 ± 0.607	13.1 ± 0.741	200
Silicate (mg/L)	3.2-7.8	1.9-7.2	2.9-7.5	6.2083 ± 1.343	4.3083 ± 1.677	5.1083 ± 1.504	-
Iron (mg/L)	0.33-1.1	0.23-1.3	0.24-1.55	0.6383 ± 0.260	0.722 ± 0.373	0.945 ± 0.434	1

Table 23. Range value Mean value and Standard Deviation of nutrient concentration of River Arasalar.

Water quality Parameters	**Range value**			**Mean value ± Standard Deviation**			**WHO Guide line**
	S1	**S2**	**S3**	**Station 1**	**Station 2**	**Station 3**	
Calcium (mg/L)	26.66 - 72.14	32.06 - 67.33	33.66 - 88.77	47.61 ± 15.311	52.535 ± 12.099	54.254 ± 16.152	75
Magnesium (mg/L)	18.7 - 35.1	16.67- 37.73	13.13 - 36.41	24.65 ± 4.717	24.964 ± 6.172	24.271 ± 7.843	50
Chloride (mg/L)	93.72 - 272.2	83.72 - 252.1	56.8 - 173.24	158.14 ± 69.755	141.161 ± 54.000	94.406 ± 32.345	200
Sodium (mg/L)	145 - 260	118 - 249	142 - 245	200.58 ± 53.615	175.583 ± 44.914	175.333 ± 36.82	200
Potassium (mg/L)	8.15 - 17.25	8.32 - 15.25	6.5 - 12.5	12.68 ± 2.717	12.013 ± 2.355	8.85 ± 1.819	10
Ammonia (mg/L)	0.26 - 0.82	0.16 - 0.73	0.06 - 0.6	0.45 ± 0.163	0.319 ± 0.166	0.29 ± 0.179	-
Nitrite (mg/L)	2.2-4.9	2.3 - 4.7	2.2 - 4.8	3.75 ± 0.799	3.366 ± 0.806	3.6 ± 0.737	3
Nitrate (mg/L)	13.91- 40	12.61 - 32.84	15.82 - 34.2	30.74 ± 7.651	26.413 ± 6.375	25.979 ± 6.707	50
Phosphate (mg/L)	0.85 - 1.9	0.9 - 1.8	0.9 – 2.2	1.26 ± 0.314	1.259 ± 0.277	1.521 ± 0.381	0.1
Sulfate (mg/L)	33.93 - 114.4	42.52 - 109.1	42.9 - 132	67.17 ± 25.377	66.492 ± 22.913	82.730 ± 27.850	200
Silicate (mg/L)	10.52 - 41.2	9.1 - 20.2	10.32 - 28.8	18.33 ± 8.229	12.8116 ± 3.2539	15.398 ± 5.206	-
Iron (mg/L)	0.22 - 1.72	0.89 - 2.1	0.33 - 1.56	0.89 ± 0.529	1.369 ± 0.652	0.852 ± 0.420	1

Table 24. Correlation matrix among various nutrients in river Cauvery at S1.

S1	Calcium	Magnesium	Chloride	Sodium	Potassium	Ammonia	Nitrite	Nitrate	Phosphate	Sulphate	Silicate	Iron
Calcium	1											
Magnesium	0.312555	1										
Chloride	-0.54153*	-0.53038*	1									
Sodium	0.324688	0.440289	-0.68325*	1								
Potassium	0.41078	0.442459	-0.25493	0.065743*	1							
Ammonia	0.123134	-0.01437	0.251591	-0.49367	-0.00973	1						
Nitrite	-0.81495**	0.008798	0.318363	-0.15034	-0.06734	0.047374	1					
Nitrate	-0.3536	0.182973	0.091012	-0.33617	0.399082	0.061511	0.561089 *	1				
Phosphate	-0.00794	-0.12925	-0.33867	-0.1523	-0.15271	0.017029	0.12889	0.312391	1			
Sulfate	0.199818	0.072242	0.167929	0.288392	0.166267	-0.13911	0.019424	-0.24293	-0.38296	1		
Silicate	-0.49639	-0.15201	0.544947*	-0.11369	-0.24228	-0.05085	0.292844	0.11481	-0.65046*	0.279786	1	
Iron	0.554022*	-0.24042	0.051329	-0.33961	0.305172	0.330048	-0.49386	0.183298	0.269616	-0.1101	-0.3568	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 25. Correlation matrix among various nutrients in river Cauvery at S2.

S2	Calcium	Magnesium	Chloride	Sodium	Potassium	Ammonia	Nitrite	Nitrate	Phosphate	Sulphate	Silicate	Iron
Calcium	1											
Magnesium	0.511475*	1										
Chloride	-0.10091	0.064969*	1									
Sodium	-0.05049	0.245396	0.37094	1								
Potassium	-0.20168	-0.27399	0.497535	-0.46937	1							
Ammonia	-0.06009	-0.38952	-0.34666	-0.84364**	0.428149	1						
Nitrite	-0.12964	0.230731	-0.07152	0.060691	-0.20395	0.214512	1					
Nitrate	-0.37433	-0.54483*	0.609177*	0.199254	0.298246	-0.04346	0.00171	1				
Phosphate	-0.43548	-0.61192*	0.146666	-0.57432*	0.665622*	0.755566**	0.154374	0.533389*	1			
Sulfate	0.470998	-0.05499	-0.12387	-0.06739	0.005162	-0.08921	-0.13868	-0.15201	-0.26916	1		
Silicate	-0.24661	-0.3061	-0.0271	0.30715	-0.07641	-0.53757*	-0.65307*	0.06156	-0.36909	0.341852	1	
Iron	-0.03146	0.050016	-0.06982	0.425136	-0.40666	-0.5437*	-0.0638	0.065207	-0.51615	0.269899	0.600445*	1

** Correlation is significant at the 0.01 level (2-tailed)   * Correlation is significant at the 0.05 level (2-tailed)

Table 26. Correlation matrix among various nutrients in river Cauvery at S3

S3	Calcium	Magnesium	Chloride	Sodium	Potassium	Ammonia	Nitrite	Nitrate	Phosphate	Sulphate	Silicate	Iron
Calcium	1											
Magnesium	0.074957	1										
Chloride	0.26477	-0.15676	1									
Sodium	0.479326	-0.44875	0.454454	1								
Potassium	-0.36614	0.0284	0.294038	-0.29172	1							
Ammonia	-0.35111	-0.11488	-0.15976	-0.58397 *	0.193626	1						
Nitrite	0.334949	-0.30304	0.195753	0.188207	0.071053	0.432387	1					
Nitrate	0.272408	0.363164	-0.39007	-0.17989	0.230528	-0.19161	0.179471	1				
Phosphate	0.207271	-0.33442	-0.12832	-0.34263	-0.20734	0.563539 *	0.316385	-0.05476	1			
Sulfate	-0.22763	-0.20657	-0.09367	-0.46563	0.193642	0.410367	0.022415	-0.26979	0.428205	1		
Silicate	-0.57643 *	-0.08973	-0.12603	0.205228	0.001076	-0.33152	-0.42992	-0.23776	-0.60956 *	-0.22755	1	
Iron	0.397618	-0.23952	0.665492 *	0.188191	0.477968	0.119607	0.519598 *	-0.0005	0.186706	0.243836	-0.64228 *	1

** Correlation is significant at the 0.01 level (2-tailed)   * Correlation is significant at the 0.05 level (2-tailed)

Table 27. Correlation matrix among various nutrients in river Arasalar at S1.

S1	Calcium	Magnesium	Chloride	Sodium	Potassium	Ammonia	Nitrite	Nitrate	Phosphate	Sulphate	Silicate	Iron
Calcium	1											
Magnesium	0.449894	1										
Chloride	0.36143	0.405644	1									
Sodium	0.655671*	0.496237	0.330423	1								
Potassium	-0.01756	0.11961	0.149453	-0.10724	1							
Ammonia	-0.8558**	-0.38748	-0.32416	-0.62317 *	0.326841	1						
Nitrite	0.042007	-0.45673	0.000259	0.294709	-0.02607	-0.08895	1					
Nitrate	0.044951	0.281263	0.196991	0.293054	-0.74124**	-0.18586	-0.11191	1				
Phosphate	0.425481	0.598965*	0.260991	0.720424**	0.186706	-0.48881	0.122179	-0.03837	1			
Sulfate	-0.22037	-0.17303	0.056162	-0.20139	0.587443 *	0.453495	0.226163	-0.35613	0.084301	1		
Silicate	-0.20481	0.096956	-0.17933	0.083661	-0.33555	0.122925	0.147315	0.525677 *	0.160656	0.414724	1	
Iron	0.169365	0.061178	0.214561	-0.04467	0.669808 *	0.132709	-0.09071	-0.35355	0.138303	0.729615**	0.047308	1

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed)

Table 28. Correlation matrix among various nutrients in river Arasalar at S2.

S2	Calcium	Magnesium	Chloride	Sodium	Potassium	Ammonia	Nitrite	Nitrate	Phosphate	Sulphate	Silicate	Iron
Calcium	1											
Magnesium	0.793389**	1										
Chloride	0.563536*	0.828312**	1									
Sodium	0.448676	0.133548	-0.30341	1								
Potassium	0.008315	0.102038	0.315738	-0.29447	1							
Ammonia	-0.41176	-0.3657	-0.0604*	-0.1966	-0.17006	1						
Nitrite	-0.07654	-0.22856	-0.18205	-0.09559	0.444397	-0.10547	1					
Nitrate	0.487565	0.473108	-0.00028	0.748241**	-0.41417	-0.17272	-0.14029	1				
Phosphate	0.154591	0.037286	-0.30407	0.733865**	0.254555	-0.20245	0.333345	0.583402*	1			
Sulfate	-0.44075	-0.2541	0.09671	-0.66825*	0.629098*	0.380364	0.441189	-0.55251	-0.10656	1		
Silicate	0.129046	0.483846	0.477345	-0.32134	0.170903	-0.02577	0.419074	0.248504	0.033678	0.382299	1	
Iron	0.223419	0.253712	-0.04487	0.329834	-0.34234	-0.14581	-0.26986	0.554072	0.259395	-0.13869	0.182322	1

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed)

Table 29. Correlation matrix among various nutrients in river Arasalar at S3.

S3	Calcium	Magnesium	Chloride	Sodium	Potassium	Ammonia	Nitrite	Nitrate	Phosphate	Sulphate	Silicate	Iron
Calcium	1											
Magnesium	0.947262**	1										
Chloride	0.069655	0.070069	1									
Sodium	-0.27846	-0.26433	-0.16741	1								
Potassium	0.005664	0.064033	-0.21521	-0.58047*	1							
Ammonia	-0.02284	-0.11223	0.536669*	0.108103	-0.66908*	1						
Nitrite	-0.57311*	-0.5417*	-0.43611	0.008371	0.153796	-0.03306	1					
Nitrate	0.487182	0.486687	-0.26584	-0.26882	0.421259	-0.4828	-0.41129	1				
Phosphate	-0.30644	-0.37923	-0.18367	0.455129	-0.45764	0.503505*	0.320282	-0.70562**	1			
Sulfate	-0.43344	-0.47016	-0.1107	0.530728*	-0.04033	0.140529	0.464739	-0.5339*	0.594223*	1		
Silicate	0.875216**	0.776835**	-0.00049	-0.27693	0.069843	0.158155	-0.40602	0.372392	-0.02007	-0.11147	1	
Iron	0.702665**	0.606182*	0.346312	-0.32465	0.15198	0.096271	-0.71742	0.322064	-0.14463	-0.18353	0.761124**	1

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed)

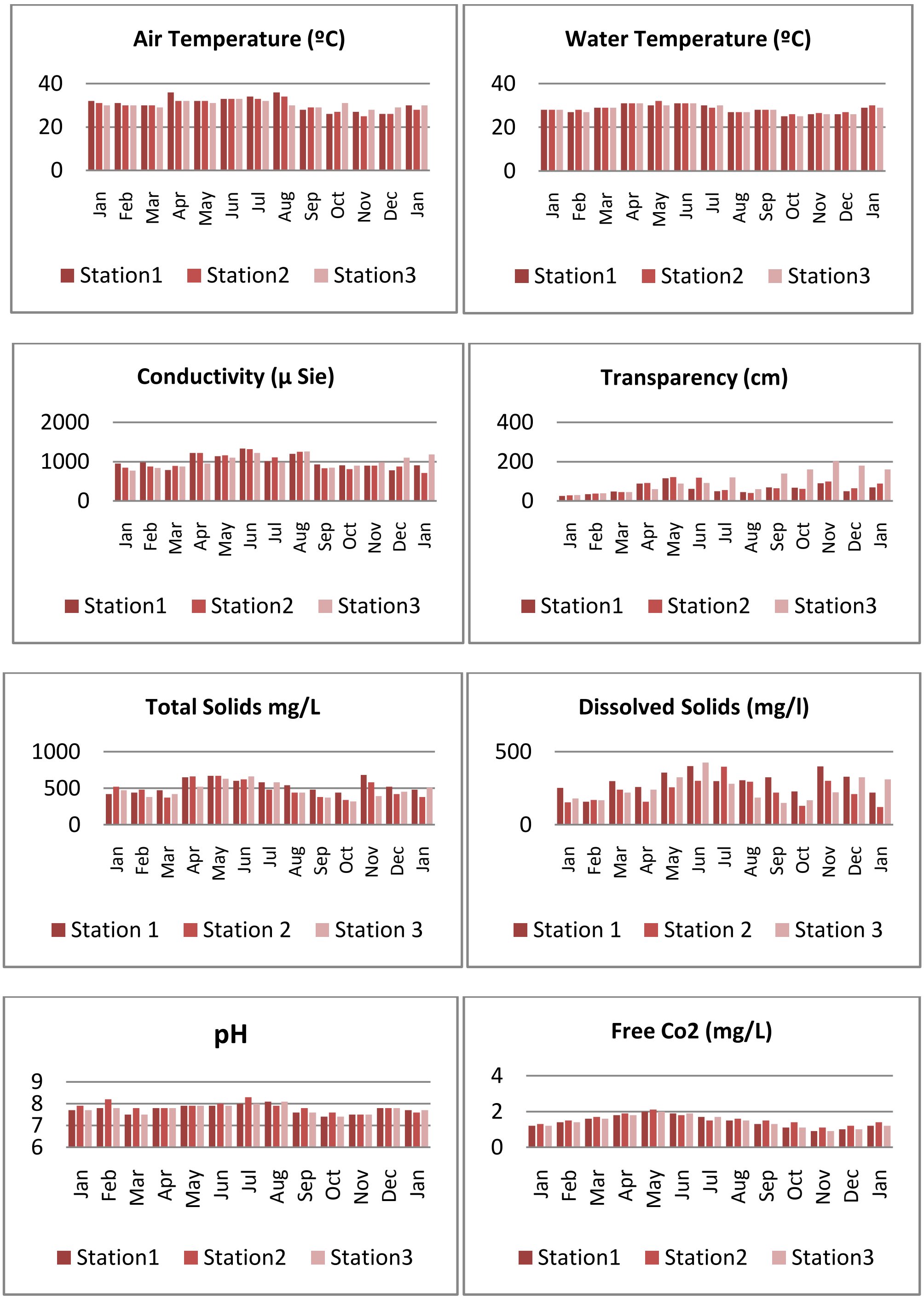


Figure 9 a. Monthly variations of physicochemical characters of River Cauvery.

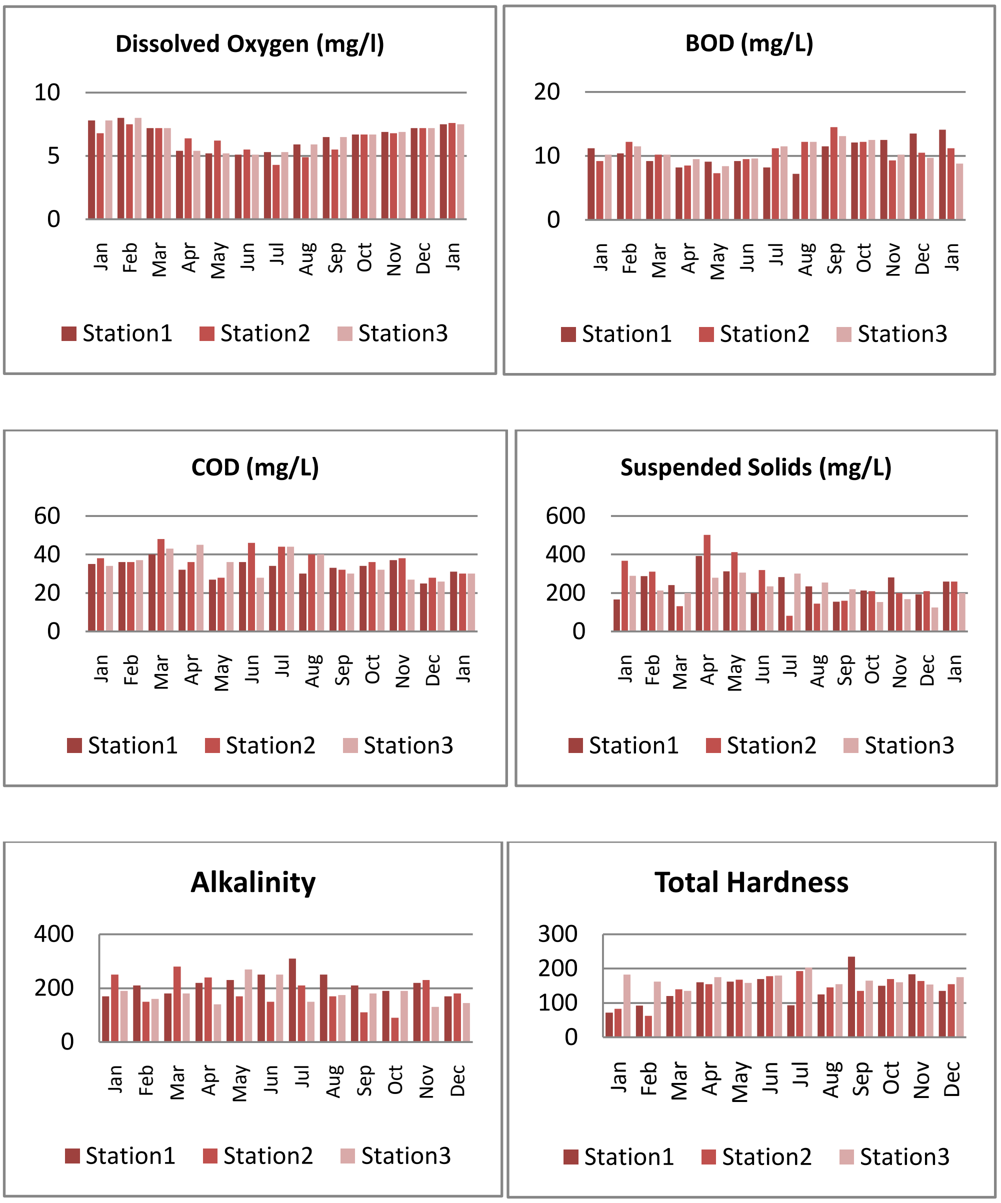


Figure 9 b. Monthly variations of physicochemical characters of River Cauvery.

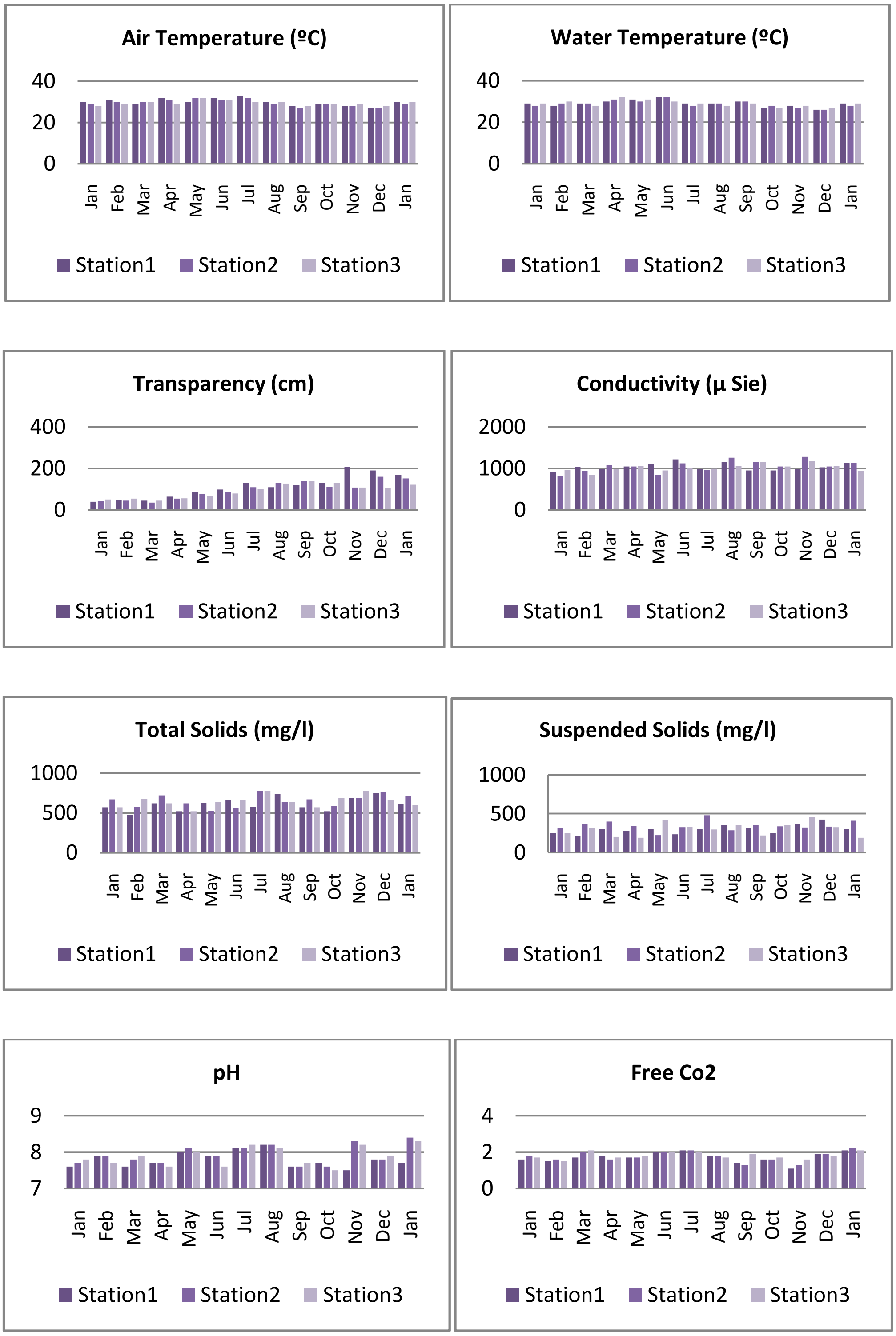


Figure 10 a. Monthly variations of physicochemical characters of River Arasalar

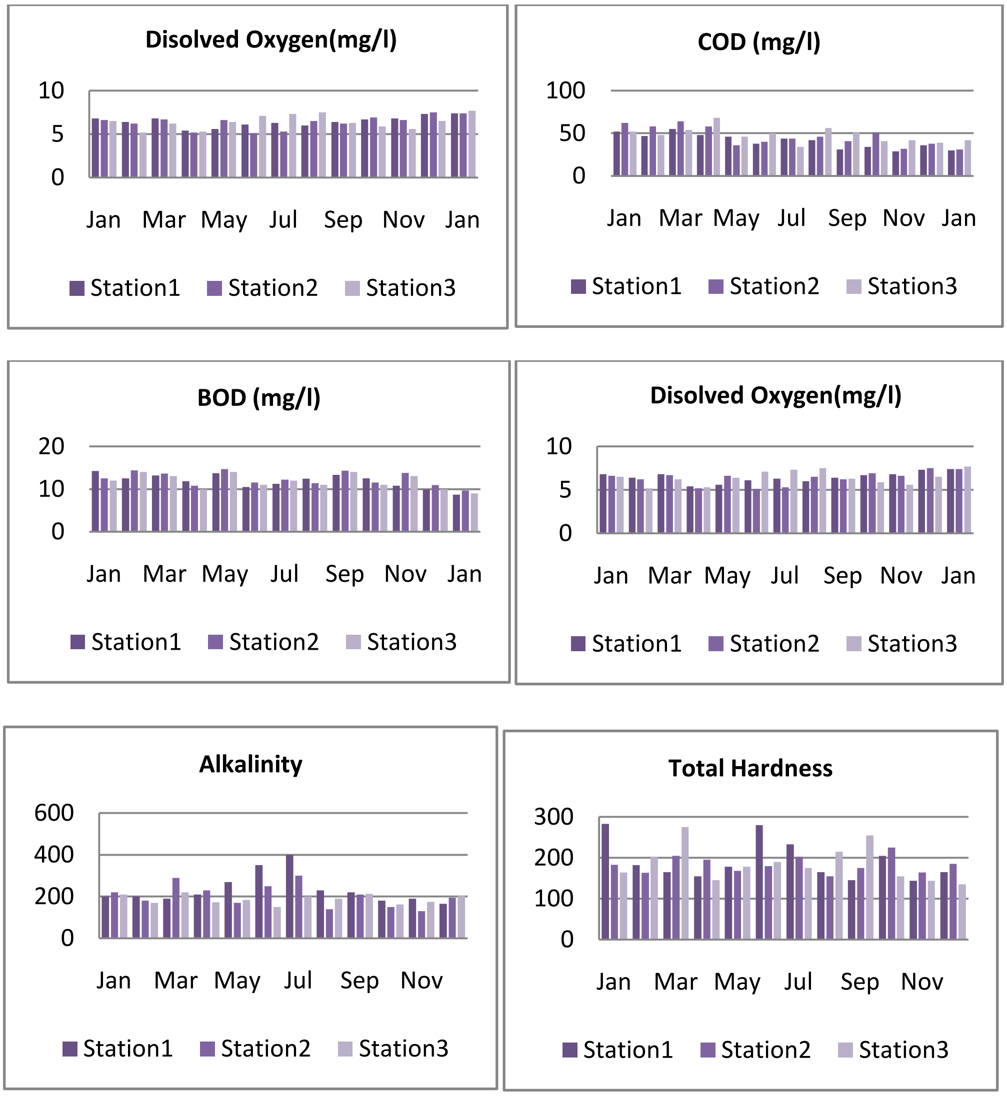


Figure 10 b. Monthly variations of physicochemical characters of River Arasalar

2.3.1.2 Water temperature

The water temperature was recorded between 25°C to 31°C in the river Cauvery and 26ºC to 32ºC in the river Arasalar during the study period. The lowest water temperature of 25°C was recorded in the river Cauvery and highest water temperature of 32°C was observed in the river Arasalar. The mean value of water temperature in the river Cauvery observed to be 28.23±1.96ºC, 28.65±1.88ºC and 28.23±1.96ºC for S1, S2, and S3 respectively. Similarly in the river Arasalar recorded was 29±1.58ºC, 28.84±1.62ºC and 29±1.47ºC for S1, S2 and S3 respectively.

2.3.1.3 Transparency

In the present study the transparency was ranging from 26 cm to 121 cm in the river Cauvery and 45 cm to 160 cm in the river Arasalar. The lowest transparency of 26 cm was recorded in the river Cauvery and highest transparency of 160cm was observed in the River Arasalar. The mean value of transparency in the river Cauvery recorded was 62.61±24.56 cm, 70.61±30.48 cm and 105.84±58.17 cm for S1, S2, and S3 respectively. Similarly in the river Arasalar recorded was 111±54.76 cm, 96.53±43.03 cm and 91.61±34.07 cm for S1, S2 and S3 respectively.

2.3.1.4 Conductivity

Conductivity is the measure of capacity of a substance or solution to conduct electrical current through the water. The electrical conductivity of water samples of Cauvery river and Arasalar river was observed to be in the ranges of 710 (μScm^{-1}) – 1280 (μScm^{-1}) and 810 (μScm^{-1}) – 1330 (μScm^{-1}). The lowest conductivity of 710 ($\mu S\ cm^{-1}$) was recorded in the river Cauvery and highest conductivity of 1330 (μScm^{-1}) was observed in the river Arasalar.

This conductivity of average value was found to be 30.84±3.43 (µS cm^{-1}), 30±2.85 (µS cm^{-1}) and 30.30±1.43 (µS cm^{-1}) for S1, S2, and S3 in the river Cauvery and 30.84±3.43 (µS cm^{-1}), 30±2.85 (µS cm^{-1}) and 30.30±1.43 (µS cm^{-1}) for S1, S2, and S3 in the river Arasalar respectively.

2.3.1.5 **Total solids** (Suspended solids and Dissolved Solids)

In the present study the value of total solids (Suspended solids and Dissolved Solids) was ranging from 370 mg/l to 680 mg/l in Cauvery and 480 mg/l to 780 mg/l in Arasalar. The minimum value of 370 mg/l of total solids was recorded in the river Cauvery and maximum value of total solids 780 mg/l was recorded in the river Arasalar. The mean value of total solids in the river Cauvery recorded was 536.15±91.15 (mg/l), 487.69±113.95 (mg/l) and 475.30±103.53 (mg/l) for S1, S2, and S3 respectively. Similarly in the river Arasalar recorded was 610.76±83.21 (mg/l), 655.38±77.20 (mg/l) and 646±75.56 (mg/l) for S1, S2, and S3 respectively.

2.3.1.6 pH

One of the important factors that serve as an indicator of pollution of water body is pH. The pH of natural water can provide important information about many chemical and biological processes and provides indirect correlations to a number of different impairments. pH is the scale of intensity of acidity and alkalinity of water and measures the concentration of hydrogen ions. At the period of study, the pH ranges from 7.4 to 8.3 in the river Cauvery and 7.4 to 8.4 in the river Arasalar. The minimum pH of 7.4 was recorded in the river Cauvery and maximum pH of 8.4 was observed in the river Arasalar. The mean value of pH in the river Cauvery recorded was 7.74±0.20, 7.85±0.22 and 7.74±0.20 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 7.79±0.21, 7.93±0.26 and 7.88±0.26 for S1, S2, and S3 respectively.

2.3.1.7 Free Co2

The Carbon dioxide ranges from 0.9 (mg/l) to 2.1 (mg/l) in the river Cauvery and 1.1 (mg/l) to 2.2 (mg/l) in the river Arasalar. The minimum Carbon dioxide of 0.9 was recorded in the river Cauvery and maximum Carbon dioxide of 2.2 was observed in the river Arasalar. The mean value of Carbon dioxide in the river Cauvery recorded was 1.43±0.35 (mg/l), 1.53±0.2 (mg/l) and 1.43±0.35 (mg/l) for S1, S2, and S3 respectively. While in the river Arasalar recorded was 1.71±0.28 (mg/l), 1.76±0.28 (mg/l) and 1.81±0.19 (mg/l) for S1, S2, and S3 respectively.

2.3.1.8 Alkalinity TA

Alkalinity is constituted mainly by the bicarbonate ions, which represent the main carbon source for assimilation during photosynthesis. Total alkalinity of water samples ranged between 1.2 and 2.4 mg/L. in the river Cauvery and 1.3 to 3.6 in the river Arasalar. The minimum alkalinity of 1.2 was recorded in the river Cauvery and maximum alkalinity of 3.6 was observed in the river Arasalar. The mean value of alkalinity in the river Cauvery recorded was 1.70±0.311, 1.68±0.265 and 1.76±0.267 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 1.87±0.409, 2.68±0.58 and 2.591±0.662 for S1, S2, and S3 respectively.

2.3.1.9 Dissolved Oxygen

In the present study dissolved oxygen level ranges between 4.3 mg/l to 7.8 mg/l in the river Cauvery and 5.1 (mg/l) to 7.7 (mg/l) in the river Arasalar. The minimum dissolved oxygen of 4.3 (mg/l) was recorded in the river Cauvery and maximum dissolved oxygen of 7.8 (mg/l) was also observed in the river Cauvery. The mean value of dissolved oxygen in river Cauvery recorded was 6.51±1.03 (mg/l), 6.35±1.02 (mg/l) and 6.51±1.03 (mg/l) for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded was 6.46±0.59 (mg/l), 6.36±0.76 (mg/l) and 6.42±0.80 (mg/l) for S1, S2, and S3 respectively.

2.3.1.10 Biochemical oxygen demand

The BOD ranges from 7.2 (mg/l) to 14.5 (mg/l) in the river Cauvery and 8.7 (mg/l) to 14.4 (mg/l) in the river Arasalar. The minimum BOD value was recorded as 7.2 mg/l in the river Cauvery and maximum value of BOD 14.5(mg/l) was also recorded in the river Cauvery. The mean value of BOD in the river Cauvery recorded was 10.46±2.17 (mg/l), 10.61±1.91 (mg/l) and 10.56±1.46 (mg/l) for S1, S2, and S3 respectively. Similarly in the river Arasalar recorded was 11.9±1.60 (mg/l), 12.40±1.60 (mg/l) and 11.84±1.67 (mg/l) for S1, S2, and S3 respectively.

2.3.1.11 Chemical Oxygen Demand

COD is the measure of the oxygen required for chemical oxidation of organic matter. The COD ranges from 25 (mg/l) to 48 (mg/l) in the river Cauvery and 30 (mg/l) to 68 (mg/l) in the river Arasalar. The minimum COD value was recorded as 25 mg/l in the river Cauvery and maximum value of COD 68 (mg/l) was recorded in the river Arasalar. The mean value of COD in the river Cauvery recorded was 33.07±4.11 (mg/l), 36.92± 6.46 (mg/l) and 34.76±6.63 (mg/l) for S1, S2, and S3 respectively. Similarly in the river Arasalar recorded was 40.92±8.58 (mg/l), 46.23±11.33 (mg/l) and 47.92±8.80 (mg/l) for S1, S2, and S3 respectively.

2.3.1.12 Total hardness

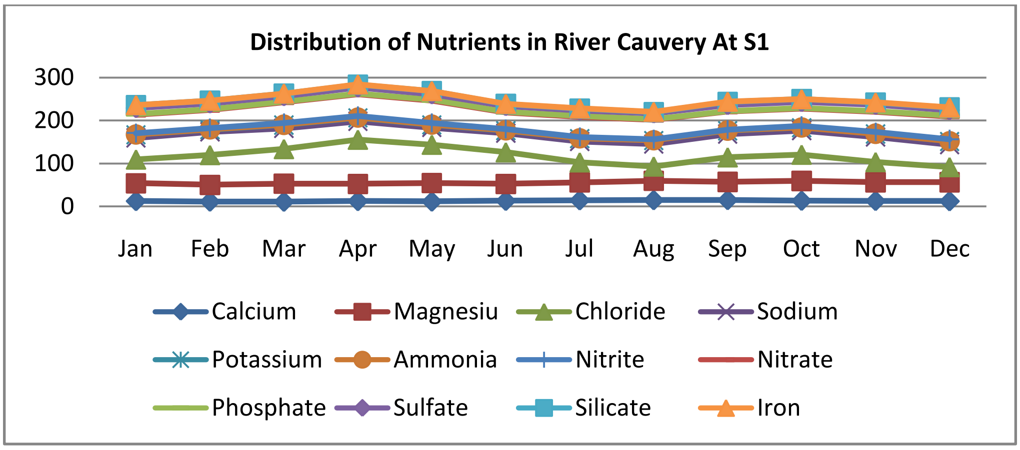
In the present study value of total hardness ranged from 300-778 mg/l in the river Cauvery and 1.3 to 3.6 in the river Arasalar. The minimum total hardness of 1.2 was recorded in the river Cauvery and maximum total hardness of 3.6 was observed in the river Arasalar. The mean value of total hardness in the river Cauvery recorded was 1.70±0.311, 1.68±0.265 and 1.76±0.267 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 1.87±0.409, 2.68±0.58 and 2.591±0.662 for S1, S2, and S3 respectively.

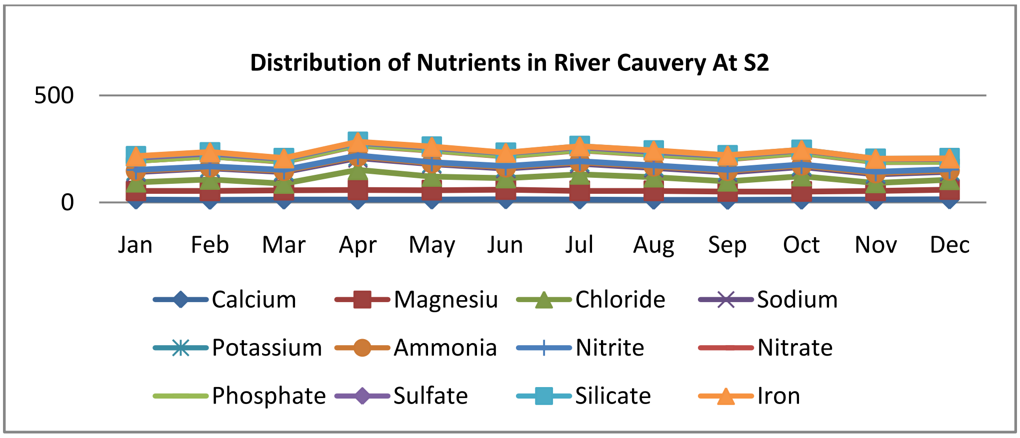
2.3.2 Nutrient Analysis

Presence of nutrients in water is judged on several factors among the various physicochemical, biological and biochemical factors are considered as most vital factor which indicates oxygen level, ionic status and biological activity in water respectively. Monthly variations of nutrients (Calcium, Magnesium, Sodium, Potassium, Chloride, Phosphate, Nitrite, Nitrate Ammonia, Sulfate, Silicate and Iorn) of the river Cauvery and its tributary Arasalar for a period of one year (Jan 2010 to Dec 2010) are presented in table 16-21 and Fig11 and Fig 12. Data of the mean and range values of nutrients of the river Arasalar for a period of one year (Jan to Dec 2010) are presented in the table 22 and 23 while correlation matrix among various nutrients in river Arasalar at three stations has been shown in table 24-29.

2.3.2.1 Calcium and magnesium

Principal cations imparting hardness are calcium and magnesium. The Calcium content of water samples ranged between 10.2 -15.1 mg/L in the river Cauvery. The minimum value of calcium in the river was 10.2 mgl/L at Station 3 in the month of January and maximum value was 15.1 mg/L at Station 1 in the month of September. The mean calcium concentration in the study area varied from 13.041 ± 1.296, 13.183 ± 0.755, 12.983 ± 1.029 for the





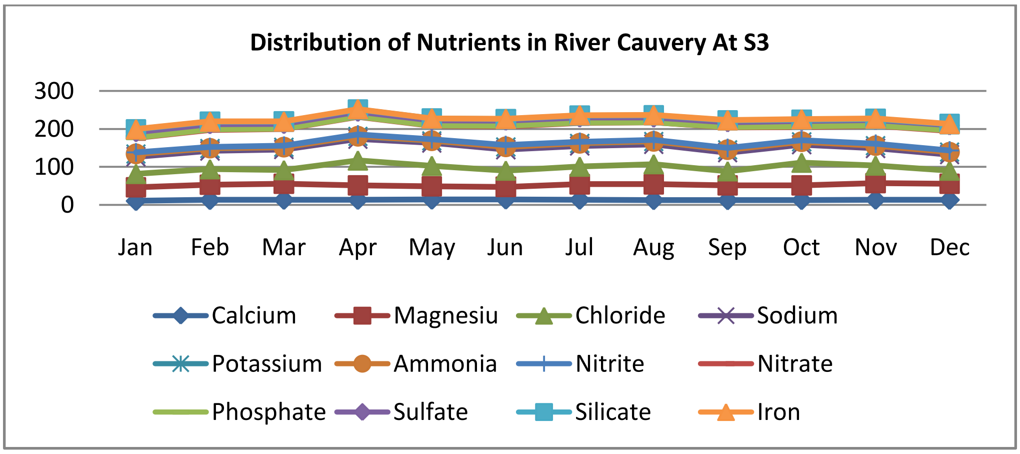
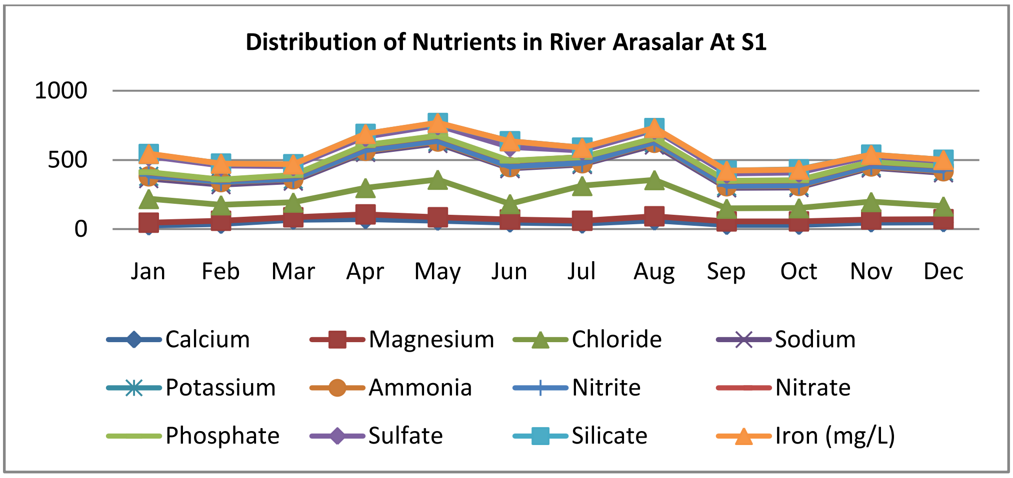
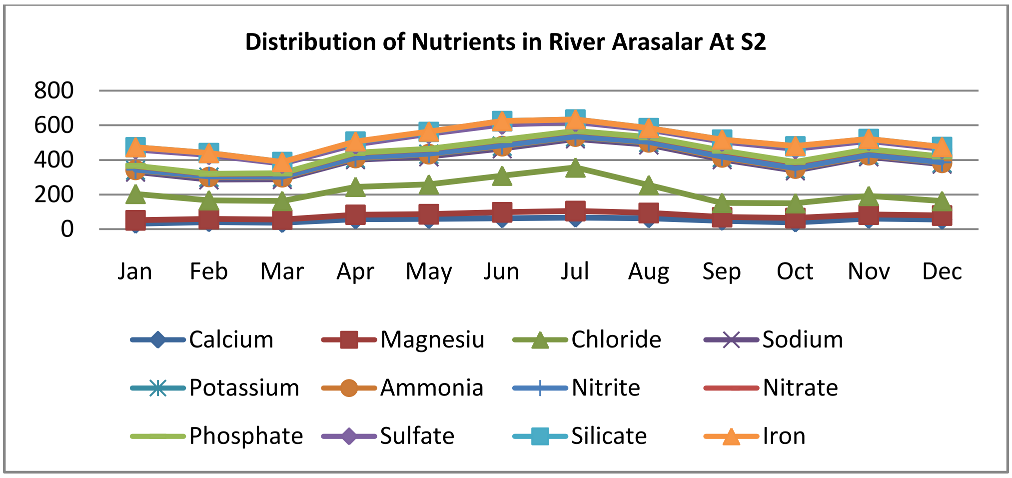


Figure 10. Results of Nutrient Distribution in River Cauvery (Jan 2010 to Jan 2011).





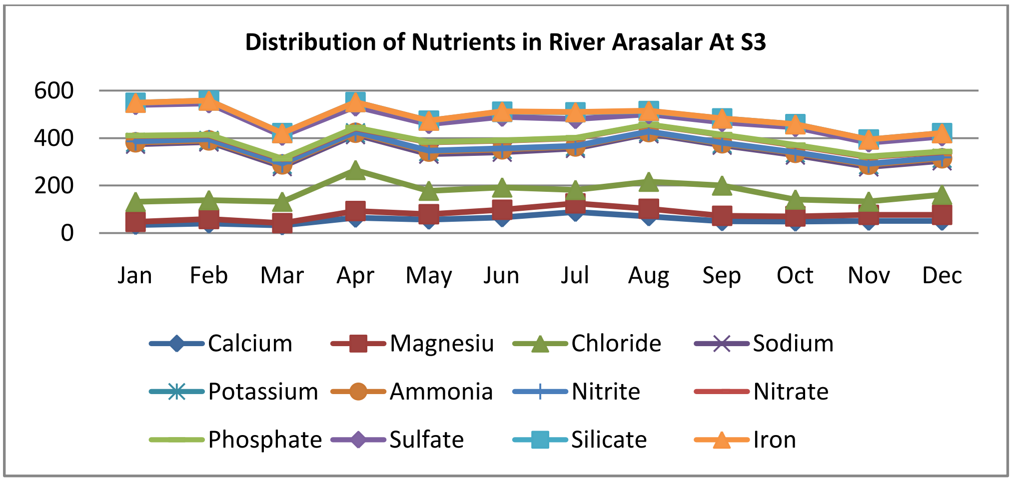


Figure 12. Results of Nutrient Distribution in River Arasalar (Jan 2010 to Jan 2011).

S1, S2 and S3 respectively. Similarly the magnesium was ranging from 33mg/L to 46.1mg/L in the river Cauvery during the study period. The minimum magnesium (33mg/L) was observed in June at station 3 and maximum (46.1 mg/L) was observed in October at station1. The mean value of magnesium observed to be 42.316 ± 2.189, 13.183 ± 0.755, 12.983 ± 1.029 for the S1, S2 and S3 respectively.

The Calcium content of water samples ranged between 26.66 and 88.77 mg/L in the river Arasalar. The minimum value of calcium in the river was 26.66 mgl/L at S1 in the month of January and maximum value was 88.77mg/L at Station 3 in the month of July. The mean calcium concentration in the study area varied from 47.616±15.311, 52.535±12.099 and 54.254±16.152 mg/L for S1, S2 and S3 respectively. Similarly the magnesium was ranging from 13.13mg/L to 37.73mg/L during the study period. The minimum magnesium (13.13 mg/L) was observed in July at S2 and maximum (37.73 mg/L) was observed in January at S3. The mean value of magnesium observed to be 24.650±4.717, 24.964±6.172 and 24.271±7.843 mg/L for the S1, S2 and S3 respectively.

2.3.2.2 Chloride

The monthly variation in chloride ranged between 30.7 mg/L and 93 mg/L in the river Cauvery. The minimum value (30.7 mg/L) was recorded in March at S3 and maximum (93 mg/L) in the month of April at S1. The annual mean values were observed to be 62.65 ± 21.409, 56.241 ± 18.14 and 46.291 ± 10.242 mg/L for the S1, S2 and S3 respectively. The monthly variation in chloride ranged between 56.8 mg/L and 272.2 mg/L in the river Arasalar. The minimum value (56.8 mg/L) was recorded in July at S3 and maximum (272.2 mg/L) in the month of May at S1. The annual mean values were observed to be 93.72 ± 272.2, 83.72 ± 252.1 and 56.8 ± 173.24mg/L for the S1, S2 and S3 respectively.

2.3.2.3 Sodium and potassium

The major source of both the cat ions may be weathering of rocks besides the sewage and industrial effluents. The Sodium content of water samples ranged between 39.5 and 60 mg/L in the river Cauvery. The minimum value of Sodium in the river was 39.5 mg/L at Station 1 in the month of May and maximum value was 60 mg/L at Station 3 in the month of May. The mean Sodium concentration in the study area varied from 49.8 ± 5.610, 47.541 ± 6.534 and 50.583 ± 5.401 mg/L for the S1, S2 and S3 respectively. Similarly, the Potassium was ranging from 5.1 mg/L to 8.4 mg/L during the study period. The minimum Potassium (5.1 mg/L) was observed in May at station 2 and maximum (8.4 mg/L) was observed in August at station1. The mean value of Potassium observed to be 7.2666 ± 0.847, 6.525 ± 0.725 and 6.7916 ± 0.608 mg/L for S1, S2 and S3 respectively.

The sodium content of water samples ranged between 118 and 260 mg/L in the river Arasalar. The minimum value of sodium in the river was 118mg/L at S2 in the month of February and maximum value was 260 mg/L at S1 in the month of May. The mean Sodium concentration in the study area varied from 200.583±53.615, 175.583±44.914 and 175.333±36.824mg/L for the S1, S2 and S3 respectively. Similarly, the Potassium was ranging from 6.5 mg/L to 17.25 mg/L during the study period. The minimum Potassium (6.5mg/L) was observed in February at S3 and maximum (17.25mg/L) was observed in February at S1. The mean value of Potassium observed to be 12.688±2.717, 12.013±2.355 and 8.85±1.819mg/L for the S1, S2 and S3 respectively.

2.3.2.4 Ammonia

Cauvery River had a range of ammonia concentration between 0.25 mg/L and 0.46 mg/L. It was minimum (0.25 mg/L) in May at S2 and maximum (0.45 mg/L) in the month of November at S3. Mean levels of Ammonia were 0.3608 ± 0.029, 0.36 ± 0.0620 and 0.3758 ± 0.0568 mg/L for S1, S2 and S3, respectively. Arasalar River had a range of ammonia concentration between 0.06 mg/L and 0.82mg/L. It was minimum (0.06 mg/L) in June at S3 and maximum (0.82 mg/L) in the month of January at S1. Mean levels of ammonia were 0.455±0.163, 0.319±0.166 and 0.29±0.179mg/L for S1, S2 and S3, respectively.

2.3.2.5 Nitrite and Nitrate

The nitrite content of water samples ranged between 2.5 and 4.9 mg/L in the river Cauvery. In the present investigation nitrite level was minimum (2.5 mg/L) in September at station S1 while maximum (4.9 mg/L) in November at S3. The average nitrite levels were 3.725 ± 0.636, 3.95 ± 0.464 and 0.3758 ± 0.0568 mg/L for S1, S2 and S3, respectively. The nitrite content of water samples ranged between 2.2 and 4.9 mg/L in the river Arasalar. In the present investigation nitrite level was minimum (2.2 mg/L) in September at S1 while maximum (4.9 mg/L) in November at S1. The average nitrite levels were 3.75±0.799, 3.366±0.806 and 3.6±0.737 mg/L for S1, S2 and S3, respectively.

The nitrate is also one of the important factors of water quality. The range of nitrate concentration between 35 mg/L and 56 mg/L in the river Cauvery. The minimum value (35mg/L) was observed in December at S2 and maximum value (56 mg/L) in the month of January at S1. Mean levels of nitrate were 45.583 ± 4.737, 45.916 ± 5.728 and 45.083 ± 6.229 mg/L for S1, S2 and S3, respectively. Nitrates however were noted in higher concentrations throughout the sampling, values ranging from as low as 12.61mg/L to 40 mg/L in the river Arasalar. The minimum value (12.61mg/L) was observed in February at S2 and maximum value (40 mg/L) in the month of July at S1. Mean levels of nitrate were 30.746±7.651, 26.413±6.375 and 25.979±6.707mg/L for S1, S2 and S3, respectively.

2.3.2.6 Phosphate

During the present study, phosphate values were fluctuated between 0.85 mg/L to 1.8 mg/L in water samples collected from three sampling sites of River Cauvery. Phosphate values of water samples were found minimum (0.85 mg/L) in the month of July at S3 and maximum (1.8 mg/L) in the month of October at S2. The average value of phosphate was found to be 1.3583 ± 0.257, 1.2241 ± 0.348 and 1.275 ± 0.2893 mg/L for the S1, S2 and S3 respectively. The phosphate content of water samples ranged between 0.85 mg/L to 2.2mg/L in river Arasalar. Phosphate values of water samples were found minimum (0.85 mg/L) in the month of July at S1 and maximum (2.2 mg/L) in the month of February at S3. The average value of phosphate was found to be 1.267±0.314, 1.259±0.277 and 1.521±0.381mg/L for S1, S2 and S3 respectively.

2.3.2.7 Sulfate

In Cauvery River, sulfate fluctuated from 12.5-14.2 mg/L. In the present investigation sulfate level was minimum (12.5 mg/L) in July at station 1 while maximum (14.2 mg/L) in April at S1. The average Sulphate levels were 13.225 ± 0.606, 12.783 ± 0.607 and 15.1083 ± 1.504 mg/L for S1 and S2 and S3. In the river Arasalar the mean concentration of sulphate was found in the range of 33.93 to 132 mg/l which is within the range of prescribed drinking water standards (200 mg/l). In the present investigation sulfate level was minimum (33.93mg/L) in December at station S1 while maximum (132 mg/L) in February at S3. The average Sulphate levels were 167.174±25.377, 66.492±22.913 and 82.730±27.850mg/L for S1 and S2 and S3 respectively.

2.3.2.8 Silicate

The monthly variations in silicate ranged between 1.9 mg/L and 7.5 mg/L in the river Cauvery. The minimum value (1.9 mg/L) was recorded in November at S2 and maximum (7.5 mg/L) in the month of January at S3. The annual mean values were observed to be 6.2083 ± 1.343, 4.3083 ± 1.677, and 5.1083 ± 1.504 mg/L for the S1, S2 and S3 respectively. The monthly variations in silicate ranged between 9.1mg/L and 41.2mg/L in the river Arasalar. The minimum value (9.1mg/L) was recorded in August at S2 and maximum (41.2 mg/L) in the month of June at S1. The annual mean values were observed to be 18.332±8.229, 12.811±3.253 and 15.398±5.206mg/L for the S1, S2 and S3 respectively.

2.3.2.9 Iron

The iron content of water samples ranged between 0.23 and 1.55 mg/L. in the river Cauvery. The minimum value (0.23 mg/L) was recorded in November at S2 and maximum (1.55 mg/L) in the month of October at S3. The average nitrite iron levels were 0.6383 ± 0.260, 0.722 ± 0.373 and0.945 ± 0.434 mg/L for S1, S2 and S3, respectively. The iron content of water samples ranged between 0.22 and 2.1 mg/L. in the river Arasalar. The minimum value (0.22 mg/L) was recorded in December at S1 and maximum (2.1 mg/L) in the month of May at S2. The average nitrite iron levels were 0.89 ± 0.529, 1.369 ± 0.652 and 0.852 ± 0.420 mg/L for S1, S2 and S3, respectively.

2.4. DISCUSSION

2.4.1 Physicochemical Analysis

2.4.1.1 Air and water Temperature

Temperature is an important biologically significant factor, which plays an important role in the metabolic activities of the organism and determining the physico-chemical property of water. Water samples collected in the river Cauvery showed lower temperature in the monsoon season. In the summer season it was found to be highest. In the river Arasalar the temperature was found more when compare to the river Cauvery. This may be due to mixing of the effluent from the municipal sewage situated in the banks of Arasalar. The variation is mainly related with the temperature of atmosphere and weather conditions (Adebowale and Sawyer 2008).

2.4.1.2 Transparency

Transparency or light penetration depends on the intensity of sunlight, suspended soil particles, turbid water received from catchment area and density of plankton etc. (Mishra and Saksena, 1991; Kulshrestha and Sharma, 2006). Transparency of river water is also affected due to total solids partly or fully decomposed organic matters, silts and turbulence caused by the currents, waves, human and cattle activities (Singh et al., 1999). In the river Arasalar the transparency was found more when compare to the river Cauvery. This may be due to the more turbid condition of the river due to the mixing of the effluents. The reason for the minimum transparency in the river Cauvery due to the dilution of the sewage and effluents and also the water flow is more when compare to the river Arasalar.

2.4.1.3 Electrical conductivity

The value of electrical conductivity was greatest in the river Arasalar due to more concentration of the TDS. The reason for decrease in the values of the electrical conductivity of the river Cauvery due to poor irrigation management, minerals from rain water runoff, or other discharges. Several factors influence the conductivity including temperature, ionic mobility and ionic valences. Conductivity measurement is an excellent indicator of TDS, which is a measure of salinity that affects the taste of potable water (Pradeep, 1998).

2.4.1.4 Total solids (Suspended solids and Dissolved Solids)

Solids refer to matter suspended or dissolved in water or waste water. Total dissolved solids are composed of carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of Ca, Mg, Na, K, and Mn and organic matter, salts and others particles (Mishra and Saksena, 1991). In the present study the value of total solids (Suspended solids and Dissolved Solids) was ranging from 370 mg/l to 680 mg/l in Cauvery and 480 mg/l to 780 mg/l in Arasalar.

The Total Dissolved Solids values in the river Arasalar exceed the maximum permissible limits of WHO (600mg/l). In this study the primary sources for elevated TDS level in river water are agricultural runoff, particulate matter of cement and other raw material used in construction of river front, leaching of soil contamination and non point source of water pollution. (Moniruzzaman, 2009). River Cauvery show a lower TDS value than Arasalar. The reason for the minimum total solids in the river Cauvery due to the dilution of the sewage and effluents and also the water flow is more when compare to the river Arasalar. The same is reported by Subbarao *et al*. (1997). The result showed that there was no significant difference in the suspended solids and dissolved solids between the two rivers.

2.4.1.5 pH

Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent. Optimal pH range for sustainable aquatic life is pH 6.5 – 8.2. In the present study the mean values of pH at three sites of river ranged between 7.5 and 8.4 which are in accordance with the prescribed limit of 6.5-8.5 (Wetzel, R. G. 2001). All these six stations showed alkaline condition throughout the study period. Alkaline pH was also observed by (Saksena, D.N. and Kaushik, S. 1994) in river Chambal during whole study period. However the alkaline pH formed throughout the year reveals that it is a potential for high production characteristic. The result also shows that the alkaline pH is particularly due to bicarbonate and not due to carbonate alkalinity.

2.4.1.6 Free Co2

Carbon dioxide in water bodies is contributed by the respiratory activity by animals and other organisms. The Carbon dioxide ranges from 0.9 (mg/l) to 2.1 (mg/l) in the river Cauvery and 1.1 (mg/l) to 2.2 (mg/l) in the river Arasalar.The values of free carbon dioxide were inversely proportional to dissolved oxygen at the sampling stations. This may be depends upon plants aquatic animals present in water body as well as alkalinity and hardness of water. According to Koroosh (2009) the free carbon dioxide values were extremely high and high values of free carbon dioxide may result from breakdown of organic matter. The less values of carbon dioxide during rainy and winter season might be due to its utilization in photosynthetic activity or it was being inhabited by presence of appreciable amount of carbonate in water.

2.4.1.7 Alkalinity TA

The alkalinity of water is measure of its capacity to neutralize acids. The alkalinity of natural water is due to the salts of weak acids although weak or strong bases may contribute. Bicarbonate represents the major form of alkalinity. In the present study, alkalinity was recorded throughout the investigation. The concentration of alkalinity is uniform without much significant variation confirming the findings of Rammakrishna and sarkar (1982). The values are high during winter and low during monsoon. BIS acceptable limit for total alkalinity is 30 mg/l. The high alkalinity may be attributed to increased rate of organic decomposition during which CO2 is liberated and reacts with water to form HCO3 thereby increasing the total alkalinity (Goel *et al*., 1984).

2.4.1.8 Dissolved Oxygen

Dissolved oxygen (DO) is very crucial for the survival of aquatic organisms and it is also used to evaluate the degree of freshness of a river (Agbaire 2009). The distribution of dissolved oxygen affects the solubility of nutrient (WHO1999). Oxygen content of water varies with temperature, salinity, turbulence, photosynthetic activity of algae and higher plants atmospheric pressure *etc*. Concentrations of dissolved oxygen in unpolluted waters are usually about 8-10 mg/l. In the present study dissolved oxygen level ranges between 4.3 (mg/l) to 7.8 mg/l in the river Cauvery and 5.1 (mg/l) to 7.7 (mg/l) in the river Arasalar. The results showed that there is no significant difference in the dissolved oxygen concentration between the two rivers.

2.4.1.9 Biological Oxygen Demand

The BOD is used as an approximate measure of the amount of biochemically degradable organic matter present in a sample. At both the rivers, the BOD values were high during the study period. The results indicate that the water body had suffered deterioration and degradation due to agricultural runoff and continuous discharge of domestic and municipal sewage. Desirable limit for BOD is 4.0 mg/l and permissible limit is 6.0 mg/l according to Indian standards. BOD demand below 3 mg/l or less is required for the best use. Fokmare and Musaddiq (2002) recorded high value of biochemical oxygen demand (BOD) as 20.00 mg/l in river Purna and said that this river is highly polluted due to organic enrichment, decay of plants and animal matter in the river. Thus, the high value of BOD encountered in both rivers, above the permissible limit of WHO (<2 mg/l), indicates the pollution by biochemically degradable organic wastes from various sources.

2.4.1.10 Chemical Oxygen Demand

The COD ranges from 25 mg/l to 48 mg/l in the river Cauvery and 30 mg/l to 68 mg/l in the river Arasalar. The COD is a measure of oxygen equivalent to the organic matter content of the water susceptible to oxidation and thus is an index of organic pollution in river (Khaiwal et al, 2003). High COD may cause oxygen depletion on account of decomposition by microbes (Sivakumar *et al*. 1989) to a level detrimental to aquatic life.

2.4.1.11 Total Hardness

Both rivers showed soft waters character. In the present study value of total hardness ranged from 300-778 mg/l. when compared to various standards, the present water samples are well above the permissible limit of WHO (1993). Similar findings were reported by Mazher Sultana & Dawood Sharief, (2004). In general, surface water is softer than ground water. The hardness of water reflects the nature of geological formation with which it has been in contact.

2.4.2 Nutrient Analysis

2.4.2.1 Calcium and Magnesium

Calcium is an important micronutrient in an aquatic environment. Magnesium content of water is considered as one of the most important qualitative criteria in determining quality of water for irrigation. Generally, calcium and magnesium maintain a state of equilibrium and contribute to the hardness of water (Shrivastava and Patil, 2002). Barrett (1953) has reported that the hard waters are more productive than the soft water from fisheries point of view. The magnesium also follows the same trend as that of calcium. However magnesium content was less than that of calcium in natural bodies, but due to the entry of sewage and other waste in the river cauvery, which increases the higher values of magnesium than calcium. These elements increase hardness of the river water (Purohit and Saxena 1990). The calcium and magnesium concentration in the present study was found to be well within the permissible limits of WHO.

2.4.2.2 Chloride

Chloride is a major anion of the element chlorine (Wetzel, R. G. 2001). Chloride ions are important compounds of all living systems contributing to the osmotic, ionic as well as water regulation functions within organisms. Chloride ions exhibit no toxic effects upon living systems (Dallas, H.F. and Day, J.A. 1993). In the present study high values of chloride in summer months may be associated with high temperature which enhances the evaporation, reducing the volume of water thus resulting in the high concentration of salts. Chloride also gets added to waters from the discharge of industrial effluents or contamination with sewage (Suthar, 2008). High concentration of chloride is considered to be the indicators of pollution due to organic wastes of animal or industrial origin and troublesome in irrigation water and also harmful to aquatic life (Venkatesharaju, 2010).

2.4.2.3 Sodium and Potassium

Sodium and potassium are the most important minerals occurring naturally. The major source of both the cations may be weathering of rocks (Singh *et al.*, 1999) besides the sewage and industrial effluents.In the present study, high values of sodium and potassium are attributed to the possible contamination by domestic sewages and effluents. Soils retain sodium and potassium to a greater degree than chloride or nitrate. Therefore, sodium and potassium are not as useful as pollution indicators (Yalcin Tepe *et.al,* 2005). The sodium and potassium values lie within the safe range of WHO limit of 200 and 12 ppm respectively and is suitable for irrigation and domestic purposes. The concentration of sodium is important in classifying irrigation waters because it reacts with soil permeability (Adak and Purohit, 2001).

2.4.2.4 Ammonia

Ammonia in natural waters is the product of the breakdown of nitrogenous organic and inorganic matter in soil and water as well as excretion by biota and reduction of nitrogen gas by microbes (WHO 1999). In the present study presence of ammonia is an evidence of sewage inflow to a water body. Ammonia is commonly associated with sewage and industrial effluents and forms part of many fertilizers (Dallas and Day, 1993). Cauvery River had a range of ammonia concentration between 0.29 mg/L to 0.45 mg/L and 0.06

mg/L to 0.82 mg/L in Arasalar River. The concentrations of ammonia in these rivers for the duration of the study were alarming due to anthropogenic activities reaching the river.

2.4.2.5 Nitrite

Nitrite is the intermediate in the conversion of ammonia in to nitrates through the process of nitrification and denitrification by bacteria. It is widely assumed that nitrite concentrations in freshwaters are negligible (Stanley and Hobbie, 1981; Paul and Clarke, 1989), and the worldwide average concentration has been estimated to be 1 mg of nitrite/liter (Meybeck, 1982). Nitrite levels were higher than 1 mg/L during the present study. This increase of nitrite indicates the river receives very rich amount of organic matter. In the present study the nitrite content is found to be above the permissible limit (10 mg/l). The concentrations of nitrite in the Arasalar River for the duration of the study were alarming due to high anthropogenic activities reaching the river.

2.4.2.6 Nitrate

The nitrate is also one of the important factors of water quality. Nitrate is an essential nutrient but also a good indicator of contamination from natural and human activities. Sources include manures, inorganic fertilizer and on-site sewage disposal systems. Levels above 5 mg/l are considered harmful to aquatic organisms (sudesh *et al.,* 2009). In the present study the nitrate content is found to be above the permissible limit (45 mg/l). The WHO safe limit for nitrate for life time use is 10 mg/L as N (WHO, 1984). This limit was exceeded in the river water; thus, nitrate is not considered to pose a problem for the domestic use of water from the river. However, nitrate could be a problem for other uses because of eutrophication (Rast & Thornton, 1996).

2.4.2.7 Phosphate

During the present study, phosphate values were fluctuated between0.85 mg/L to 1.8 mg/L and 0.85 mg/L to 2.2 mg/L in water samples collected from river Cauvery and Arasalar respectively. The permissible limit for phosphate is 0.1 mg/l. Major source of phosphate in water are domestic sewage, agriculture effluents and industrial waste waters. Sinha et al. (1998) have reported higher phosphate content in lower stretch of Ganga River during monsoon season. In the present investigation same thing was encountered. Many researchers have observed an increase in phosphate concentration in such of the water bodies that receives domestic waste (Nirmala Kumari, 1984 Sampathkumar 1977).

2.4.2.8 Sulfate

Sulphate is the stable form of sulphur and is non-toxic, however occurring in excess sulphates form sulphuric acid ($H2SO_4$). This acid can have a devastating effect upon aquatic ecosystems (Taylor, 1984, Nussey, 1998). The mean concentration of sulphate was found in the range of 11.8 mg/L to 14.2 mg/L in river Cauvery and 33.93 to 132 mg/l in river Arasalar which is within the range of prescribed drinking water standards (200 mg/l). Similar report was recorded by the studies of (Mazher Sultana and Dawood Sharief 2004). The lower values of sulphate recorded could be because sulphate easily precipitates and settles to the bottom sediment of the river [Abdul, 2009). The sulfates are derived from discharge of domestic sewage, surface runoff and agricultural activity.

2.4.2.9 Silicate

The occurrence of silicate was fairly detectable in all the stations of the river stretch studied; it varied between 1.9 mg/L and 7.5 mg/L in the river

Cauvery and 9.1mg/L and 41.2mg/L in river Arasalar. It was high during summer and low during rainy season. A sandy river bed appears to increase silicate concentration in the water. The observed values are in agreement with the results recorded earlier by Devaraj et al., 1998 and Murugesan & Manoharan, 2000). Silicates in river water exist mainly in the form of silicic acid and reactive polymer.

2.4.2.10 Iron

Iron is the fourth most abundant element found within the earth crust and can therefore occur in waters in varying degrees depending on the geology of the area (DWAF, 1996). It commonly occurs in two oxidative states, namely ferrous and ferric of which the later is essentially unavailable for uptake. At high concentrations Fe becomes toxic, inhibiting various enzymes (Dallas and Day, 1993). In the current study, the iron concentration in the river water varying from 0.22-1.55 mg/l which is slightly below the permissible limit set by WHO (1993). This result coincides with the findings of Valsala *et al.,* (2005).

The results indicated that most of the physico-chemical quality parameters of River Cauvery were within the WHO limits for drinking water and, therefore, may be suitable for domestic purposes. In contrast, however, nutrient levels were low during the study period and did not give any clear seasonal variation. During the period of monsoonal flow from contributories of Cauvery River, the sampling stations recorded comparatively higher pollutants such as phosphate and nitrate. Higher phosphate and Nitrate content recorded in water samples indicate pollution from fertilizer runoff from agricultural fields, sewage, and other non-point sources. In conclusion, surface water in the delta regions of Cauver River showed contamination of phosphate and Nitrate if compared with WHO standards.

CHAPTER 3

DETERMINATION OF SEDIMENT PROFILE OF RIVER CAUVERY AND ITS TRIBUTARIES ARASALAR

3.1 INTRODUCTION

Sediments form a natural buffer and filter system in the material cycles of waters. Sediment in our rivers is an important habitat as well as a main nutrient source for aquatic organisms. Furthermore, sediments have an impact on ecological quality because of their quality, or their quantity, or both (Stronkhorst *et al*., 2004). Waters are subject to strong variations of flow rate, substance input and transport, and sedimentation. Sediment analysis is increasingly important in evaluating qualities of the total ecosystem of a body of water, in addition to the water sample analysis practiced for years. In comparison to water testing, sediment testing reflects the long-term quality situation independent of current inputs (Hodson, 1986; Haslam, 1990).

The sediments, both suspended and precipitated substances stored on the water bottom, form a reservoir for many pollutants and trace substances of low solubility and low degree of degradability (Biney *et al.*, 1994; Barbour *et al.*, 1998, 1999). Pollutants are conserved in sediments over long periods of time according to their chemical persistence and the physical-chemical and biochemical characteristics of the substrata. This can also allow conclusions to be drawn regarding sources of contamination. The introduction of waste products and industrial effluents into rivers and estuaries, especially those from industrial and populated centers, leads to a significant increase in trace metal contamination (Forstner 1983; Tessier and Campbell 1988).

Sediments play an important role in elemental cycling in the aquatic environment. They are responsible for transporting a significant proportion of many nutrients and contaminants. They also mediate their uptake, storage, release and transfer between environmental compartments. Most sediment in surface waters derives from surface erosion and comprises a mineral component, arising from the erosion of bedrock, and an organic component arising during soil-forming processes (including biological and microbiological production and decomposition).

An additional organic component may be added by biological activity within the water body. For the purposes of aquatic monitoring, sediment can be classified as deposited or suspended. Deposited sediment is that found on the bed of a river or lake. Suspended sediment is that found in the water column where it is being transported by water movements. Suspended sediment is also referred to as suspended matter, particulate matter or suspended solids. Generally, the term suspended solids refers to mineral + organic solids, whereas suspended sediment should be restricted to the mineral fraction of the suspended solids load.

Sediment transport in rivers is associated with a wide variety of environmental and engineering issues. The study of river suspended sediments is becoming more important, nationally and internationally, as the need to assess fluxes of nutrients and contaminants to lakes and oceans, or across international boundaries, increases. One of the most serious environmental problems is erosion and the consequent loss of topsoil. Although erosion is a natural phenomenon, the rate of soil loss is greatly increased by poor agricultural practices which result, in turn, in increased suspended sediment loads in freshwaters. Loss of topsoil results in an economic loss to farmers, equivalent to hundreds of millions of US dollars annually, through a reduction in soil productivity. Good environmental practice in agriculture, which may include contour ploughing and terracing, helps to protect against soil loss and against contamination of surface waters.

The Chemical enrichment in river system are derived through a combined effect of both industrial and municipal effluents and runoffs from surrounding area or through solution effects from adjacent soil. The presence of nutrients in rivers may be attributed to the process of organic mineralization of nitrates and phosphates derived principally from surface runoffs from the immediate vicinity (forests, farms and settlement) and perhaps by insitu mineralization (Ikomi 1997; Kaizer and Adaipkoh 2007; Kaizer and Osakwe 2007).

Soils from agricultural fields and other areas where wastes have been dumped and the sediments from polluted water bodies are often analyzed for their physico chemical characteristics in order to judge the effects of pollution on these properties. In aquatic ecosystems, the sediments are in a complex milieu with the overlying water; they affect water chemistry and are being affected by it. This chapter describes methods of determination of major physic chemical characteristics of soil and aquatic sediments.

Sediments in general are rich in nutrients (Pandit, 2003). According to Ishaq and Kaul (1990), the nutrient pools in different compartments of the water body indicate 99%phosphorus, 96% calcium locked within the sediments were as the remaining 4% and 1%calcium and phosphorus is distributed between macrophytic and water compartments. The diversity of phytoplankton in the reservoir is influenced by pH and electrical conductivity (Pangavhane *et al.,* 2003).

The role of sediment requires evaluation because it exhibits a potential to deliver environmental goods beyond habitat creation; it has the potential to take up particular elements and trap nutrients. This is particularly important where there is eutrophication of water from agriculture and wastewater and also physical degradation of the environmental bed of riverine system. Sedimentation initiates the permanent removal of material from aquatic systems via sediment burial. Sedimentation can play a role in the community composition of the food web by influencing phytoplankton succession.

Sedimentation is important in riverine systems where it plays a role in the global cycling of important elements. The sedimentation of nutrient elements such as phosphorus and nitrogen that limit production is of particular interest. Phytoplankton community composition also influences sedimenting particles. Periods of overturn can coincide with diatom blooms and subsequent sedimentation events.

Many of the chemical reactions are biologically mediate; their relative importance depends on several factors, such as sediment composition, sedimentation rate, hydrodynamics, bioturbation and irrigation as well as the physical and chemical characteristics of bottom waters. The chemical transformations that take place at the sediment water interface determine the cycling of nutrients between sediment and waters (Kuwae *et al*., 2003).

Temperature as well as pH alteration has a dramatic effect influencing remineralization of organic matter and nutrients in sediments on very short time scales. Sediment acts like a dynamical buffer representing sources and sinks for nutrients simultaneously. Surface runoff transporting sediment with high phosphorus (P) concentrations has been identified as a major hydrological pathway for sediment associated P delivery to surface waters and is considered a major threat to water quality, due to the ability of P to cause eutrophication in freshwater (Ballantine *et al.*, 2008). Realizing this fact river ecosystem are studied worldwide to understand the nutrient status and to know their relationship with other physico-chemical factors.

Studies on basic physicochemical characteristics carried out in various rivers have focused on the water quality parameters of the rivers' water columns with little or no consideration given to the bottom or sediment characteristics. Unfortunately, river or lagoon beds which are ideal habitats for several species of organisms usually serve as a 'sink' for both domestic industrial wastes from anthropogenic activities. Dumping of such wastes could alter the ecological state of these ecosystems.

Hence baseline studies are required to determine the status of sediment structure and quality to give complimentary data on the physicochemical characteristics of these habitats. This present chapter concentrates on some of the fundamental procedures required for the more common sediment measurements necessary for water quality monitoring programmes.

3.2 MATERIALS AND METHODS

3.2.1. Sampling

Three sampling stations were selected for river Cauvery such as station 1. Melakaveri (upstream of the river) station 2. Palakarai (midstream of the river) and station 3. Manancherry (downstream of the river) and similarly for river Arasalar such as station 1. Women's College Bridge (upstream of the river) 2. Patthadi palam (midstream of the river) and station 3. Sakkottai (downstream of the river) for sampling purpose. Sediment samples were collected from these six locations on monthly basis using a standard water sampler for a period of one year (January 2010 to December 2010).

The bottom sediment samples for physicochemical analysis were collected in triplicate directly (hand sampling) from the rivers in to acid-prewashed bottles. These were stored deep frozen until analysis. Sediment samples were thawed and dried in an oven at 60ºC for a period of 24 hours.

This temperature allows for drying without altering the chemical and physical properties.

3.2.2. Analysis of soil sediment

Soil quality assessments provide a better understanding and awareness that soil resources are truly living bodies with biological, chemical, and physical properties and processes performing essential ecosystem services. The samples were analyzed by following the international standard methodology of APHA (1998) during the study period (Jan 2010 to Jan 2011). Table 30 describes the methods adopted for analysis of soil sediment characteristics.

Table 30. Methods adopted for analysis of soil sediment characteristics.

S.No.	Parameters	Method/Instrument
1.	pH	pH meter (Henna pen type) made in Portugal
2.	Conductivity	Conductivity meter (Henna pen type - Portugal)
3.	Moisture	Mobile burner drying method
4.	Alkalinity TA	Titrimetric method
5.	Carbonates	Calculation from alkalinity
6.	Bicarbonates	Calculation from alkalinity
7.	Phosphorus	Colorimetric at 420 nm
8.	Sulfate	Turbidimetric at 420nm
9.	Chloride	Titration method
10.	Calcium	EDTA method
11.	Magnesium	EDTA method
12.	Nitrogen	Colorimetric (Phenol disulphonic acid method)
13.	Organic carbon	Walkley and Black (modified)
14.	Organic matter	Walkley and Black (modified)

3.3 RESULTS

The result of physicochemical analyses carried out on the soil sediment samples collected from the selected rivers within the studied area showed various concentrations of the parameters studied. Monthly variations of soil sediment characters (pH, Conductivity, Moisture, Alkalinity TA, Carbonates, Bicarbonates, Phosphorus, Sulfate, Chloride, Calcium Magnesium, Nitrogen, Organic carbon and Organic matter) of the river Cauvery and its tributary Arasalar for a period of one year (Jan 2010 to Dec 2010) are listed in table 31-33, 35-37 and Figure13, and 14. While the range and mean values of sediment profile of the river Cauvery and its tributaries Arasalar are presented in table 34 and 38. The Pearson's correlation analysis was used to assess the relationship between physico-chemical parameters and their significance was presented in the table 39-44.

3.3.1 pH

pH is the scale of intensity of acidity and alkalinity of water and measures the concentration of hydrogen ions. The standard for any purpose in terms of pH is 6.5-8.5 (Alam *et al.*, 2007). At the period of study, the pH ranges from 7.4 to 8.5 in the river Cauvery and 7.6 to 8.6 in the river Arasalar.The minimum pH of 7.4 was recorded in the river Cauvery and maximum pH of 8.6 was observed in the river Arasalar. The mean value of pH in the river Cauvery recorded was 7.92±0.351, 7.95±0.345 and 7.96±0.314 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 7.796±0.2640, 7.95±0.3414 and 7.95±0.3147 for S1, S2, and S3 respectively.

3.3.2 Conductivity

The electrical conductivity of water samples of Cauvery river and Arasalar river was observed to be in the ranges of 560 (μScm^{-1}) – 820 (μScm^{-1}) and 620 (μScm^{-1}) – 960 (μScm^{-1}).The lowest conductivity of 560 ($\mu S\ cm^{-1}$) was recorded in the

Table 31. Sediment profile of River Cauvery S1.

Parameters / Months	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
pH	7.4	7.8	7.9	8.2	8.3	8.4	7.4	8	8.4	7.9	7.8	7.6
Conductivity (µ Sie)	650	620	560	580	600	620	590	610	600	630	610	680
Moisture (%)	39.6	38.8	36.07	33.3	33.22	34.66	36.77	37.68	39.88	37.66	34.68	27.76
Alkalinity (caco3 mg/100g)	2.2	1.6	2.4	1.4	1.4	1.2	1.6	1.8	2	1.7	1.6	1.8
Carbonates (mg/100mg)	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonates (mg/100mg)	146.4	85.4	134.2	85.4	73.2	61.4	48.29	73.2	109.8	122.4	109.8	103.8
phosphorus (mg/100mg)	0.014	0.013	0.012	0.006	0.005	0.0124	0.0128	0.007	0.0114	0.0112	0.0098	0.013
Sulphate (mg/100mg)	0.926	0.8045	0.4491	0.5907	0.6122	0.6492	0.5799	0.7996	0.5236	0.7729	0.6143	0.319
Chloride (mg/100mg)	17.04	15.62	17.04	14.2	15.62	14.2	16.3	8.52	14.2	15.62	11.36	9.94
Calcium (mg/100mg)	128.26	110.2	125.25	105.21	110.2	80.16	120.24	59.117	75.15	110.2	74.15	50.1
Magnesium (mg/100mg)	101.84	77.35	85.19	61.38	52.35	77.36	79.5	45.69	57.36	81.38	70.16	36.56
Nitrogen (mg/100mg)	1.754	2.115	0.945	0.685	1.222	2.8	2.1	1.46	2.97	2.525	2	4.21
Organic carbon (%)	1.806	0.214	1.241	1.354	1.806	2.257	0.903	1.354	0.564	1.58	0.54	1.966
Organic matter (%)	3.114	0.369	2.14	2.334	3.114	3.892	1.557	2.334	0.972	2.724	12.445	3.39

Table 32. Sediment profile of River Cauvery S2.

Parameters / Months	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
pH	7.4	7.6	8.1	8.4	8.2	7.9	7.6	7.9	8.3	8	7.6	8.3
Conductivity (µ Sie)	720	710	700	680	660	680	760	680	690	750	730	730
Moisture (%)	33.73	35.9	33.88	26.5	34.09	33.87	39.76	37.7	38.5	34.9	38.8	39.8
Alkalinity (caco3 mg/100g)	1.8	1.7	2.1	1.6	1.7	1.3	1.5	1.9	2.1	1.7	1.5	1.3
Carbonates (mg/100mg)	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonates (mg/100mg)	170.8	122.4	485.4	43.8	85.4	85.4	61.4	73.2	109.8	122.4	109.8	35.7
phosphorus (mg/100mg)	0.0094	0.013	0.0098	0.0078	0.0064	0.0112	0.0211	0.0111	0.0112	0.014	0.005	0.0048
Sulphate (mg/100mg)	0.7214	0.7014	0.6416	0.6122	0.4907	0.463	0.3645	0.4907	0.5337	0.6122	0.5491	0.8046
Chloride (mg/100mg)	19.88	14.2	17.77	11.36	12.50	8.52	11.32	14.2	17.04	15.62	21.2	7.1
Calcium (mg/100mg)	145.29	75.15	140.28	74.15	70.14	61.12	53.1	70.14	110.22	128.25	115.23	217.22
Magnesium (mg/100mg)	140.12	73.36	140.12	70.16	63.96	55.44	45.69	63.6	91.38	121.84	115.75	164.38
Nitrogen (mg/100mg)	3.38	0.94	1.14	1.495	4.565	1.94	1.49	0.895	1.28	0.05	0.35	4.21
Organic carbon (%)	0.8102	1.98	0.803	0.757	1.529	1.693	1.154	0.977	0.851	1.529	0.699	0.416
Organic matter (%)	1.362	2.724	1.557	1.167	1.946	2.919	2.334	1.167	0.777	1.946	1.362	1.751

Table 33. Sediment profile of River Cauvery S3.

Parameters / Months	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
pH	7.6	7.7	7.8	8.1	8	8	7.6	7.7	8.5	8.2	7.9	8.3
Conductivity (µ Sie)	590	650	640	620	660	580	660	610	600	650	750	820
Moisture (%)	28.9	27.6	21.29	20.9	36.28	26.28	24.12	28.19	29.9	31.7	27.7	25.7
Alkalinity (caco3 mg/100g)	2	1.6	2.4	1.8	1.6	1.5	1.4	1.8	2.2	1.9	1.7	1.5
Carbonates (mg/100mg)	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonates (mg/100mg)	82.5	97.8	122	85.4	122.2	48.8	85.4	97.8	85.4	66.3	99.8	48.4
phosphorus (mg/100mg)	0.029	0.01	0.0088	0.0094	0.0172	0.006	0.0114	0.0058	0.108	0.0058	0.0136	0.0048
Sulphate (mg/100mg)	0.7614	0.8122	0.606	0.646	0.7614	0.5799	0.4491	0.4631	0.4630	0.3632	0.5491	0.6122
Chloride (mg/100mg)	9.52	17.04	7.52	21.3	12.33	14.22	12.78	16.02	17.04	14.2	15.63	9.22
Calcium (mg/100mg)	196.28	125.25	55.1	53.22	73.15	74.15	65.13	70.14	110.2	125.25	111.22	110.22
Magnesium (mg/100mg)	55.45	138.19	45.69	46.29	164.45	70.19	54.21	63.4	112.7	138.89	91.38	109.66
Nitrogen (mg/100mg)	3.38	2.44	1.84	1.81	2.97	2.46	1.84	2.08	2.24	5.09	4.71	4.89
Organic carbon (%)	1.016	0.885	0.128	0.903	1.467	1.016	1.129	1.354	1.918	0.112	1.805	1.354
Organic matter (%)	1.751	1.181	0.221	1.557	2.529	1.751	1.946	2.335	3.307	0.194	3.112	3.114

Table 34. Range value Mean value and Standard Deviation of Sediment profile of River Cauvery.

Water quality Parameters	Range value			Mean value ± Standard Deviation		
	S1	S2	S3	Station 1	Station 2	Station 3
pH	7.4 - 8.4	7.5-8.4	7.6-8.5	7.925±0.351	7.95±0.345	7.96±0.314
Conductivity (µ Sie)	560-680	660-750	610-820	610±26.6	707.5±31.079	652.5±69.167
Moisture (%)	27.76-39.88	26.5-39.8	25.7-36.28	35.84±3.41	35.71±3.471	27.18±3.856
Alkalinity (caco3 mg/100g)	1.2-2.4	1.3 -1.8	1.4-2.4	1.70±0.311	1.68±0.265	1.76±0.267
Bicarbonates (mg/100mg)	48.29-146.4	35.7-170.8	48.4-122	96.10±29.96	125.45±119.42	87.96±23.97
Available phosphorus (mg/100mg)	0.005-0.014	0.0048-0.0211	0.00480.0172	0.010±0.003	0.00956±0.0029	0.019±0.028
Sulphate (mg/100mg)	0.3199-0.943	0.3645-0.8046	0.3632-0.8122	0.63±0.168	0.582±0.124	0.57±0.122
Chloride (mg/100mg)	8.52-17.04	7.1-21.2	7.52-21.3	14.1±2.78	14.22±4.327	13.91±3.85
Calcium (mg/100mg)	50.1-128.25	53.1-217.22	49.2-196.28	95.68±26.63	105.024±47.69	97.515±40.971
Magnesium (mg/100mg)	36.56-132.19	55.44- 164.38	54.21-164.45	68.84±18.61	95.48±39.40	92.07±40.19
Nitrogen (mg/100mg)	0.685-4.21	0.05-4.565	1.84-4.89	2.06±0.97	1.81±1.46	2.97±1.24
Organic carbon (%)	0.214-2.257	0.416-1.98	0.128-1.805	1.29±0.63	1.099±0.476	1.09±0.56
Organic matter (%)	0.369-3.892	0.777-2.919	0.221-3.112	3.19±3.08	1.751±0.653	1.91±1.040

Table 35. Sediment profile of River Arasalar S1.

Parameters / Months	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
pH	7.7	7.9	7.8	8.3	8.2	8.4	7.6	8.1	8.2	7.8	7.9	7.7
Conductivity (µ Sie)	620	720	660	680	700	720	690	710	700	730	710	750
Moisture (%)	40.8	39.6	35.09	34.2	32.42	33.67	35.74	36.62	38.44	36.24	33.35	28.46
Alkalinity (caco3 mg/100g)	2.8	1.7	2.4	1.4	1.8	1.3	1.7	1.9	2.1	1.8	1.9	1.7
Carbonates (mg/100mg)	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonates (mg/100mg)	126.4	75.4	124.2	95.4	93.2	71.4	58.29	63.2	99.8	112.4	100.8	110.8
phosphorus (mg/100mg)	0.012	0.014	0.011	0.005	0.006	0.0114	0.0138	0.006	0.0212	0.0314	0.0088	0.012
Sulphate (mg/100mg)	0.836	0.7025	0.3191	0.6207	0.5120	0.5292	0.4399	0.6226	0.4436	0.6228	0.5123	0.2188
Chloride (mg/100mg)	16.04	14.62	17.04	15.2	14.62	13.21	15.22	9.42	12.3	14.52	12.26	8.74
Calcium (mg/100mg)	118.26	120.2	115.25	99.21	115.2	90.16	120.20	66.17	85.15	110.2	64.20	40.12
Magnesium (mg/100mg)	101.84	87.25	122.20	90.22	92.25	87.26	109.8	55.20	67.16	80.28	69.16	46.44
Nitrogen (mg/100mg)	1.254	1.115	1.945	0.785	1.235	2.2	2.3	1.86	2.57	2.025	1.456	3.20
Organic carbon (%)	1.906	0.714	1.641	1.854	1.506	1.257	0.803	2.354	1.564	1.38	0.74	1.956
Organic matter (%)	2.114	3.369	1.14	2.534	3.014	2.892	2.557	3.334	1.952	1.824	4.435	2.49

Table 36. Sediment profile of River Arasalar S2.

Parameters / Months	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
pH	7.6	7.7	7.6	8.6	8.3	8	7.7	7.8	8.2	8.1	7.7	8.4
Conductivity (µ Sie)	820	810	800	750	770	790	850	970	780	840	810	920
Moisture (%)	43.73	45.9	38.88	37.74	34.99	34.85	32.76	31.7	35.5	37.9	30.8	32.8
Alkalinity (caco3 mg/100g)	2.8	2.7	3.1	2.6	2.7	3.3	1.9	2.9	2.5	3.7	2.5	1.5
Carbonates (mg/100mg)	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonates (mg/100mg)	190.5	145.4	385.4	243.8	185.4	185.4	91.4	130.2	170.8	142.4	160.8	65.7
phosphorus (mg/100mg)	0.0024	0.0043	0.0078	0.0088	0.0064	0.0112	0.0011	0.0021	0.0122	0.0014	0.0054	0.0046
Sulphate (mg/100mg)	0.6214	0.8514	0.7816	0.7222	0.5507	0.4635	0.2945	0.3907	0.6237	0.5422	0.6591	0.7246
Chloride (mg/100mg)	22.78	24.20	25.77	18.36	17.50	18.52	19.32	16.2	10.04	17.62	27.2	9.1
Calcium (mg/100mg)	125.29	95.15	120.28	84.15	75.14	81.12	63.1	50.14	110.22	118.25	95.23	171.22
Magnesium (mg/100mg)	90.12	76.36	80.12	75.16	53.96	65.44	55.69	73.6	81.38	98.84	70.75	74.38
Nitrogen (mg/100mg)	2.38	1.84	2.54	2.195	3.265	1.84	2.39	0.995	2.28	0.09	0.350	3.21
Organic carbon (%)	0.7902	1.58	0.903	0.0857	1.129	1.693	1.354	0.6772	0.451	1.129	0.799	1.016
Organic matter (%)	2.332	3.224	2.157	2.667	2.446	1.819	1.234	2.267	0.877	0.946	2.362	1.151

Table 37. Sediment profile of River Arasalar S3.

Parameters / Months	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
pH	7.7	7.8	7.9	8.2	7.5	8.1	7.6	7.9	8.5	8.1	7.7	8.4
Conductivity (µ Sie)	790	680	760	820	560	770	960	730	720	660	750	710
Moisture (%)	26.5	22.5	20.28	24.77	30.88	25.48	26.22	23.62	21.95	28.72	24.71	28.22
Alkalinity (caco3 mg/100g)	3	2.6	3.2	2.8	3.6	2.5	2.4	2.8	3.2	1.9	1.8	1.3
Carbonates (mg/100mg)	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonates (mg/100mg)	90	87.8	76.3	95.4	112.2	68.8	75.4	87.8	95.4	76.3	89.8	58.4
phosphorus (mg/100mg)	0.039	0.0122	0.0078	0.0064	0.0172	0.0092	0.0514	0.0068	0.1082	0.0048	0.0196	0.0098
Sulphate (mg/100mg)	0.6614	0.7122	0.806	0.926	0.5514	0.8299	0.6291	0.5431	0.9430	0.7332	0.6591	0.6222
Chloride (mg/100mg)	28.83	18.04	9.52	12.42	14.33	16.22	9.78	15.02	16.04	13.2	14.63	9.52
Calcium (mg/100mg)	168.34	145.20	63.1	73.1	54.15	64.15	75.13	78.14	122.2	124.25	115.22	120.22
Magnesium (mg/100mg)	120.35	148.19	65.69	56.29	64.16	65.19	74.21	53.1	72.7	128.89	81.38	74.66
Nitrogen (mg/100mg)	2.22	1.44	2.44	1.41	1.27	3.46	3.84	1.08	4.24	5.09	3.71	2.89
Organic carbon (%)	0.956	0.785	0.828	1.903	1.867	1.416	1.229	0.354	0.918	1.112	1.705	1.254
Organic matter (%)	2.651	2.781	0.721	0.557	1.529	2.251	1.446	2.635	3.107	1.194	2.112	2.114

Table 38. Range value Mean value and Standard Deviation of Sediment profile of River Arasalar.

Water quality Parameters	Range value			Mean value ± Standard Deviation		
	S1	S2	S3	Station 1	Station 2	Station 3
pH	7.6-8.4	7.6-8.6	7.5-8.5	7.966±0.2640	7.975±0.3414	7.95±0.3147
Conductivity (µ Sie)	620-750	750-970	660-960	701.66±28.55	825.83±63.16	742.5±96.49
Moisture (%)	28.46-40.8	31.7-38.88	20.28-30.88	35.38±3.35	36.46±4.66	25.32±3.035
Alkalinity (caco3 mg/100g)	1.3-2.8	1.9-3.7	1.3-3.6	1.87±0.409	2.68±0.58	2.591±0.662
Bicarbonates (mg/100mg)	58.29-126.4	65.7-385.4	58.4-95.4	94.27±22.85	183.1±106.10	84.46±14.23
Available phosphorus (mg/100mg)	0.005-0.0314	0.0024-0.0088	0.0048-0.1082	0.010±0.0030	0.0056±0.0037	0.024±0.300
Sulphate (mg/100mg)	0.2188-0.836	0.2945-0.8514	0.5514-0.926	0.548±00.153	0.60±0.163	0.71±0.133
Chloride (mg/100mg)	8.74-17.04	9.1-27.2	9.52-28.83	13.59±2.533	18.88±5.602	14.79±5.22
Calcium (mg/100mg)	40.12-120.2	50.14-171.22	54.15-168.34	95.36±26.60	99.10±32.57	100.26±36.93
Magnesium (mg/100mg)	46.44-122.20	53.96-98.84	53.1-128.89	84.08±22.009	74.65±12.76	83.73±31.01
Nitrogen (mg/100mg)	0.785-3.20	0.09-3.265	1.08-5.09	1.82±0.691	1.94±1.0076	2.75±1.32
Organic carbon (%)	0.74-2.354	0.451-1.693	0.785-1.903	1.47±0.521	0.96±0.457	1.19±0.468
Organic matter (%)	1.14 - 4.435	0.877-3.224	0.557-2.651	2.63±0.860	1.95±0.748	1.92±0.830

Table 39. Correlation matrix among various sediment characteristics of river Cauvery at S1.

	pH	EC	Moisture	Alkalinity	Bicarbonate	phosphorus	sulphate	chloride	calcium	magnesium	Nitrogen	OC	OM
pH	1												
EC	-0.26899	1											
Moisture	0.055531	-0.08671	1										
Alkalinity	-0.35762	0.043802	0.379959	1									
Bicarbonate	-0.1798	0.211491	0.206958	0.765894**	1								
phosphorus	-0.46131	0.404897	0.226956	0.415066	0.326864	1							
sulphate	-0.06935	0.338567	0.685021*	0.013088	0.081079	0.005793	1						
chloride	-0.04038	-0.26082	0.417809	0.142452	0.216799	0.293364	0.204769	1					
calcium	-0.23343	-0.31214	0.420633	0.169605	0.208683	0.135367	0.348602	0.924434**	1				
magnesium	-0.2341	-0.42798	0.44617	0.237558	0.170376	0.239737	0.208923	0.923527**	0.956179**	1			
Nitrogen	-0.10317	0.651276	-0.27994	0.002192	0.006268	0.565058*	-0.32942	-0.33382	-0.57478*	-0.52507*	1		
OC	0.157057	0.338179	-0.46873	-0.15988	-0.00387	-0.07652	-0.05874	-0.05041	-0.07845	-0.15037	0.139568	1	
OM	-0.09565	0.119863	-0.28153	-0.17466	0.1538	-0.1208	-0.06626	-0.35716	-0.30236	-0.26569	0.026739	-0.05224	1

** Correlation is significant at the 0.01 level (2-tailed)   * Correlation is significant at the 0.05 level (2-tailed)

Table 40. Correlation matrix among various sediment characteristics of river Cauvery at S2.

	pH	EC	Moisture	Alkalinity	Bicarbonate	phosphorus	sulphate	chloride	calcium	magnesium	Nitrogen	OC	OM
pH	1												
EC	-0.41248	1											
Moisture	-0.24473	0.483231	1										
Alkalinity	-0.13415	-0.2697	-0.09276	1									
Bicarbonate	-0.51948*	-0.02558	-0.17027	0.595381*	1								
phosphorus	-0.25574	0.143849	-0.05737	0.351759	0.140948	1							
sulphate	0.047983	0.137855	-0.13695	0.016059	0.20361	-0.21696	1						
chloride	-0.5189*	0.146321	0.035533	0.60947	0.480806	0.066091	0.079593	1					
calcium	0.062443	0.353303	0.242165	-0.01904	0.240196	-0.38946	0.784456**	0.098242	1				
magnesium	-0.10668	0.365514	0.13281	0.09722	0.414026	-0.3318	0.788829**	0.313343	0.962439**	1			
Nitrogen	0.289361	-0.27829	-0.03742	-0.26407	-0.19116	-0.55443*	0.252763	-0.40663	0.302971	0.176473	1		
OC	-0.18002	-0.13551	-0.15729	-0.0948	-0.09984	0.619548*	-0.28823	-0.17801	-0.59864*	-0.56191*	-0.16152	1	
OM	-0.30711	0.165385	0.025827	-0.56042*	-0.09718	0.313226	-0.1474	-0.4854	-0.30921	-0.33481	0.060278	0.75646**	1

** Correlation is significant at the 0.01 level (2-tailed)　　* Correlation is significant at the 0.05 level (2-tailed)

Table 41. Correlation matrix among various sediment characteristics of river Cauvery at S3.

	pH	EC	Moisture	Alkalinity	Bicarbonate	phosphorus	sulphate	chloride	calcium	magnesium	Nitrogen	OC	OM
pH	1												
EC	0.342902	1											
Moisture	0.159656	-0.04515	1										
Alkalinity	0.136999	-0.3981	-0.00088	1									
Bicarbonate	-0.56698 *	-0.26305	0.267328	0.306246	1								
phosphorus	0.423598	-0.28661	0.281767	0.545353 *	0.142893	1							
sulphate	-0.18718	0.00571	-0.02043	-0.06061	0.474119	-0.12886	1						
chloride	-0.35132	-0.43901	0.533723 *	0.185008	0.418207	0.380957	-0.00684	1					
calcium	-0.03804	0.02953	0.46162	0.195526	0.214937	0.236364	0.187729	0.72498**	1				
magnesium	0.102832	0.048288	0.530908*	0.173532	0.075054	0.250531	0.051424	0.660139*	0.952623**	1			
Nitrogen	0.387565	0.650824 *	0.436185	-0.13217	-0.25217	-0.18004	-0.09638	0.054422	0.527538*	0.556667*	1		
OC	0.231972	0.219239	0.302181	-0.2091	0.157839	0.497635	0.10173	0.287945	0.074937	-0.0079	0.027845	1	
OM	0.356454	0.369439	0.250967	-0.24292	0.021628	0.437276	0.106523	0.147411	0.070316	-0.0121	0.143176	0.9706**	1

** Correlation is significant at the 0.01 level (2-tailed)   * Correlation is significant at the 0.05 level (2-tailed)

Table 42. Correlation matrix among various sediment characteristics of river Arasalar at S1.

	pH	EC	Moisture	Alkalinity	Bicarbonate	phosphorus	sulphate	chloride	calcium	magnesium	Nitrogen	OC	OM
pH	1												
EC	0.080406	1											
Moisture	-0.09417	-0.49045	1										
Alkalinity	-0.47959	-0.63407*	0.505247*	1									
Bicarbonate	-0.29543	-0.30324	-0.02349	0.623086*	1								
phosphorus	-0.59661*	0.120547	0.289133	0.186487	0.039204	1							
sulphate	0.063695	-0.51431*	0.781665**	0.36489	0.070117	-0.08292	1						
chloride	-0.12398	-0.71096**	0.436352	0.292766	0.257049	0.167549	0.518483*	1					
calcium	-0.10956	-0.5736*	0.578277*	0.228328	0.011001	0.230077	0.582988*	0.913414**	1				
magnesium	-0.18045	-0.73779**	0.333063	0.282553	0.120557	0.213097	0.379388	0.942848**	0.8623**	1			
Nitrogen	-0.25553	0.480728	-0.38707	-0.06351	-0.00339	0.440704	-0.76384**	-0.54282*	-0.51516*	-0.39552	1		
OC	0.176904	-0.15828	-0.09785	0.266458	0.284612	-0.48947	0.025033	-0.32642	-0.33288	-0.29669	0.128777	1	
OM	0.208719	0.376774	-0.16777	-0.39103	-0.50745*	-0.26824	0.024439	-0.42337	-0.36972	-0.42996	-0.30127	-0.36905	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 43. Correlation matrix among various sediment characteristics of river Arasalar at S2.

	pH	EC	Moisture	Alkalinity	Bicarbonate	phosphorus	sulphate	chloride	calcium	magnesium	Nitrogen	OC	OM
pH	1												
EC	-0.14349	1											
Moisture	-0.27449	-0.36371	1										
Alkalinity	-0.20429	-0.25145	0.326786	1									
Bicarbonate	-0.26467	-0.44252	0.294143	0.42166	1								
phosphorus	0.385389	-0.60515*	-0.05526	0.092974	0.391611	1							
sulphate	0.077083	-0.34486	0.555667*	-0.03849	0.408503	0.292284	1						
chloride	-0.75104**	-0.30741	0.360985	0.352875	0.474006	-0.2021	0.227681	1					
calcium	0.213176	0.051437	0.23382	-0.23003	0.061441	0.04121	0.588319*	-0.23425	1				
magnesium	-0.09521	0.073175	0.480361	0.452986	0.168587	-0.13971	0.375718	0.017053	0.532644*	1			
Nitrogen	0.300811	-0.18369	0.124658	-0.5376*	0.147012	0.282334	0.172637	-0.32531	0.241065	-0.42834	1		
OC	-0.29762	0.080427	0.139073	0.120444	-0.22049	-0.20354	-0.19398	0.196369	-0.06327	-0.28785	0.008295	1	
OM	-0.30588	-0.23739	0.443285	0.144809	0.285203	-0.0164	0.414331	0.639428*	-0.33919	-0.18192	0.026308	-0.00871	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 44. Correlation matrix among various sediment characteristics of river Arasalar at S3.

	pH	EC	Moisture	Alkalinity	Bicarbonate	phosphorus	sulphate	chloride	calcium	magnesium	Nitrogen	OC	OM
pH	1												
EC	-0.03282	1											
Moisture	-0.17495	-0.30887	1										
Alkalinity	-0.36639	-0.15036	-0.24051	1									
Bicarbonate	-0.46762	-0.35942	0.056113	0.705153**	1								
phosphorus	0.083416	0.217311	-0.23077	0.294588	0.243396	1							
sulphate	0.584895*	0.197509	-0.50359*	0.177375	-0.01952	0.32728	1						
chloride	-0.26022	-0.09164	0.01853	0.295845	0.341931	0.203487	-0.04647	1					
calcium	0.111997	-0.07925	-0.02834	-0.31184	-0.07304	0.257984	-0.01439	0.628489*	1				
magnesium	-0.14778	-0.19923	0.062783	-0.21308	-0.05533	-0.04092	-0.06887	0.487755	0.787363**	1			
Nitrogen	0.283084	0.19332	0.086771	-0.46346	-0.42718	0.386117	0.285053	-0.18158	0.207014	0.1793	1		
OC	-0.08989	-0.0421	0.515989*	-0.08553	0.258011	-0.14534	0.128317	-0.20024	-0.3191	-0.26406	0.047521	1	
OM	0.04191	-0.16905	-0.16446	-0.01171	0.05638	0.462851	-0.15566	0.573983*	0.556243*	0.273114	0.00552	-0.47165	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

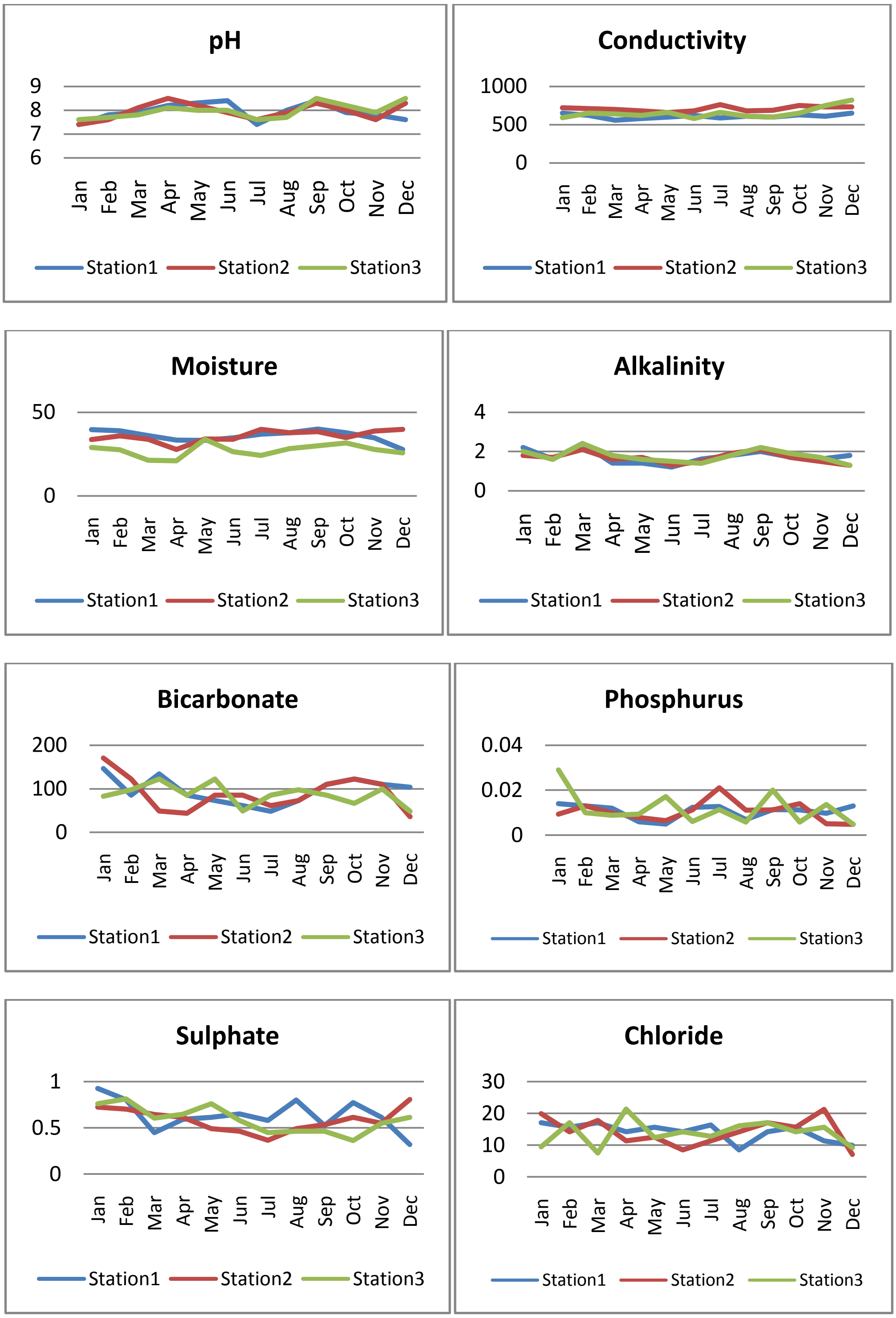


Figure 13 a. Physico-chemical characteristics of Cauvery river sediments from 3 stations.

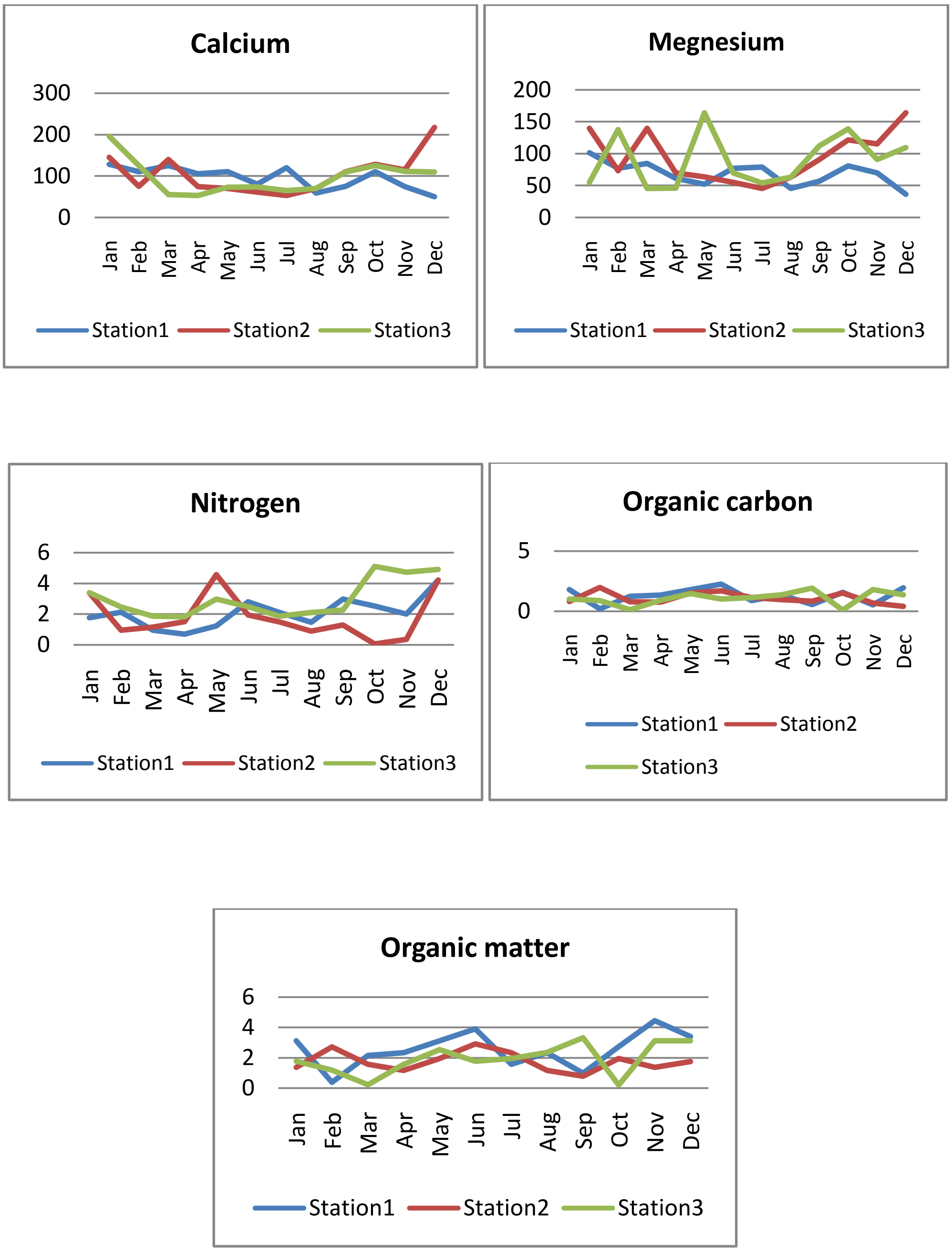


Figure 13 b. Physico-chemical characteristics of Cauvery river sediments from 3 stations.

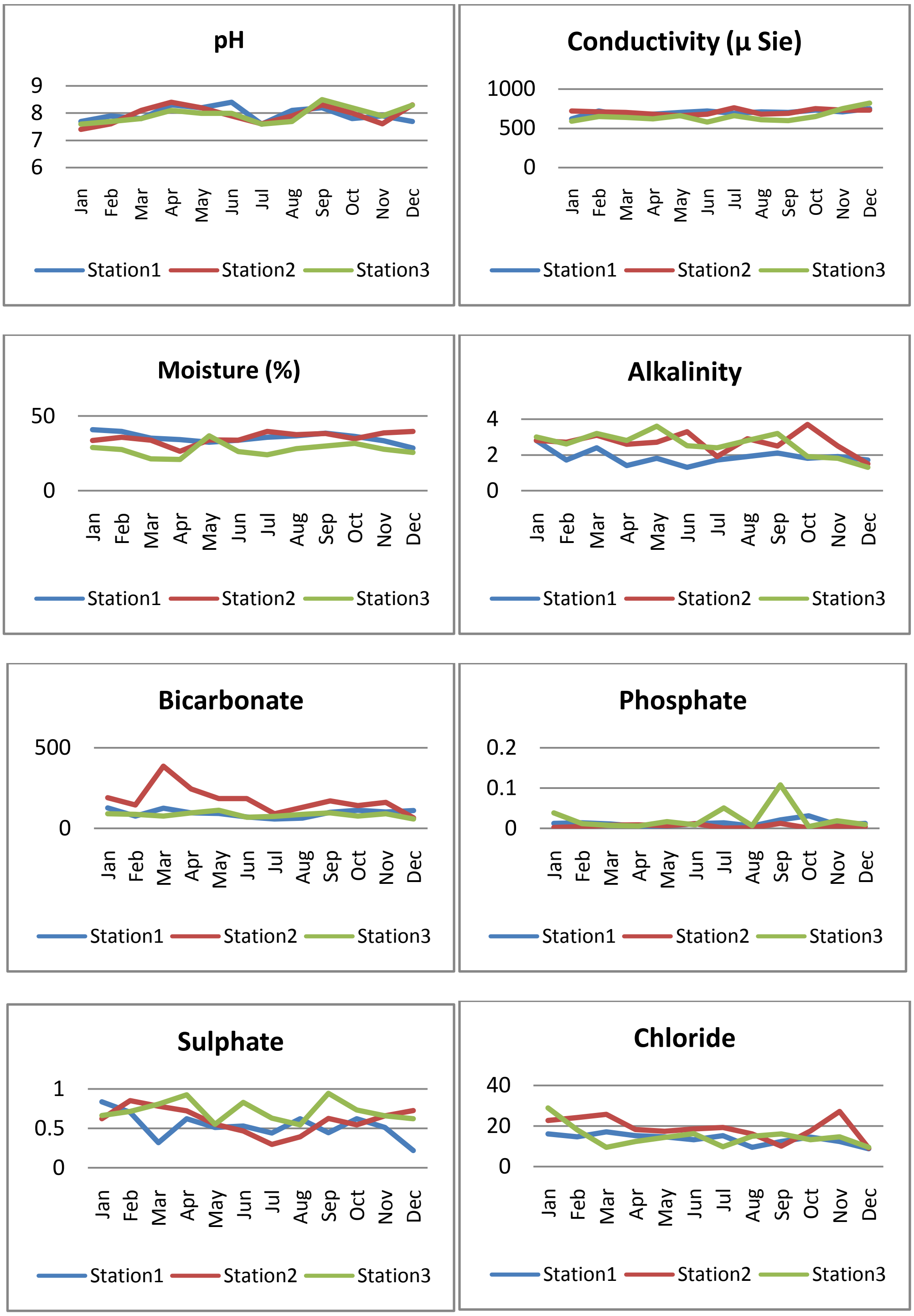


Figure 14 a. Physico-chemical characteristics of Cauvery river sediments from 3 Stations

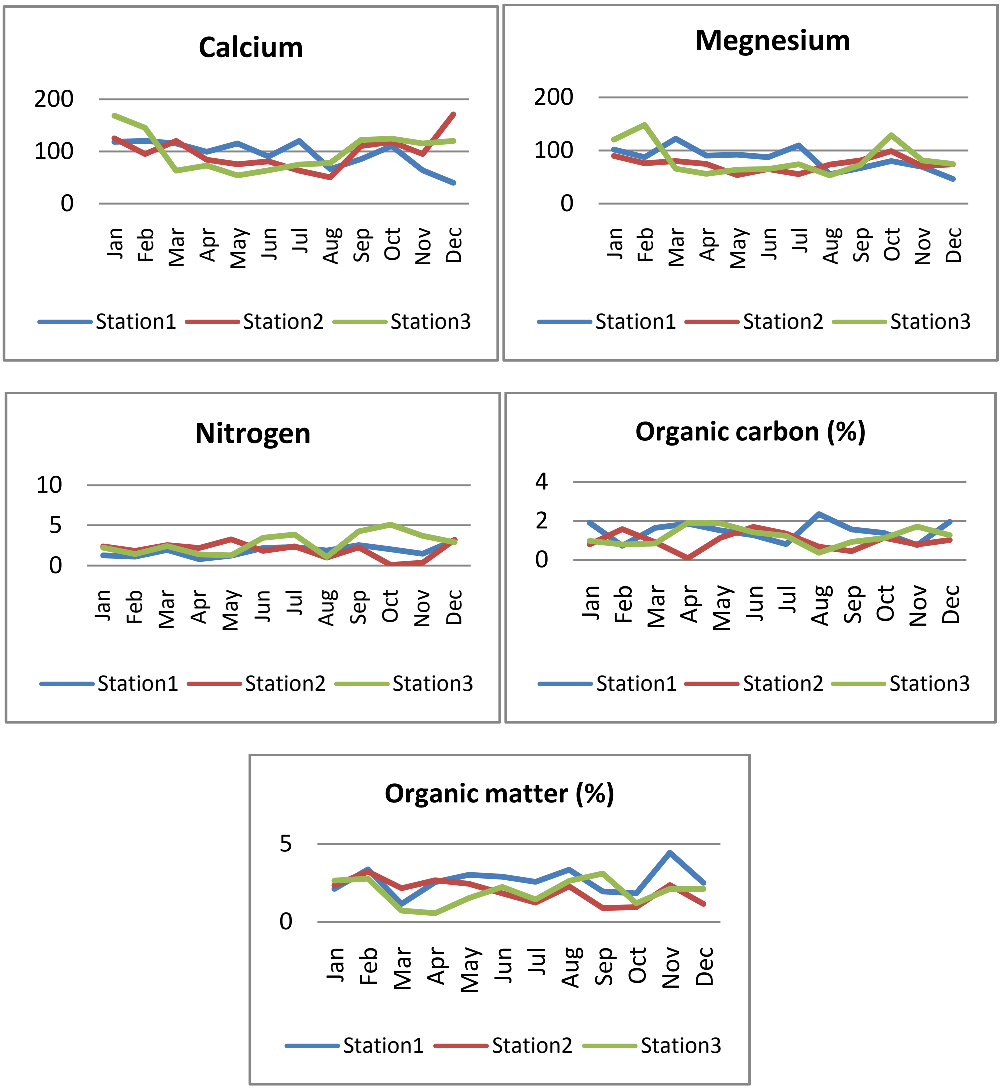


Figure 14 b. Physico-chemical characteristics of Cauvery river sediments from 3 stations

River Cauvery and highest conductivity of 960 (µScm-^{1}) was observed in the river Arasalar. This conductivity of average value was found to be 610±26.6.(µS cm-^{1}), 707.5±31.079 (µS cm-^{1}) and 652.5±69.167 (µS cm-^{1}) for S1, S2, and S3 in the river Cauvery and 701.66±28.55 (µS cm-^{1}), 825.83±63.16 (µS cm-^{1}) and 742.5±96.49 (µS cm-^{1}) for S1, S2, and S3 in the river Arasalar respectively

3.3.3 Moisture

The sediment moisture content of water samples ranged between 25.7 and 39.8 mg/L. in the river Cauvery and 20.28 to 40.8 in the river Arasalar. The minimum moisture content of 20.28 was recorded in the river Arasalar and maximum moisture content of 40.8 was also observed in the river Arasalar. The mean value of moisture content in the river Cauvery recorded was 35.84±3.41, 35.71±3.471 and 27.18±3.856 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 35.38±3.35, 36.46±4.66 and 25.32±3.035 for S1, S2, and S3 respectively.

3.3.4 Alkalinity TA

In the present study, alkalinity was recorded throughout the investigation. Total alkalinity of water samples ranged between 1.2 and 2.4mg/L. in the river Cauvery and 1.3 to 3.6 in the river Arasalar. The minimum alkalinity of 1.2 was recorded in the river Cauvery and maximum alkalinity of 3.6 was observed in the river Arasalar. The mean value of alkalinity in the river Cauvery recorded was 1.70±0.311, 1.68±0.265 and 1.76±0.267 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 1.87±0.409, 2.68±0.58 and 2.591±0.662 for S1, S2, and S3 respectively.

3.3.5 Carbonates and Bicarbonates

In the present investigation, carbonate content appear to be comparatively less**.** In many of the collections it was found to be nil. On the other hand the bicarbonates were recorded in all collections of the study period. In the present study the month wise Bicarbonates distribution in the sediments varied from 35.7 mg/l to 170.8 mg/l in the river Cauvery and 58.4 to 385.4 in the river Arasalar. The minimum Bicarbonates of 35.7 mg/l was recorded in the river Cauvery and maximum Bicarbonates of 385.4 mg/l was observed in the river Arasalar. The mean value of Bicarbonates in the river Cauvery recorded was 96.10±29.96, 125.45±119.42 and 87.96±23.97 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 94.27±22.85 183.1±106.10 and 84.46±14.23 for S1, S2, and S3 respectively.

3.3.6 Phosphorus

In the present study the month wise phosphorous distribution in the sediments varied from 0.005 mg/l to 0.0211 mg/l in the river Cauvery and 0.006 mg/l to 0.0314 mg/l in the river Arasalar. The minimum phosphorous of 0.005 was recorded in the river Cauvery and maximum phosphorous of 0.0314 was observed in the river Arasalar. The mean value of phosphorous in the river Cauvery recorded was 0.010±0.003, 0.00956±0.0029 and 0.019±0.028 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 0.010±0.0030, 0.0056±0.0037 and 0.024±0.300 for S1, S2, and S3 respectively.

3.3.7 Sulfate and Chloride

Sulfate fluctuated from 0.319 mg/L to 0.943 in the River Cauvery and 0.218 mg/l to 0.926 mg/l in the river Arasalar. In the present investigation sulfate level was minimum (0.218 mg/l) in River Arasalar while maximum (0.943 mg/L) in river Cauvery. The average Sulphate levels were 13.184mg/L, 12.761mg/L and 13.138mg/L for S1 and S2 and S3 in the River Cauvery. Whereas in the river Arasalar recorded were 13.59±2.533, 18.88±5.602 and 14.79±5.22 for S1, S2, and S3 respectively. Similarly the Chlorides were ranging from 7.10 to 21.3 in the River Cauvery and 8.74 mg/l to 28.83 mg/l in the river Arasalar. The minimum Chlorides (7.10 mg/L) was observed in the River Cauvery and maximum (28.83 mg/l) was observed in the river Arasalar. The mean value of Chlorides in the river Cauvery observed to be 14.1±2.78, 14.22±4.327 and 13.91±3.85 for the S1, S2 and S3 respectively. Similarly in the river Arasalar observed to be 13.59±2.533, 18.88±5.602 and 14.79±5.22 for S1, S2, and S3 respectively.

3.3.8 Calcium and Magnesium

Principal cat ions imparting hardness are calcium and magnesium. The Calcium content of water samples ranged between 49.21 to 217.22 mg/L in the River Cauvery and 40.12 mg/l to 171.22 mg/l in the river Arasalar. In the present investigation Calcium level was minimum (49.21 mg/l) in River Arasalar while maximum (217.22 mg/L) in river Cauvery. The average Calcium levels were 95.68±26.63, 105.02±47.69 and 97.34±41.16 mg/L for S1 and S2 and S3 in the River Cauvery whereas in the river Arasalar recorded were 95.36±26.60, 99.10±32.57 and 100.26±36.93 for S1, S2, and S3 respectively.

Similarly the Magnesium was ranging from 36.56 to 164.45 in the River Cauvery and 46.44 mg/l to 128.89 mg/l in the river Arasalar. The minimum Magnesium (36.56 mg/L) was observed in the River Cauvery and maximum (164.45 mg/l) was observed in the river Arasalar. The mean value of Magnesium in the river Cauvery observed to be 68.84±18.61, 95.48±39.40 and 92.07±40.19 for the S1, S2 and S3 respectively. Similarly in the river Arasalar observed to be 84.08±22.009, 74.65±12.76 and 83.73±31.01 for S1, S2, and S3 respectively

3.3.9 Available Nitrogen

Sediment can be considered as the major nitrogen compartment. Present study, the average level of total nitrogen ranged from 0.05 mg/gm to 4.89 mg/gm in the river Cauvery and 0.09 to 3.265 in the river Arasalar. The minimum nitrogen of 0.05 mg/gm and maximum nitrogen of 4.89 mg/gm was observed in the river Cauvery. The mean value of nitrogen in the river Cauvery recorded was 2.06±0.97, 1.81±1.46 and 2.97±1.24 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 1.82±0.691, 1.94±1.0076 and 2.75±1.32 for S1, S2, and S3 respectively.

3.3.10 Organic matter

The oxidizable organic matter in the river Cauvery ranged from 0.128 mg/l to 2.257 mg/l and 0.451 mg/l to 2.354 mg/l in the river Arasalar. The minimum organic matter of 0.128 mg/l was recorded in the river Cauvery and maximum organic matter of 2.354 mg/l was observed in the river Arasalar. The mean value of organic matter in the river Cauvery recorded was 1.29±0.63, 1.099±0.476 and 1.09±0.56 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 1.47±0.521, 0.96±0.457 and 1.19±0.468 for S1, S2, and S3 respectively.

3.3.11 Organic carbon

Sediment organic carbon is an important determinant of the fate of nutrients in aquatic systems. Sediment organic carbon in the sediments of Cauvery River varied from 0.221 mg/l to 3.892 mg/l and 0.557 to 4.435 mg/l in the river Arasalar. The minimum organic matter of 0.221 mg/l was recorded in the river Cauvery and maximum organic matter of 4.435 was observed in the river Arasalar. The mean value of organic matter in the river Cauvery recorded was 3.19±3.08, 1.751±0.653 and 1.91±1.040 for S1, S2, and S3 respectively. Whereas in the river Arasalar recorded were 2.63±0.860, 1.95±0.748 and 1.92±0.830 for S1, S2, and S3 respectively.

3.4. DISCUSSION

Sediments comprise an important component of aquatic ecosystems, providing habitat for a wide range of benthic and epi-benthic organisms. Exposure to certain substances in sediments represents a potentially significant hazard to the health of these organisms. Effective assessment of this hazard requires an understanding of the relationships between concentrations of sediment-associated chemicals and the occurrence of adverse biological effects. Sediment quality guidelines are scientific tools that synthesize information regarding the relationships between the sediment concentrations of chemicals and any adverse biological effects resulting from exposure to these chemicals.

3.4.1 pH

One of the important factors that serve as an indicator of pollution of water body is pH. The pH of natural water can provide important information about many chemical and biological processes and provides indirect correlations to a number of different impairments. Many workers have noted in their studies (Murdock *et al.,* 2001) that alkaline condition of water prevails in the reverine system. Our observation reveals that by and large, all the stations under study showed the alkaline pH. The EC and pH of the sediment showed a highly negative correlation in river Cauvery and Arasalar. Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent (Wang *et al*., 2002). Optimal pH range for sustainable aquatic life is pH 6.5 - 8.2.

3.4.2 Conductivity

Conductivity is the measure of capacity of a substance or solution to conduct electrical current through the water. Electrical conductivity pronounced considerable variation among samples. (Rao *et al.,* 1990) have noted out that the electrical conductivity of sediment reached the lowest during rainy season and the highest during summer while investigating on the water quality of river Ganga. The foregoing observations reveal that the values of conductance were high during summer and low during rainy months. A similar observation has been made by khare *et al.* (1991) in Kolar River. Higher conductivity depend upon the percentage of ions such as chloride, sulphate, phosphate, bicarbonate, sodium, potassium, calcium, magnesium etc and lower electrical conductance is the indications of highly silicates material.

3.4.3 Moisture

Very low percentage of moisture which could be attributed to the sandy nature of the sediments. Stations 2 and 3 did not show wide variations whereas; all other stations changed the moisture content during different periods of collection in river Cauvery and Arasalar. The highest mean value was at the Arasalar station 1 in non monsoon (40.8%) and the lowest value was at the Cauvery station 3 in monsoon (25.7%). Other stations also retained high moisture. The in situ sediment moisture content varied in different sediment samples.

3.4.4 Alkalinity

The alkalinity of water is measure of its capacity to neutralize acids. The alkalinity of natural water is due to the salts of weak acids although weak or strong bases may contribute. Bicarbonate represents the major form of alkalinity. In the present study, alkalinity was recorded throughout the investigation. Alkalinity is constituted mainly by the bicarbonate ions, which represent the main carbon source for assimilation during photosynthesis. There was no significant difference in the Alkalinity between the two rivers.

3.4.5 Carbonate and bicarbonates

In the present investigation, carbonate content appear to be comparatively less**.** In many of the collections it was found to be nil. On the other hand the bicarbonates were recorded in all collections of the study period. Carbonates and Bicarbonates are the anions which influence the alkalinity of the water. Bicarbonates alkalinity will predominate over the carbonate alkalinity. Where carbonate takes water, it becomes bicarbonate ion that influence increase in the alkaline condition of water.

3.4.6 Phosphate

The maximum amount of available phosphate is attributed to high pollutant which discharged through streams from various tributaries to the Cauvery River. These discharges may contain fertilizers pesticides, insecticides, herbicides used by cultivators in their field and this agricultural run-off to the tributary's, industrial discharge and also due to decomposition & mobilization of phosphatic rocks. The lower concentration of phosphorous may be attributed to higher pH value of the sediment because at very lower and very high pH value of sediments or soil, considerable decreases the available phosphorous. Phosphate shows negative correlation with pH and Alkalinity in river Cauvery. Where as Phosphate shows significant correlation at the 0.05 level in Arasalar.

3.4.7 Sulfates

Sulfates and Chlorides are the two important anions which appear to be dominant in the aquatic system. The Sulfate and Chloride content in natural water is an important consideration in determining their suitability for public and industrial usage. Sulphate exhibits positive correlation with chloride, Calcium and magnesium hardness and negatively correlated with pH, Alkalinity, phosphate and nitrogen at three river sites of river Cauvery whereas in Arasalar sulphate showed positive correlation with Calcium and magnesium and chloride.

3.4.8 Chlorides

Chloride exhibits positive correlation with calcium and magnesium hardness and negatively correlated with nitrogen OC and OM at three river sites of river Cauvery whereas in Arasalar Chloride showed positive correlation with Calcium and magnesium. Chloride also gets added to waters from the discharge of industrial effluents or contamination with sewage (Suthar, 2008). High values of chloride are troublesome in irrigation water and also harmful to aquatic life (Venkatesharaju, 2010).

3.4.9 Calcium

Calcium is one of the important cations that greatly influence the distribution of phytoplankton in the aquatic environment. Phytoplankton needs calcium for growth and other physiological activity. Therefore in adequate amount of calcium in the water may influence with their normal physiological activities. Thus it plays a significant role in the biological productivity also. Calcium exhibits positive correlation with chloride, magnesium, nitrogen, bicarbonate, and sulfate negatively correlated with pH, EC, Alkalinity, phosphate at three river sites of river Cauvery whereas in Arasalar Calcium showed positive correlation with chloride and magnesium. The concentration of calcium observed was always higher than magnesium concentration.

3.4.10 Magnesium

The average values of Mg hardness varied between 49.21 to 217.22 mg/L in the River Cauvery and 40.12 mg/l to 171.22 mg/l in the river Arasalar. Magnesium is a component of chlorophyll and must be present for its proper development. Many workers are of the opinion that magnesium was observed always lower than calcium concentration. (Mazher Sultana and Dawood Sharief, 2004). The concentration of calcium and magnesium in the present study on conformity of the above workers. Mg hardness exhibit strong positive correlation with Cl which reveals that magnesium mainly remains present as MgCl2. It also showed positive correlation with phosphate, sulphate and nitrate.

3.4.11 Nitrogen

Several studies have been conducted in the analysis of nitrogen in the sedimentary environments of aquatic systems. Present study, the average level of total nitrogen ranged from 0.05 mg/gm to 4.89 mg/gm in the river Cauvery and 0.09 to 3.265 in the river Arasalar. Among the sampling stations, station III sediments showed higher levels of total nitrogen. This may be due to organic matter brought down to this station by flowing water settle down in the slit of this site. According to Mini, (2003), the nitrogen in aquatic system is recycled between waters and sediments through plankton and benthic the organisms that resulted in the fluctuation of its concentration in sediments.

Increased nitrogen content in the sediments of certain sampling station is due to the high percentage of silt and clay which accumulate in this site with high deposits of nitrogen matter. According to Fisher *et al.* (1999) sediments act as a major site controlling the cycling and availability of nitrogen in aquatic environment. In sediments, nitrogen can diffuse to the over lying waters and absorbed into sediments or denitrified (Morlock *et al.,* 1997).

3.4.12 Organic carbon and Organic matter

Organic carbon is an organic pollutant. Sediment organic carbon in the sediments of Cauvery River varied from 0.221 mg/l to 3.892 mg/l and 0.557 to 4.435 mg/l in the river Arasalar. The oxidizable organic matter in the river Cauvery ranged from 0.128 mg/l to 2.257 mg/l and 0.451 mg/l to 2.354 mg/l in the river Arasalar. The high total organic carbon and total organic matter concentrations in this Cauvery and Arasalar might be attributed to the raw human faeces and domestic wastes from the waterfront dwellers as well as dredged materials. These organic wastes are rich in organic matter. Dredging has pollution implication. These organic wastes are rich in organic matter. The decomposition of the organic matter releases total organic carbon into the water which finally accumulates in the sediments.

TOC correlated positively with silt and clay in these rivers. These sediment fractions retain organic matter. Griggs (1975) reported that sediments with organic matter values exceeding 1% are said to have high organic content thus it can be said that the sediments from all the stations contain very high organic content. Quantity and quality of organic carbon in surface sediments are major factors affecting benthic fauna dynamics and metabolism (Pusceddu *et al.*, 1999). Riverine fluxes of organic carbon and nutrients are highly seasonally variable; primarily due to seasonal variations of water discharge and sediment load (Hung and Huang, 2005).

Low organic carbon may be due to course sandy nature of the sediments, as the organic carbon variation is largely controlled by the fine fraction of the sediment. SOC is a reliable index of nutrient degradation and productivity of the water body (Anilakumary *et al.*, 2001). Either the impact of organic carbon is controlled by the rate of supply of allochthonous materials produced by terrigenious run off or autochthonous matter by plantation and from biological debris, rate of decomposition of organic matter and texture of the sediments. Reports of the distribution of SOC in freshwater environments include that of rivers (Koshy, 2002; Mini, 2003), while the sediment organic carbon of reservoirs has been less worked up on.

The deterioration in the physicochemical quality and rise in the nutrient level observed in this study is alarming, and periodic monitoring and preventative measures are required to save the aquatic system from eutrophication. Further work is therefore needed to determine the dynamics of the watershed's response to runoffs and land management practices under varying climatic conditions to better understand the complex physical and chemical processes causing the degradation observed in the present study. The findings also have important implications for the development of effective watershed management strategies for the control of point and diffuse-source pollution. The presence of high levels of TOM and TOC indicate organic pollution in the river Cauvery and Arasalar. Therefore, environmental surveillance of these parts of the area is advocated.

CHAPTER 4

ASSESSMENT OF ZOOPLANKTON COMPOSITION OF RIVER CAUVERY AND ITS TRIBUTARY ARASALAR

4.1 INTRODUCTION

The term ‘‘plankton’’ refers to those microscopic aquatic forms having little or no resistance to currents and living free-floating and suspended in natural waters. Planktonic plants, phytoplankton and planktonic animals, zooplankton. Zooplankton are small animals that float freely in the water column of lakes and oceans and whose distribution is primarily determined by water currents and mixing. Zooplankton plays a pivotal role in aquatic food webs because they are important food for fish and invertebrate predators and they graze heavily on algae, bacteria, protozoa, and other invertebrates. Zooplanktons are rarely important in rivers and streams because they cannot maintain positive net growth rates in the face of downstream losses.

The zooplanktons occupy a central position between the autotrophs and other heterotrophs and form an important link in food webs of the fresh water ecosystem. Zooplankton is intermediate link between phytoplankton and fish. Zooplankton community contains both herbivores and carnivores, the latter belonging to the tertiary producers, or even to some higher level of production. Knowledge of their abundance, composition, and seasonal variation, therefore, is an essential pre-requisite for any successful aqua culture programme. Zooplankton density has also been reported to vary depending on the availability of nutrients and the stability of the water (Redmond, 2008)

Zooplankton communities are highly sensitive to environmental variation. As a result, changes in their abundance, species diversity, or community composition can provide important indications of environmental change or disturbance. Zooplankton is a good indicator of changes in water quality because it is strongly affected by environmental conditions and responds quickly to changes in environmental quality. Among the zooplankton, rotifers are apparently the most sensitive indicators of the water quality (Mishra and Panigrahy 1999).

Zooplankton communities often respond quickly to environmental change because most species have short generation times (usually days to weeks in length). Zooplankton communities respond to a wide variety of disturbances including nutrient loading (McCauley and Kalff 1981), acidification (Brett, 1989; Keller), contaminants, fish densities and sediment inputs. According to Suontama (2004), an advantage of zooplankton as fish food is that they contain lower amounts of environmental toxins than organisms higher up the food chain. This is because environmental toxins accumulate as they move up the food chain. Nearly all fish depend on zooplankton for food during their larval phases, and some fish continue to eat zooplankton in their entire lives (Madin *et al.*, 2001).

The freshwater zooplankton comprise of Protozoa, Rotifers, Cladocerans, Copepods and Ostracods. Most of them depend to a large extent, on various bacterioplankton and phytoplankton for food. Many of the larger forms feed on smaller zooplankton, forming secondary consumers. Some of them are detritivore feeders, browsing and feeding on the substrate attached organic matter, phytoplankton or concentrating on the freely suspended organic matter particles or those lying on the bottom sediment. Many of these organisms are also fish food organisms and are consumed by the other aquatic macro fauna. The freshwater zooplankton is mainly constituted of five groups:

Protozoan (first animals): A very diverse group of unicellular organisms are found in this major zooplanktonic community. Among the protozoans are two orders of amoebae that are primarily associated with the sediments and littoral aquatic vegetation and large numbers of meroplanktonic species (Edmondson, 1959; Battish, 1992). Rotifers (wheel bearers): Rotifers, typically an order of magnitude less abundant the protozoans, are the most important soft-bodied metazoans (invertebrates) among the plankton. Since the rotifers have short reproductive stages they increase in abundance rapidly under favorable environmental conditions (Dhanapathi, 2000).

Crustaceans**:** This group comprises of members all belonging to the well-known Phylum Arthropoda. This is the largest phylum in terms of number of species and among zooplankton holds the highest position both in terms of systematic and as secondary consumers in the food chain.

Cladocerans (Branched horns): Cladocerans are a crucial group among zooplankton and form the most useful and nutritive group of crustaceans for higher members of fishes in the food chain. Cladocerans are highly sensitive against even low concentrations of pollutants. The food source of this group is smaller zooplankton, bacterioplankton and algae (Murugan, 1998).

Copepods (Oar foot): The copepods comprise of calanoids, cyclopoids and harpacticoids. The copepods also form important organisms for fish and are influenced by negative environmental factors as caused by excessive human interference in water bodies but to a lesser extent than the cladocerans. Among the three orders of copepods, cyclopoid copepods are generally predatory on (carnivorous) other zooplankton, and fish larvae. The cyclopoid copepods also feed on algae, bacteria and detritus.

The second group of copepods, calanoid copepods changes their diet with age, sex, season, and food availability. The calanoid copepods are omnivorous feeding on ciliates, rotifers, algae, bacteria and detritus. The third group harpacticoid copepods are primarily benthic. Copepods, in general can withstand harsher environmental conditions as compared to cladocera (Kalff, 2002). Ostracods (Shell like): The Ostracods are bivalved organisms and belong to phylum Arthropoda. They mainly inhabit the lake bottom and among macrophytes and feed on detritus and dead plankton. Ostracods are in turn consumed by fishes and benthic macroinvertebrates (Chakrapani, 1996).

The rate of zooplankton production can be used as a tool to estimate the exploitable fish stock of an area (Twari and Nair 1991). It has been reported that in many countries the failure of fishery was attributed to the reduced zooplankton especially copepod population (Scottrup 2000). According to Nasser et al. (1998), some fishes are exclusively zooplankton feeder and therefore their abundance is directly linked to their presence (Mishra and panigraphy). Therefore any adverse effect to them will be indicated in the wealth of the fish populations. Thus, monitoring them as biological indicators of pollution could act as a forewarning for the fisheries particularly when the pollution affects the food chain (Mahajan, 1981).

Furthermore many zooplankton species are used as indicators of water quality and pollution, (Mishra and Panigrahy 1999). They respond more rapidly to environmental changes than fishes, which have been traditionally used as indicators of water quality. Zooplankton used in the pollution assessment and monitoring studies in various ways which include change in community structure, species diversity, species preference and biological toxicants. Thus, the use of zooplankton for ecological biomonitoring of the water bodies helps in the analysis of water quality trends, development of cause-effect relationships between water quality and environmental data and judgments of the adequacy of water quality for various uses.

This study was therefore designed to determine if various anthropogenic stressors actually impact the water body and if they do, in what way and to determine if there is any significant difference in the abundance and diversity of the zooplankton population at different stations as a result of these stressors.

4.2 METHODS

4.2.1 Sampling of Zooplankton:

Water was collected from the surface with minimal disturbance and filtered in a No. 25 bolting silk cloth net of mesh size 63 mm and 30 cm diameter. The final volume of the filtered sample was 125ml. The sample was transferred to another 125ml plastic bottle and labeled mentioning the time, date and place of sampling. The samples collected in 125ml plastic bottles were preserved by adding 5ml of 4% formalin.

The preserved samples were kept for 24 hours undisturbed to allow the sedimentation of plankton suspended in the water. After 24 hours, the supernatant was discarded carefully without disturbing the sediments and the final volume of concentrated sample was 50ml. The preserved samples were brought to the laboratory for quantitative and qualitative analysis. Counting of the planktons was done by using a Sedgwick-rafter cell method (Welch, 1952). The abundance and diversity of Zooplankton at the six stations were determined by counting and identifying using standard identification keys.

4.2.3 Laboratory analysis of zooplankton:

In the laboratory, samples were allowed to stand for a minimum of 24 h before decanting the supernatant. The supernatant was removed carefully until a 50 ml concentrated sample was properly shaken and 1 ml of sub sample was collected from it and transferred into a Sedgwick–Rafter counting chamber using a sample pipette. Identification and enumeration (standing crop estimation) was carried out under a binocular compound microscope with magnification 40 x 400. Three replicates of the subsamples were analyzed. For each sample, each solitary cell or groups of cells were counted as one unit except for the diatoms which were counted in a cell by cell base. Results were expressed in a number of organisms per ml of sample. The Sedgwick-Rafter counting chamber contains exactly 1 ml (50 mm long x 20 mm wide x 1 mm deep) and has a surface area of 1000 mm 2. The exact area viewed within the ocular micrometer grid is also known. The following formula was used for the calculation of plankton density:

Density of plankton (Number of plankters per ml)

$$= (T) \frac{1000}{AN} \times \frac{\text{Volume of concentrate (ml)}}{\text{Volume of sample (ml)}}$$

Where:

T = Total number of plankters counted

A = area of grid in mm2

N = number of grids employed

1,000 = area of counting chamber in mm2 (Boyd, 1981)

Identification and characteristics of planktonic species were made by the descriptive keys by Mill (1932) Needham and Needham (1962); Newell and Newell (1963); Han (1978) Durans and Leveque (1980), Prescott (1982); Kediri (1988) amongst others.

4.3 RESULTS

The total number of zooplankton and monthly percentage of zooplankton n/L were shown in the table 45-48 and fig 17-18 while annual percentage and annual average of zooplankton components has been shown in Fig 15, 16, 19 and 20.

Table 45. Zooplankton species composition (n/L) from Cauvery River (2010).

Components	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010	**Annual Total**
Station - I Protozoa	753	606	496	428	304	206	166	158	152	164	383	688	4504
Rotifera	1972	1959	1907	1313	506	144	137	62	164	1270	1560	1732	12726
Cladocera	1478	648	379	500	298	298	902	850	896	1660	1728	1544	10883
Copepoda	943	1193	1468	649	616	124	130	102	162	156	200	1056	6799
Ostracoda	432	706	588	328	262	136	84	94	78	73	196	182	3159
Monthly Total	**5578**	**5112**	**4838**	**3218**	**1986**	**908**	**1419**	**1266**	**1452**	**3323**	**4067**	**5202**	**38369**
Station - II Protozoa	723	666	558	398	274	176	136	128	122	134	353	466	4134
Rotifera	2106	2036	2073	1181	702	267	176	88	161	1228	1383	1592	12993
Cladocera	1497	636	454	599	362	224	650	896	992	1566	1718	1877	11471
Copepoda	912	1264	1499	724	710	124	136	124	68	152	232	744	6689
Ostracoda	337	624	810	291	280	142	96	138	142	76	202	162	3300
Monthly Total	**5575**	**5226**	**5394**	**3193**	**2328**	**933**	**1194**	**1374**	**1485**	**3156**	**3888**	**4841**	**33746**
Station - III Protozoa	773	726	608	448	324	226	186	178	172	184	403	516	4744
Rotifera	2056	1986	2023	1131	652	217	126	83	111	1178	1333	1542	12438
Cladocera	1397	536	354	499	262	124	550	796	892	1566	1618	1706	10300
Copepoda	892	1244	1479	704	690	104	116	104	58	132	212	714	6449
Ostracoda	317	604	790	271	260	122	76	118	122	56	182	142	3060
Monthly Total	**5435**	**5096**	**5254**	**3053**	**2188**	**793**	**1054**	**1279**	**1355**	**3116**	**3748**	**4620**	**36991**

Table 46. Zooplankton species composition (n/L) from Arasalar River (2010).

Components	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010	**Annual Total**
Station - I Protozoa	158	132	170	328	404	306	383	118	102	99	65	164	2429
Rotifera	185	154	147	1713	1562	1870	1402	740	564	670	860	264	10131
Cladocera	142	78	109	1030	1098	1198	1002	450	396	560	628	152	6843
Copepoda	160	92	78	990	916	724	830	302	262	256	301	140	5001
Ostracoda	117	104	160	471	560	422	76	118	112	66	172	142	2620
Monthly Total	**762**	**560**	**664**	**4532**	**4540**	**4520**	**3693**	**1728**	**1436**	**1651**	**2026**	**862**	**26974**
Station - II Protozoa	128	102	230	298	370	276	353	108	112	109	95	134	2315
Rotifera	265	234	207	1513	1362	1670	1202	640	464	570	760	164	9051
Cladocera	112	84	119	950	1048	1098	952	350	356	460	428	132	6089
Copepoda	110	102	82	1090	866	924	110	702	362	256	252	122	4978
Ostracoda	107	124	148	421	500	402	396	122	142	85	152	160	2759
Monthly Total	**722**	**646**	**786**	**4272**	**4146**	**4370**	**3013**	**2272**	**1436**	**1480**	**1687**	**712**	**25542**
Station - III Protozoa	117	97	202	293	340	271	308	124	122	125	130	105	2234
Rotifera	315	284	257	1563	1412	1720	1252	690	514	620	810	194	9631
Cladocera	152	144	129	1050	1188	1298	1152	400	406	510	478	182	7089
Copepoda	130	142	182	910	766	824	750	302	362	266	275	132	5041
Ostracoda	107	114	302	421	342	425	220	122	142	90	125	145	2055
Monthly Total	**821**	**781**	**1072**	**4237**	**4048**	**4538**	**3682**	**1638**	**1546**	**1611**	**1818**	**758**	**26550**

Table 47. Monthly % composition of zooplankton in river Cauvery.

Components		Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
Station - 1	Protozoa	13.49	11.85	10.25	13.30	15.30	22.68	11.69	12.48	10.46	4.93	9.41	13.22
	Rotifera	35.35	38.32	39.41	40.80	25.47	15.85	9.65	4.89	11.29	38.21	38.35	33.29
	Cladocera	26.49	12.67	7.83	15.53	15.00	22.68	63.56	12.48	61.70	49.25	42.48	29.68
	Copepoda	16.90	23.33	30.34	20.16	31.03	13.65	9.16	8.05	11.15	4.69	4.91	20.29
	Ostracoda	7.74	13.81	12.15	10.19	13.19	14.97	5.91	7.42	5.37	2.19	4.81	3.49
Station – 2	Protozoa	12.96	12.74	10.34	12.46	11.76	18.86	11.39	9.35	8.21	4.24	9.07	9.62
	Rotifera	37.77	38.95	38.43	36.98	30.15	28.61	14.74	6.04	10.84	38.91	35.57	32.88
	Cladocera	26.85	12.16	8.41	18.75	15.54	24.00	54.43	65.1	66.80	49.61	44.18	38.77
	Copepoda	16.35	24.18	27.79	22.67	30.49	13.29	11.39	9.02	4.57	4.81	5.96	15.36
	Ostracoda	6.04	11.94	15.01	9.11	12.02	15.21	8.04	10.04	9.56	2.40	5.19	3.34
Station – 3	Protozoa	14.22	14.24	11.57	14.67	14.80	28.49	17.64	13.91	172	5.90	10.75	11.16
	Rotifera	37.82	38.97	38.50	37.07	29.79	27.36	11.95	6.48	111	37.80	35.56	33.37
	Cladocera	25.70	10.51	6.73	16.34	11.97	15.63	52.18	62.23	892	50.25	43.16	36.92
	Copepoda	16.41	24.41	28.14	23.05	31.53	13.11	11.00	104	58	4.23	5.65	15.45
	Ostracoda	5.83	11.85	15.03	8.87	11.88	15.38	7.21	118	122	1.79	4.85	3.07

Table 48. Monthly % composition of zooplankton in river Arasalar

Components		Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
Station - 1	Protozoa	20.74	23.57	25.60	7.23	8.89	6.76	10.37	6.82	7.10	5.99	3.20	19.02
	Rotifera	24.27	27.5	22.13	37.79	34.40	41.37	37.96	42.82	39.27	40.58	42.44	30.62
	Cladocera	18.63	13.92	16.41	22.72	24.18	26.50	27.13	26.04	27.57	33.91	30.99	17.63
	Copepoda	20.99	16.42	11.74	21.84	20.17	16.01	22.47	17.47	18.24	15.50	14.85	16.24
	Ostracoda	15.35	18.57	24.09	10.39	12.33	9.33	2.05	6.82	7.79	3.99	8.48	16.47
Station – 2	Protozoa	17.72	15.78	29.26	70.78	8.92	6.35	11.71	4.75	7.79	7.36	5.63	18.82
	Rotifera	36.70	36.22	26.33	35.41	32.85	38.21	39.89	28.16	32.31	38.51	40.05	23.03
	Cladocera	15.51	13.00	15.13	22.23	25.27	25.12	39.59	15.40	24.79	31.08	25.37	18.53
	Copepoda	15.23	15.78	10.43	25.51	20.88	21.14	3.65	30.89	25.20	17.29	14.93	17.13
	Ostracoda	14.81	19.19	18.82	9.85	12.05	9.19	13.14	5.36	9.88	5.74	9.01	22.47
Station – 3	Protozoa	14.25	12.41	18.84	6.91	8.39	5.97	8.36	7.57	7.57	7.75	7.15	13.85
	Rotifera	38.36	36.36	23.97	36.88	34.88	37.90	34.00	42.12	33.24	38.48	44.55	25.59
	Cladocera	18.51	18.43	12.03	24.78	29.34	28.60	31.28	24.42	26.26	31.65	26.29	24.01
	Copepoda	15.83	18.18	16.97	21.47	18.92	18.15	20.36	16.43	23.41	16.51	15.12	17.41
	Ostracoda	13.03	14.59	28.17	9.93	8.44	9.36	5.97	7.44	9.18	5.58	6.87	19.12

Table 49. Correlation coefficient values of various physico-chemical parameters and important zooplankton groups of River Cauvery S1

	WT	pH	TS	Alkali	Free Co2	DO	BOD	COD	Protozoa	Rotifera	Cladocera	Copepoda	Ostracoda
WT	1												
pH	0.45587	1											
TS	0.44562	0.31682	1										
Alkali	0.47372	0.63812*	0.51067**	1									
Free CO2	0.89097**	0.56207*	0.39585	0.53226*	1								
DO	-0.664*	-0.5193*	-0.7069**	-0.7303**	-0.7228**	1							
BOD	-0.6856*	-0.648*	-0.2872	-0.6433*	-0.8219**	0.61352*	1						
COD	0.07882	-0.4724	-0.2467	-0.0013	-0.0445	0.28414	-0.0769	1					
Protozoa	-0.1647	-0.1504	-0.3062	-0.6643*	-0.3278	0.70356**	0.39363	-0.0078	1				
Rotifera	-0.391	-0.547*	-0.3714	-0.7576**	-0.498	0.80455**	0.5047	0.26043	0.85428**	1			
Cladocera	-0.8007**	-0.4439	-0.2486	-0.3565	-0.9153**	0.49798	0.74404*	-0.0817	0.21384	0.35906	1		
Copepoda	-0.0117	-0.1878	-0.3838	-0.6242*	-0.041	0.61563*	0.14587	0.10444	0.83358**	0.77942**	-0.1647	1	
Ostracoda	0.0781	-0.1605	-0.3326	-0.4214	0.07594	0.58831*	-0.0495	0.40665	0.70432**	0.71948**	-0.298	0.86404**	1

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed)

Table 49. Correlation coefficient values of various physico-chemical parameters and important zooplankton groups of River Cauvery S2

	WT	pH	TS	Alkali	Free Co2	DO	BOD	COD	Protozoa	Rotifera	Cladocera	Copepoda	Ostracoda
WT	1												
pH	0.37495	1											
TS	0.71687**	0.10761	1										
Alkali	0.21087	-0.0018	0.28122	1									
Free CO2	0.87334**	0.28861	0.48217	-0.0027	1								
DO	-0.2048	-0.3959	-0.0846	0.19379	-0.2507	1							
BOD	-0.5967*	0.1049	-0.7871**	-0.5739*	-0.3739	-0.2207	1						
COD	0.0684	0.24668	-0.0923	0.39404	0.06362	-0.2724	0.01573	1					
Protozoa	-0.0256	0.07356	0.06635	0.56241*	-0.2069	0.76644**	-0.3118	-0.0261	1				
Rotifera	-0.2314	-0.203	-0.1275	0.45295	-0.3293	0.91136**	-0.2498	-0.0399	0.908**	1			
Cladocera	-0.8031**	-0.5677*	-0.3757	-0.067	-0.8655**	0.34663	0.17663	-0.4047	0.1456	0.33145	1		
Copepoda	0.1802	0.14261	-0.0191	0.5309*	0.13792	0.72348**	-0.2989	0.03363	0.86903**	0.81968**	-0.1708	1	
Ostracoda	0.16443	0.14238	-0.0887	0.50433*	0.18551	0.59866*	-0.143	0.28379	0.73294**	0.69326*	-0.3417	0.91809**	1

** Correlation is significant at the 0.01 level (2-tailed)   * Correlation is significant at the 0.05 level (2-tailed)

Table 51. Correlation coefficient of relating various physico-chemical parameters and important zooplankton groups of River Cauvery at S3

	WT	pH	TS	Alkali	Free Co2	DO	BOD	COD	Protozoa	Rotifera	Cladocera	Copepoda	Ostracoda
WT	1												
pH	0.45587	1											
TS	0.82257**	0.65399*	1										
Alkali	0.39387	0.18387	0.54851*	1									
Free CO2	0.89097**	0.56207*	0.78464**	0.5787*	1								
DO	-0.664*	-0.5193*	-0.7288**	-0.3969	-0.7228**	1							
BOD	-0.4751	-0.1693	-0.6492*	-0.317	-0.3832	0.22696	1						
COD	0.47914	0.31821	0.17019	-0.1455	0.55892*	-0.2468	0.0167	1					
Protozoa	-0.088	-0.2027	-0.1798	-0.2192	-0.2178	0.73316**	-0.371	0.07673	1				
Rotifera	-0.3317	-0.5122*	-0.4132	-0.284	-0.4129	0.80647**	-0.2746	-0.0105	0.90819**	1			
Cladocera	-0.8262**	-0.4697	-0.6206*	-0.488	-0.9343**	0.54233*	0.23836	-0.5508*	0.12075	0.32833	1		
Copepoda	0.07678	-0.1761	-0.1075	-0.0568	0.07748	0.55339*	-0.3962	0.33168	0.86893**	0.81907**	-0.1912	1	
Ostracoda	0.11768	-0.2409	-0.1736	-0.0399	0.13996	0.50503*	-0.222	0.39313	0.73486**	0.69459*	-0.3498	0.92023**	1

** Correlation is significant at the 0.01 level (2-tailed)　　* Correlation is significant at the 0.05 level (2-tailed)

Table 52. Correlation coefficient of relating various physico-chemical parameters and important zooplankton groups of River Arasalar at S1

	WT	pH	TS	Alkali	Free Co2	DO	BOD	COD	Protozoa	Rotifer	Cladocera	Copepod	Ostracoda
WT	1												
pH	0.19876	1											
TS	-0.0823	0.22188	1										
Alkali	0.5928*	0.58731*	0.01108	1									
Free CO2	0.22223	0.64751*	0.14652	0.60625**	1								
DO	-0.7262**	-0.4435	0.24755	-0.4207	-0.2466	1							
BOD	0.24515	-0.137	-0.4477	-0.2194	-0.2914	-0.1999	1						
COD	0.21917	0.15841	-0.2976	0.05449	0.35692	-0.2418	0.49118	1					
Protozoa	0.58661*	0.4772	-0.096	0.7170**	0.67573*	-0.6343*	-0.0706	0.39032	1				
Rotifer	0.67789*	0.35712	0.02165	0.68486*	0.41125	-0.7499**	-0.3026	-0.1075	0.7606**	1			
Cladocera	0.64809*	0.34364	0.00611	0.70492**	0.37517	-0.7065**	-0.2728	-0.1508	0.75155**	0.9894**	1		
Copepod	0.63389*	0.38425	-0.0976	0.66111*	0.4607	-0.8008**	-0.1595	0.08356	0.87823**	0.94804**	0.9378**	1	
Ostracoda	0.68823**	0.12374	0.04588	0.24806	0.2157	-0.7132**	-0.0132	0.18447	0.69131*	0.74269**	0.69974*	0.75078**	1

** Correlation is significant at the 0.01 level (2-tailed)   * Correlation is significant at the 0.05 level (2-tailed)

Table 53. Correlation coefficient values of various physico-chemical parameters and important zooplankton groups of River Arasalar at S2.

	WT	pH	TS	Alkali	Free Co2	DO	BOD	COD	Protozoa	Rotifer	Cladocera	Copepod	Ostracoda
WT	1												
pH	-0.1632	1											
TS	-0.6395*	0.05434	1										
Alkali	0.27362	-0.2639	0.40891	1									
Free CO2	0.02609	0.07806	0.26978	0.65088*	1								
DO	-0.7172**	-0.0587	0.18872	-0.5053	-0.1738	1							
BOD	0.04612	0.19538	-0.1881	-0.1057	-0.4151	0.15163	1						
COD	0.12764	-0.5153	0.00053	0.37485	0.22771	-0.0708	-0.0868	1					
Protozoa	0.47088	0.16973	-0.1042	0.5808*	0.50312	-0.5592	-0.0317	-0.0766	1				
Rotifer	0.65282*	0.27004	-0.4016	0.18644	0.14088	-0.7539**	-0.2131	-0.3402	0.75243**	1			
Cladocera	0.594*	0.23912	-0.3563	0.22511	0.17997	-0.6978*	-0.1703	-0.3884	0.80976**	0.97924**	1		
Copepod	0.7617**	0.10574	-0.619	-0.1097	-0.0594	-0.5099*	-0.2565	-0.2108	0.47614	0.8001**	0.72844**	1	
Ostracoda	0.55564*	0.24317	-0.272	0.36574	0.29816	-0.629*	-0.0531	-0.2844	0.93211**	0.88973**	0.91497**	0.66926*	1

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed)

Table 54. Correlation coefficient values of various physico-chemical parameters and important zooplankton groups of River Arasalar S3

	WT	pH	TS	Alkali	Free Co2	DO	BOD	COD	Protozoa	Rotifera	Cladocera	Copepoda	Ostracoda
WT	1												
pH	-0.2224	1											
TS	-0.4232	0.54132*	1										
Alkali	-0.2949	0.37293	-0.2658	1									
Free CO2	-0.0664	0.07462	-0.0389	0.3842	1								
DO	-0.2474	0.39484	0.16274	0.23865	0.55218*	1							
BOD	0.15716	0.21454	0.13567	0.22367	-0.0311	-0.2297	1						
COD	0.53817*	-0.3858	-0.8164**	-0.0226	-0.0883	-0.2409	-0.157	1					
Protozoa	0.65522*	0.11325	-0.0173	-0.1845	0.48217	0.20695	-0.0345	0.10143	1				
Rotifera	0.66227*	-0.031	0.03553	-0.5618*	0.22103	0.18433	-0.2052	0.17053	0.84545**	1			
Cladocera	0.59909*	0.00727	0.1177	-0.4889	0.31442	0.26565	-0.1577	-0.0031	0.883**	0.97374**	1		
Copepoda	0.72217**	-0.0554	-0.0777	-0.4029	0.32102	0.1768	-0.1806	0.20565	0.90488**	0.96628**	0.96599**	1	
Ostracoda	0.68838*	-0.1864	-0.2966	-0.2591	0.49356	0.04705	-0.172	0.43226	0.84344**	0.76795**	0.72532**	0.81014**	1

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed)

Table 57. Annual average and percentage of zooplankton in River Cauvery.

Groups	No. of genera	Annual Average	Annual Percentage
Protozoa	6	4460.66	12.26
Rotifers	13	12719	34.97
Cladocera	12	10884.67	29.92
Copepoda	11	6645.66	18.27
Ostrocoda	2	3173	8.72

Table 58. Annual average and percentage of zooplankton in River Arasalar.

Groups	No. of genera	Annual Average	Annual Percentage
Protozoa	5	2326	9.17
Rotifers	12	9604.33	37.87
Cladocera	11	6673.66	26.32
Copepoda	9	5006.66	19.74
Ostrocoda	1	2478	9.4

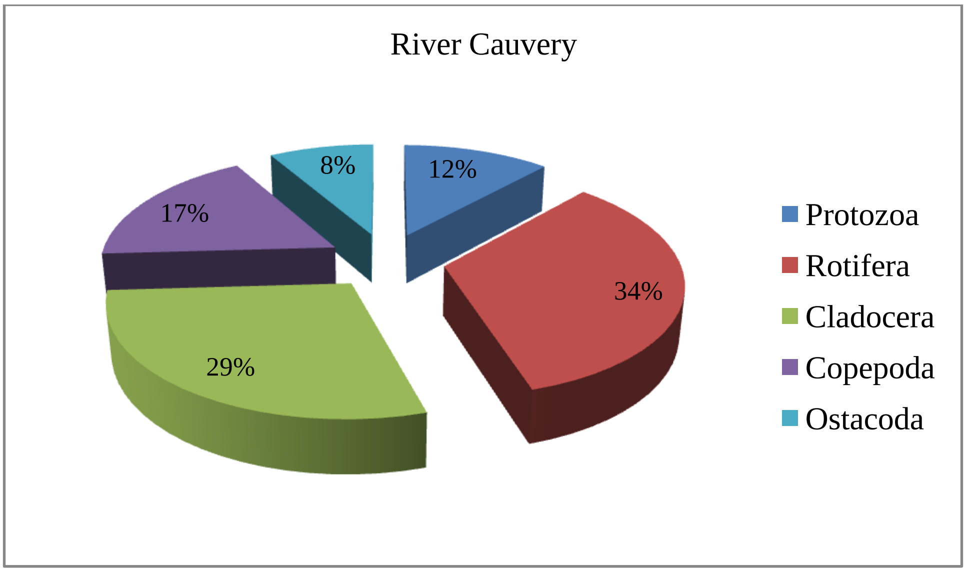


Figure 15. Annual Percentage of zooplankton genera in River Cauvery.

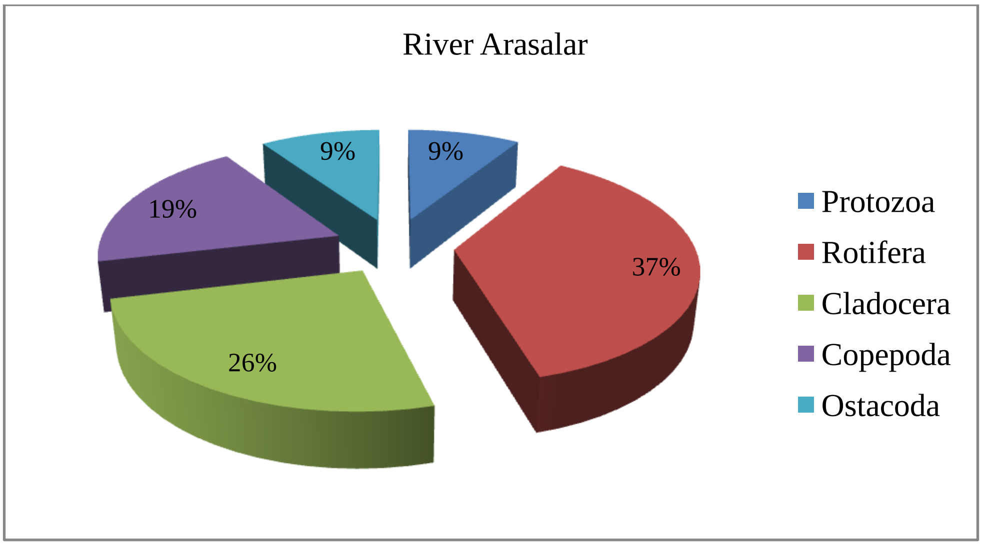


Figure 16. Annual Percentage of zooplankton genera in River Arasalar.

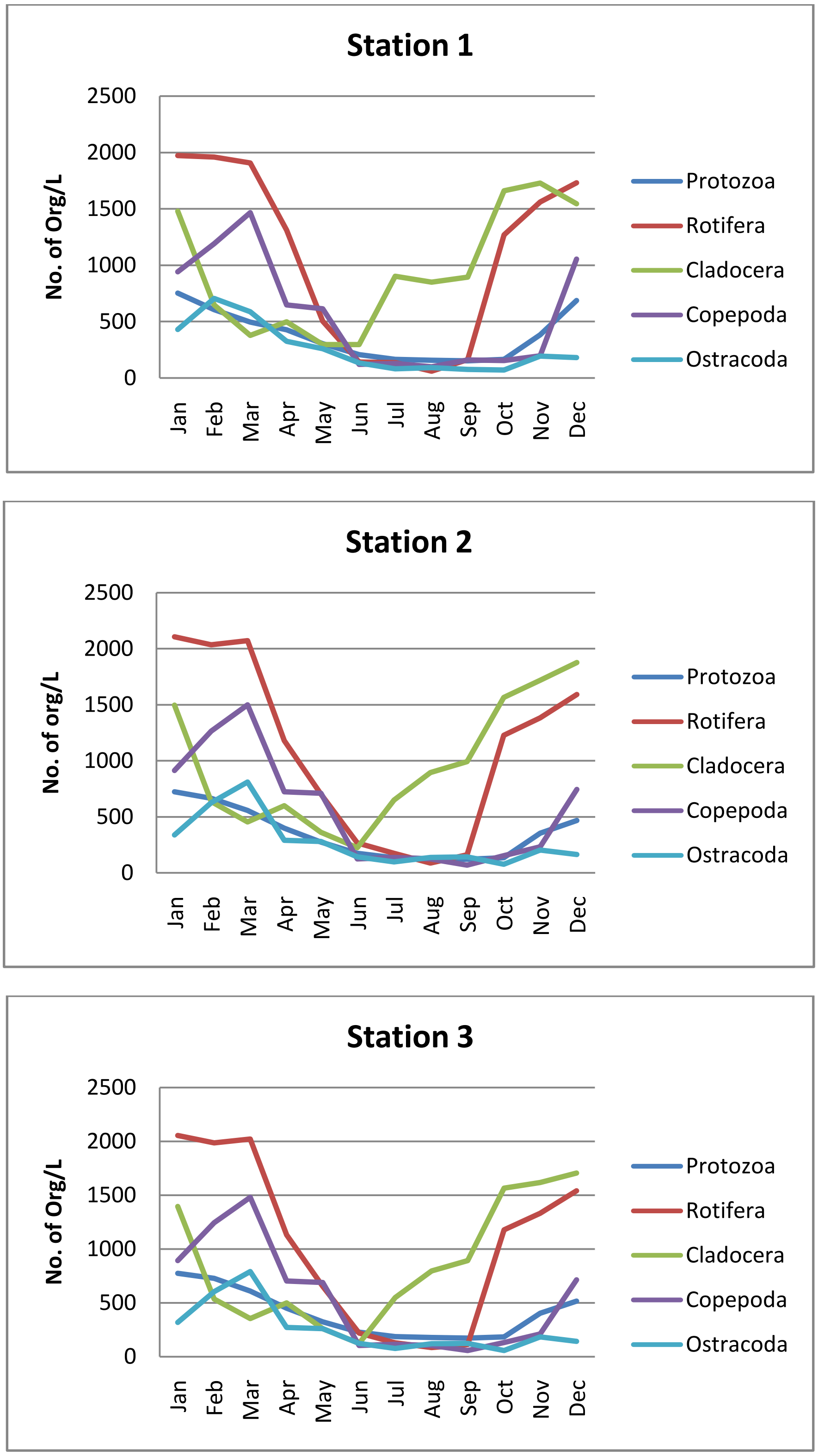


Figure 17. Monthly fluctuations of Zooplankton (N/L) at 3 stations of Cauvery River.

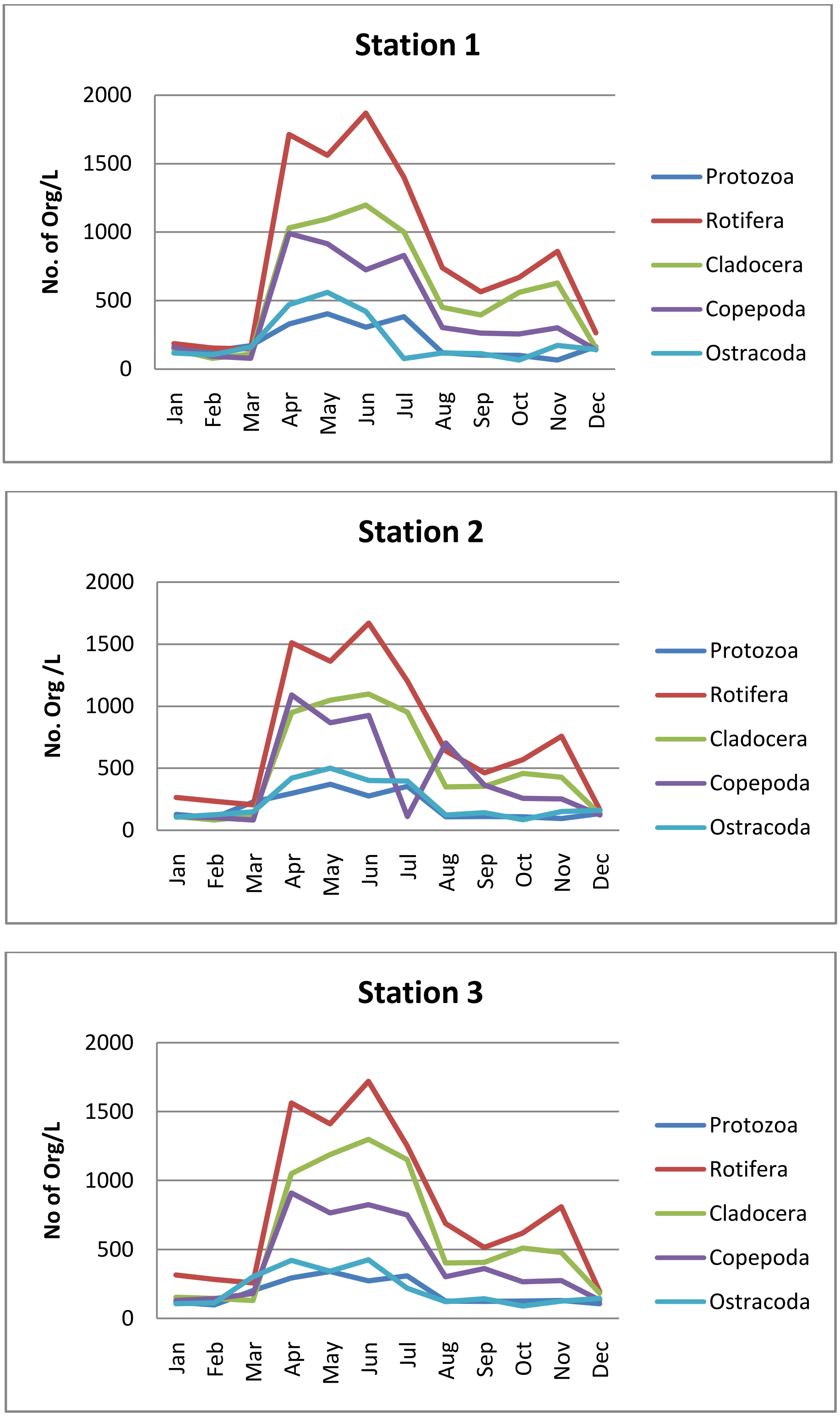


Figure 18. Monthly fluctuations of Zooplankton (N/L) at 3 stations of Arasalar River.

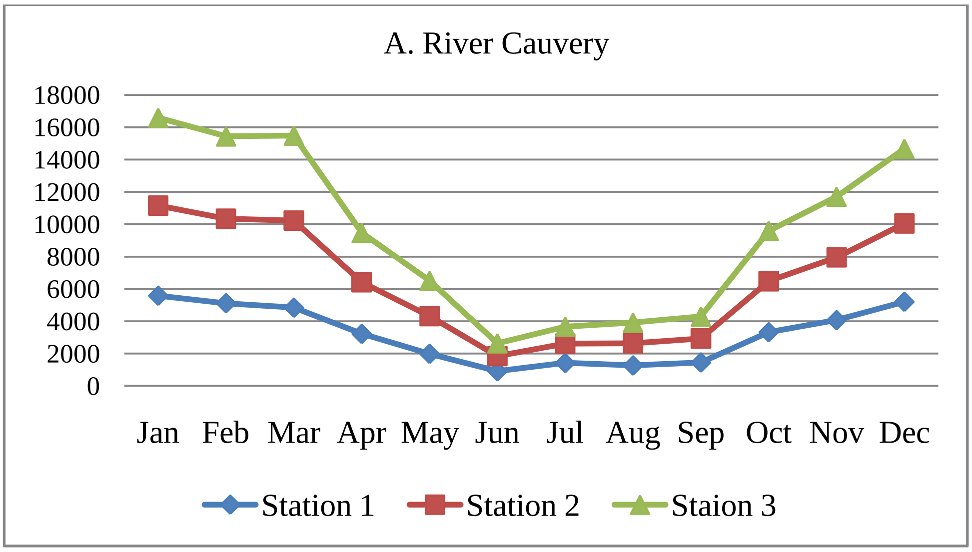


Figure 19. Annual average of zooplankton at three stations in River cauvery.

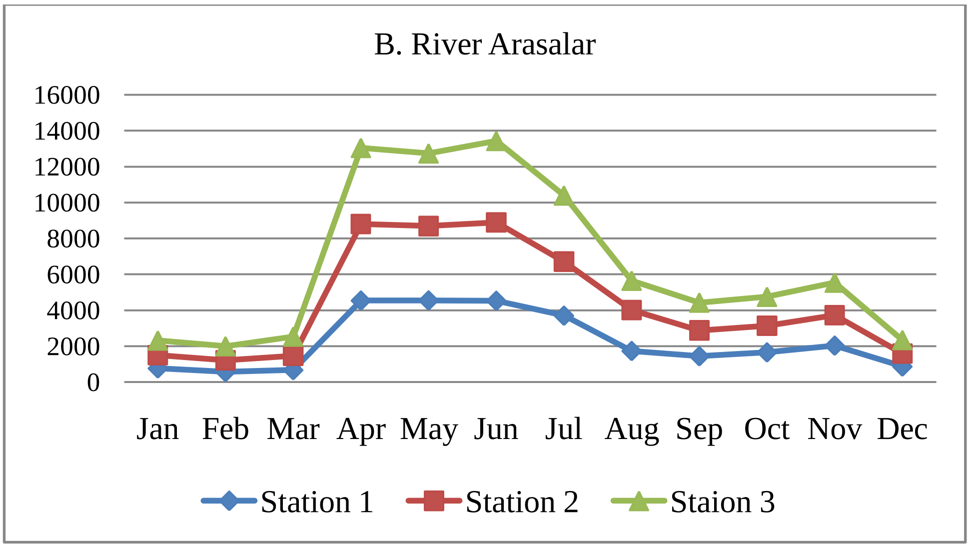


Figure 20. Annual average of zooplankton at three stations in River Arasalar.

Table 55. Zooplankton diversity of river Cauvery in during the period of investigation (Jan- Dec 2010).

SPECIES COMPOSITION	STATION 1	STATION 2	STATION 3
PROTOZOA			
1.Amoeba spp	+++	+	+
2.Paramecium spp	+	-	+++
3.Verticella spp	+	+++	++
4.Arcella spp	-	++	-
5.Actinosparium spp	+	-	+
6.Ceretium focus spp	+	-	+
ROTIFERA			
1.Branchionus spp	+++	+++	+++
2.Notholca spp	++	+++	+++
3.Trichocerca spp	++	+++	+++
4.Asplanchna spp	+++	+++	+
5.Testudinella spp	-	++	-
6.Rotaria spp	+	+	++
7.Eosphora spp	+++	+	+
8.Lepadella spp	+++	++	+
9.Cephalodella spp	+	+	+
10.Monostyla spp	+	-	+
11.Searridium spp	+	-	+
12.Filinia spp	+	++	+
13.Keratella spp	+	+	+++
CLADOCERA			
1. Branchinella spp	+++	+++	++
2. D.longipinna	+++	-	+
3. D.similis	-	+	-
4. Alona spp	-	+	+

NOTE: - Absent; + = Occurs less often, 1-10; ++ = Occurs often, 11-20; +++ = Occurs more often, 21-30

Conti…

Zooplankton diversity of river Cauvery in during the period of investigation (2010 Jan - Dec)

SPECIES COMPOSITION	STATION 1	STATION 2	STATION 3
5.Moina spp	+	-	+
6.Mysis spp	+++	+++	+
7.Zoea spp	+	+	+
8.Nauplius spp	+	++	++
9.Simocephalus spp	+	++	++
10.Camptocercus spp	++	+	++
11.Chydorus spp	++	+	-
12.Ceriodaphnia spp	-	+	+
OSTRACODA			
1.Cypridopsis spp	++	+	+
2. Crpris sp.	++	+++	++
COPEPODA			
1.Cyclops spp	+++	++	++
2.Mesocyclops spp	++	+	+
3.Ectocyclops	+++	++	+
4.Eucyclops	++	-	+
5.Microcyclops	-	+	++
6.Paracyclops	+	+	++
7.Heliodiaptomus viduur	++	-	+
8.Diaptomus spp	-	+	+
9.Neodiaptomus spp	++	+	-
10.Paradiaptomus spp	++	++	-
11.Metacyclops spp	++	++	++

NOTE: - Absent; + = Occurs less often, 1-10; ++ = Occurs often, 11-20; +++ = Occurs more often, 21-30

Table 56. Zooplankton diversity of river Arasalar in during the period of investigation (2010 Jan - Dec).

SPECIES COMPOSITION	STATION 1	STATION 2	STATION 3
PROTOZOA			
1.Amoeba spp	+++	+++	++
2.Paramecium spp	+++	+++	+
3.Verticella spp	+++	+++	+++
4.Arcella spp	+++	+++	+++
5.Actinosparium spp	+++	+++	+++
6.Ceretium focus spp	+	+	+
ROTIFERA			
1.Branchionus spp	+	+	+
2.Notholca spp	+	+	+
3.Trichocerca spp	+	+	+
4.Asplanchna spp	+	+	+
5.Testudinella spp	+	+	+
6.Rotaria spp	+	+	+
7.Eosphora spp	+	+	+
8.Lepadella spp	+	+	+
9.Cephalodella spp	+	+	+
10.Monostyla spp	+	+	+
11.Searridium spp	+	+	+
12.Filinia spp	+	+	+
13.Keratella spp	+	+	+
CLADOCERA			
1. Branchinella spp	+	+	+
2. D.longipinna	+	+	+
3. D.similis	+	+	+
4. Alona spp	+	+	+

NOTE: - Absent; + = Occurs less often, 1-10; ++ = Occurs often, 11-20; +++ = Occurs more often, 21-30

Conti…

Zooplankton diversity of river Arasalar in during the period of investigation (2010 Jan - Dec).

SPECIES COMPOSITION	STATION 1	STATION 2	STATION 3
5.Moina spp	+	+	+
6.Mysis spp	+	+	+
7.Zoea spp	+	+	+
8.Nauplius spp	+	+	+
9.Simocephalus spp	+	+	+
10.Camptocercus spp	+	+	+
11.Chydorus spp	+	+	+
12.Ceriodaphnia spp	+	+	+
OSTRACODA			
1.Cypridopsis spp	+	+	+
2. Crpris sp.	+	+	+
COPEPODA			
1.Cyclops spp	+	+	+
2.Mesocyclops spp	+	+	+
3.Ectocyclops	+	+	+
4.Eucyclops	+	+	+
5.Microcyclops	+	+	+
6.Paracyclops	+	+	+
7.Heliodiaptomus viduur	+	+	+
8.Diaptomus spp	+	+	+
9.Neodiaptomus spp	+	+	+
10.Paradiaptomus spp	+	+	+
11.Metacyclops spp	+	+	+

NOTE: - Absent; + = Occurs less often, 1-10; ++ = Occurs often, 11-20; +++ = Occurs more often, 21-30

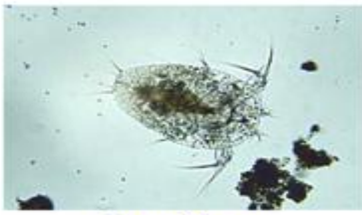
PLATE - I

Zooplankton

Bosmina longirostris

Cephalodella gibba

Dreissena polymorpha

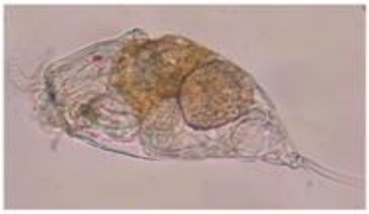


Nauplius sp.

Notonacta glauca

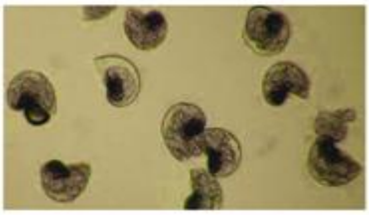
Paramecium bursaria

Rotaria rotatoria



Trichocerca stylata

Vorticella microstoma



Veliger sp.

It was noted that the total number of zooplankton in the river Cauvery recorded was 1266-5578 N/L, 933-5575 n/L and 793-5435 n/L for S1, S2 and S3 respectively. Similarly, in the river Arasalar recorded were 664-4540 n/L, 646-4370 n/L and 781-4538 n/L for S1, S2 and S3 respectively**.** The zooplankton in the six stations of both the river showed variations because of their diverse physico-chemical conditions. The correlation of temperature, pH, total solids, alkalinity, free co2, dissolved oxygen, biological oxygen demand and chemical oxygen demand on zooplankton dynamics in the River Cauvery and its tributary Arasalar during the study period are presented in table 49-54. The zooplankton component of Cauvery River and Arasalar River consisted of the members of Protozoa, Rotifera, Cladocera, Copepod and Ostracoda are presented in table 55 and 56.

River Cauvery

Forty four zooplankton species were identified from the Cauvery River (Table 57) and they were composed of protozoa (6), rotifers (13), cladocera (12), copepoda (11) and ostrocoda (2). The zooplankton fauna of Cauvery River were dominated by the Rotifers and followed by Cladocera, Copepoda, Protozoa and Ostacoda. The percentage of total annual zooplankton of the river Cauvery consisted of 12.26% Protozoa, 34.97% Rotifera, 29.92% Cladocera, 18.27% Copepoda and 8.72% Ostracoda (Fig.15). An annual average of Protozoa was 4460.66 n/L, Rotifera was 12719 n/L Cladocera was 10884.67 n/L, Copepoda was 6645.66 n/L and Ostracoda was 3173 n/L. Annual averages revealed that Rotifera were the dominant group.

Monthly fluctuation of zooplankton showed four peaks in December (5202 n/L), January (5578 n/L), February (5112 n/L) and March (4838 n/L) (Table1). Three peaks of Protozoa were observed in December (688 n/L) January (753 n/L), and February (606 n/L). Four peaks of Rotifera were observed in December (1732n/L), January (1972 n/L), February (1959 n/L) and March (1907n/L). Three peaks of Cladocera were observed in October (1660n/L), November (1728 n/L) and December (1544 n/L). The Copepoda showed two peaks, one in March (1468 n/L) and another in December (1056 n/L). Similarly, the Ostracoda showed two peaks, one in February (706 n/L) and another in March (810 n/L). During the twelve months of collection the Rotifers were the dominant forms. Cladocera and Copepods were seen throughout the year.

On the basis of qualitative study, species of *Arcella, Difflugia* and *Vorticella* were the most common species which occurred throughout the study period among the class Protozoa while as among the Rotifera class*Brachionus angularis, Brachionus falcatus, Keratella tropica, Lecane lunaris* and *Testudinella patina* were the dominant species. *Bosmina* sp., *Chydorus sphaericus, Daphnia pulex*, *Diaphanosoma excisum* were dominant among Cladocera. *Mesocyclops leuckarti and Thermocyclops Crassus* was recorded during all the seasons among Copepoda. Ostracoda occupied fifth position of zooplankton and represented very low population diversity compared to other groups. Two species were identified *Cypridopsis spp* and *Crpris spp*..

River Arasalar

Thirty eight zooplankton species were identified from the Arasalar River (Table 58) and they were composed of protozoa (5), rotifers (12), cladocera (11), copopoda (9) and ostrocoda (1). The zooplankton fauna of Cauvery River were dominated by the Rotifers and followed by Cladocera, Copepoda, Protozoa and Ostacoda. The percentage of total annual zooplankton of the river Arasalar consisted of 9.17 % Protozoa, 37.87% Rotifera, 26.32 % Cladocera, 19.74 % Copepoda and 9.74 % Ostracoda (Fig.16). An annual average of Protozoa was 2326 n/L, Rotifera was 9604.33

n/L Cladocera was 6673 n/L, Copepoda was 5006 n/L and Ostracoda was 2478 n/L. Annual averages revealed that rotifera were the dominant group.

Monthly fluctuation of zooplankton showed four peaks in April (4532 n/L), May (4540 n/L), June (4 520 n/L) and July (3693 n/L) (Table1). Two peaks of Protozoa were observed in April (328 n/L) May (404 n/L). Three peaks of Rotifera were observed in April (1713 n/L), May (1562 n/L) and June (1870 n/L). Three peaks of Cladocera were observed in April (1030 n/L), May (1098 n/L) and June (1198 n/L). The Copepoda showed two peaks, one in April (990 n/L) and another in May (916 n/L). Similarly, the Ostracoda showed two peaks, one in April (471 n/L) and another in May (560 n/L). During the twelve months of collection the Rotifers were the dominant forms. Cladocera and Copepods were seen throughout the year.

Qualitative zooplanktonic analysis has shown irregular presence of various groups of zooplankton in this river. Species of *Arcella, Difflugia* and *Vorticella* were the most common species which occurred throughout the study period among the class Protozoa Among rotifera *Branchionus spp Notholca spp Trichocerca spp Asplanchna spp and Testudinella spp* were dominated in the present investigation. In the cladocera *Nauplius spp Simocephalus spp Camptocercus spp Chydorus spp* group were dominant in the present study. Among copepods *Mesocyclops haylinus Metacyclops, Diaptomus* and *Neodiaptomus strigilipes* were dominant and only one species of class Ostracoda namely *Stenocypris malcolmsoni* was found throughout the study period.

4.4 DISCUSSION

The density of zooplankton in Cauvery River and its tributary Arasalar during the period of present study was generally low at all the representative sampling sites. Plankton populations in rivers are not nearly as dense as those of lakes. Time is too short for much multiplication of plankton, since relatively little time is needed for a given quantity of water to flow from its source to the sea. The plankton from head water to outlet varies tremendously (in quantity and quality) and the plankton of rivers at one level varies with that of others. Rivers is constantly moving so it is difficult to obtain a clear analysis of stream plankton.

Plankton of rivers varies according to (1) chemistry of the water (including gases and nutrients) (2) temperature (3) amount of suspended matter, all of which are related to elevation gradient, surface wind and current affect the horizontal distribution of plankton. Phytoplankton and zooplankton dynamics have been studied extensively in lentic fresh waters (lakes and reservoirs), yet comparatively little research has focused on lotic waters (rivers). The investigations in river planktons are scanty due to practical difficulties in the survey and sampling of flowing water.

This general trend in the comparatively less abundance of zooplankton in rivers can be justified on the basis of the reports from the other tropical rivers (Sanchez et al. 1985) of Venezuela. Yves Marneff et al (1996) from his studies of the lower river Meuse pointed out that zooplankton in rivers is scanty. Ramanujan (1984) in the study of river Kallar observed that the quantity of zooplankton was very poor. To the present study also agrees to this fact. It is generally assumed that the zooplankton of rivers is imported from stagnant water in permanent or temporary communication with the river According to Odum (1959) the flowing water is unfavorable for zooplankton.

In rivers, the flow regime is probably one of the most important factors associated with the abundance of river zooplankton. High flow generally reduces the zooplankton density (Hodsen and Green, l990). Because of unidirectional water flow in the upper reaches, river zooplankton is generally transported downstream and fresh water species are displaced by saline species at river mouth and estuarine areas (Eggs, 1992 and Turner, 2002), the present study confirmed this view. Basu and Pick (1996) in their study on temperate rivers pointed out that zooplankton biomass in rivers in much lower than in lakes and zooplankton populations in rivers are dominated by rotifers and small crustaceans. Zooplankton in rivers may be regulated by water resident time.

There was marked difference in the density of total zooplankton in the two rivers. In the river Cauvery, minimum number of zooplankton was 908 n/L in June and maximum 5578 n/L in January whereas, in river Arasalar minimum number of zooplankton was recorded 560 n/L in February and maximum was recorded 4540 n/L in May. From the observation, it is obvious that zooplankton showed their peak in January (a winter month). Bhuiyan & Nessa (1998a, b) and Islam *et al*. (2000) recorded highest density of zooplankton in January (2213 units/L and1350 units/L respectively).

A marked seasonal variation in zooplankton population was recorded during the present investigation. In general, the maximum density was observed in winter season and summer season, while low density was observed in monsoon season. The winter season is most favorable period for the growth and multiplication of zooplankton species. The same finding has been also reported by Abdus and Altaff, (1995) and Kumar, (2001). Less zooplankton population during monsoon season in on account of high turbidity which restricts growth of the planktonic population. Choudhary and Singh (1999) studied zooplankton population of Boosra lake at Muzaffarpur, Bihar State of India, and reported that the abundance of zooplankton were more during winter months and less during rainy months.

During the present investigation class Rotifera was dominated among all the zooplanktonic groups in both the rivers. In the river Cauvery the diversity of zooplankton varied from season to season and the maximum diversity was recorded in winter season while minimum was observed in monsoon season. The results indicates that the maximum number of genera occurred during winter season than summer and monsoon season which also reported by Abdus et al (1995) and Kumar (2001). The less number of genera might be attributed to the fewer nutrients in the river which consequently result in less productivity or might be due to the depletion of important factors such as dissolved oxygen and pH.

0However, in the river Arasalar the diversity of zooplankton varied from season to season and the maximum diversity was recorded in summer season while minimum was observed in monsoon season. The results indicates that the maximum number of genera occurred during summer season than winter and monsoon season which also reported by (Jhingran 1982). The reduction in the number of genera (species) may be due to predation, variation in the pH of water is always associated with the genera (species) composition of zooplankton inhibiting among them (Jhingran 1982).

In winter, it is biotic interaction operating through feeding pressure rather than water quality it seems to affect the zooplankton diversity and density particularly the stocked fish species play an important role in harvesting species of copepoda and cladocera, thereby reducing their predatory pressure on other groups. The rotifers and particle feeder cladocera were higher in winter can be linked to favorable temperature and availability of abundant food in the form of bacteria, nanoplankton and suspended detritus (Edmondson, 1965 and Baker, 1979).

The observed high density of zooplankton in cauvery could be attributed to the accumulated wastes like human activities mostly the refuse dumping, domestic sewage, detergent run-off as a result of washing activities, cow dung and poultry droppings constantly washed into the stream at this station of river Cauvery. These high organic materials enhance phytoplankton growths that support the zooplankton community. The low density of zooplankton observed in Arasalar could be linked to low dissolved oxygen and high biological oxygen demand (BOD) in this station. The low dissolved oxygen and high biological oxygen demand levels were caused by the influx of enormous domestic and industrial effluents.

The peak of zooplankton in winter may be due to the favorable conditions of the physico-chemical parameters and the availability of nutrients in the rivers. Mainly five groups of zooplankton Protozoa, Rotifera, Cladocera, Copepoda and Ostacoda were identified in the present study. Similar findings were found with Shankaran & Varghese (1981) and Hossain *et al*. (1999). Comparatively higher concentration of zooplankton was found with Cauvery River than that of Arasalar River. This might be due to the effect of fertilizer and subsequent water quality changes in the rivers. These results were more or less agreed with Naik (2005), and Elwood *et al* (1994).

Singh *et al.* (2002) reported that higher rotifer population occur during summer and winter might be dominant due to hyper tropical condition of the river at high temperature and low level of water. The dominance of rotifers was reported in winter (Kulshreshtra and Joshi, 1999). This is confirmed in the present study. Chandraseker (1996) showed that the water temperature, turbidity and transparency and dissolved oxygen were favor for rotifer population. In rainy rotifers were lower might be due to neutral pH. At the alkalinity, pH and temperature above 29 ºC the rotifers disappears (Dhanapathi, 1995). The differences in seasonal density might be the nutrition and biotic interactions.

Rotifer species showed marked difference in their tolerance and adaptability to change in physicochemical and biological events. They play important roles as grazers, suspension feeders and predators in the zooplankton community. Higher rotifer population indicates pollution from organic matter. Density and diversity of cladocera depend on water temperature, DO, turbidity and transparency (Pawar and Pulle, 2005). During the winter period cladocera species were maximum can be attributed to the favorable water temperature and food (Edmondson, 1965; Baker, 1979) and organic matter. It indicates that minimum temperature was favor for cladocera. This is confirmed in the present study.

In the river Arasalar net zooplankton species increased their abundance during summer (April-May), probably corresponding to the water quality, decaying vegetation, increased levels of organic matter in the sediment and higher abundance of bacteria in the lake during this time (Jacoby and Greenwood, 1989; Srivastava *et al*., 1990; Coman *et al*., 2003). In contrast, the abundance of net zooplankton species decreased in winter (November-January), probably corresponding to low water temperature and high alkalinity (pH 7.6-9.8) of this water body (Chattopadhyay and Banerjee, 2007).

In contrast, the river Cauvery net zooplankton species increased their abundance during winter and decreased in summer. Sarkar and Chaudhuri, (1999) noticed that the fluctuation of abiotic factors as dissolved oxygen, temperature, total alkalinity, phosphate, nitrogen, and pH can influence the growth of zooplankton. Das *et al*, (1996) showed relationship between zooplankton and physico-chemical parameters such as densities, pH, alkalinity, nitrate and phosphate. Nutrient availabilities influence the abundance of rotifer and copepoda (Kumar *et al.* 2004).

In the river Arasalar the transparency was found more when compare to the river Cauvery. This may be due to the more turbid condition of the river due to the mixing of the effluents. Moreover, the transparency appeared to be extremely low, which might be largely responsible for the very low zooplankton densities recorded during the study period as Dejen et al., (2004) had earlier reported that silt held in suspension in turbid water interferes with filter feeding mechanisms of crustaceans and this affects their reproduction success.

Arasalar River appeared to have a low diversity of zooplankton species with relatively low densities perhaps primarily due to low transparency level among other factors that strongly limit light penetration and thus photosynthesis. Similarly, Hart (1986) reported that transparency values above 0.30 - 0.35M appeared to be necessary for the development of sufficient and suitable zooplankton to benefit fishery. The reason for the minimum transparency in the river Cauvery due to the dilution of the sewage and effluents and also the water flow is more when compare to the river Arasalar. Transparency or light penetration depends on the intensity of sunlight, suspended soil particles, turbid water received from catchment area and density of plankton etc. (Mishra and Saksena, 1991; Kulshrestha and Sharma, (2006).

The zooplankton population dynamics might have been influenced by agricultural runoff and other human activities in the river Cauvery. In this study the primary sources for elevated TDS level in river water are agricultural runoff, particulate matter of cement and other raw material used in construction of river front, leaching of soil contamination and non point source of water pollution i.e. discharge from industrial and sewage treatment plants particularly during dry season with low water level and relatively low values during wet season might due to dilution effect (Moniruzzaman, 2009).

River Cauvery show a lower TDS value than Arasalar. The reason for the minimum total solids in the river Cauvery due to the dilution of the sewage and effluents and also the water flow is more when compare to the river Arasalar. The same is reported by Subbarao *et al*. (1997). The pH value was ranged 6.9 to 7.4. It indicates alkalinity nature. High pH was recorded during rainy. Tenner *et al*. (2005) noticed that the range of pH from 6 to 8.5 indicates medium production of reservoir. Present study indicates that the river is medium production of zooplankton population because pH in the range of 6.9 to 7.4.

Dissolved oxygen (DO) is an important aquatic parameter whose presence is vital to aquatic fauna. It plays crucial role in life processes of animals. It is ranged from 3.23 to 3.98 ppm. High concentration of DO was recorded during winter. This may be due to low solubility at low temperature and high degradation of organic substances. Singh and Singh (1993) drew a conclusion that DO value may be favor or not to the zooplankton. Estimation of biological oxygen demand (BOD) is an important factor to the oxygen required for the degradation of organic matter. Rajagopal *et al,* (2010) noticed BOD was favorable to zooplankton.

At both the rivers, the BOD values were high during the study period. The results indicate that the water body had suffered deterioration and degradation due to agricultural runoff and continuous discharge of domestic and municipal sewage. High BOD value is unflavored with zooplankton. In general, in all the stations, richness and evenness of zooplankton were comparatively low in pre-monsoon and post monsoon periods. During this periods the phytoplankton abundance also low due to rain. Due to rain water causes strong currents which wash away the phytoplankton, Ramanujan (1994) the depletion of phytoplankton naturally affects the population of zooplankton.

Overall it is concluded that, the diversity and density of zooplankton depends upon the nutrient condition of water body, abiotic factors, DO, BOD, food chain, soil-water chemistry and web with life cycle. Hence theirs is needed to conserve biotic and abiotic of water body. There was evidence from this study that human activities mostly the refuse dumping, domestic sewage, detergent run-off as a result of washing activities and changing environmental conditions might be responsible for the fluctuation of zooplankton abundance and seasonal succession in these rivers. It can be concluded that the present findings indicated that the Cauvery River showed better result than that of the Arasalar River regarding zooplankton production. This study showed that community size of zooplankton was the highest in summer and winter while the lowest density in rainy. Thus, the quality and quantity of zooplankton have fluctuated monthly, seasonally and altitudinal in the river Cauvery and its tributary Arasalar besides many physico-chemical factors in the rivers.

CHAPTER 5

ASSESSMENT OF PHYTOPLANKTON COMPOSITION OF RIVER CAUVERY AND ITS TRIBUTARY ARASALAR

5.1 INTRODUCTION

The term “Plankton” refers to those minute aquatic forms which are non motile or insufficiently motile to overcome the transport by currents and living suspended in the open or pelagic water. The planktonic plants are called phytoplankton and planktonic animals are called zooplankton (APHA, 1985). Phytoplankton are microscopic aquatic plants, occurring as unicellular, colonial or filamentous forms, without any resistance to currents, and are free floated or suspended in open/pelagic waters. Phytoplankton is the bottom rung of the food chain in any aquatic ecosystem. Many are photosynthetic and are grazed upon by zooplankton and other aquatic organisms. Some species flourish in highly eutrophic waters while others are very sensitive to organic and/or chemical wastes.

Phytoplankton has long been used as indicators of water quality. Because of their short life cycles, planktonic organisms respond quickly to environmental changes and hence their standing crop and species composition indicate the quality of water. Phytoplanktons are the base of aquatic food webs and energy production is linked to phytoplankton primary production. Phytoplankton mainly represented by algae form a vital part in almost all the fresh water ecosystems and plays an important role through primary productions in the food chain and is also a useful tool for the assessment of water quality. It is essential to document the diversity of algal flora for biodiversity mapping of the wetland.

Phytoplankton and zooplankton dynamics have been studied extensively in lentic fresh waters (lakes and reservoirs), yet comparatively little research has focused on lotic waters (rivers). The investigations in river planktons are scanty due to practical difficulties in the survey and sampling of flowing water. Algae play a significant ecological role and are being used extensively as indicators of water pollution. Assessment of physic-chemical and biological parameters serves a good index in providing particular status to a water body. Though the knowledge of algal forms in rivers in India is limited but recently phytoplankton of fresh water rivers have been studied in detail (Mishra et al., 2002, Jafri and Gunale 2006, Shashi Shekhar et al., 2008).

The assessment of water quality using phytoplankton diversity and their association as biological indicators has been carried out by several workers (Chaturvedi et al., 1999). Seasonal variation of algal forms in lakes and rivers is presented by many researchers (Kaur et al., 2001, Jarousha 2002, Tiwari and Chauhan 2006). Algal biodiversity of water bodies have been studied by several workers in India. (Anuja and Chandra 2012; Das and Adhikary 2012; Jadhavar and Papdiwal 2012). Diatom diversity is the best indicator of altered water quality (Szczepocka and Szule 2009). Studies on seasonal diatom variation of Mansagar Lake of Jaipur were conducted by Singh *et al* (2010).

Phytoplankton is the most important producer of organic substances in the aquatic environment and the rate at which energy is stored up by these tiny organisms determine the basic primary productivity of the ecosystem. All other living forms at higher trophic levels are directly or indirectly dependant on phytoplankton for energy supply and therefore, performing vital functions. Phytoplankton satisfy conditions to qualify as suitable pollution indicators in that they are simple, capable of quantifying changes in water quality (Naik *et al.*, 2005; Zargar and Ghosh, 2006). They are ecologically significant as they form the basic link in the food chain of all aquatic animals (Mishra *et al.,* 2008). In fresh water ecosystem primary productivity by phytoplankton involves trapping of radiant energy and its transformation into high potential biochemical energy by photosynthesis, using inorganic materials of low potential energy (Mishra and Tripathi, 2002).

The freshwater phytoplankton of the Indian region belongs to the following classes: Cyanophyceae: Cyanophyceae comprises of prokaryotic organisms popularly known as blue-green algae. Cyanophyceae members are broadly classified into coccoid and filamentous forms. The coccoid forms range from single individual cell to aggregates of unicells into groups or in regular or irregular colonies and pseudoparenchymatous conditions. The filament forms range from simple uniseriate filaments to heterotrichous filaments, which may be differentiated into heterocysts and akinetes (spores). These are truly cosmopolitan organisms occurring in habitats of extreme conditions of light, pH and nutritional resources. They abound various types of natural and artificial aquatic ecosystems.

Chlorophyceae: Chlorophyceae (green algae) constitutes one of the major groups of algae occurring in freshwater habitats. The cells are typically green in color due to the presence of chlorophyll *a* and *b.* Chlorophyceae is generally divided into several orders based on the diversity of the thallus. Euglenophyceae: The members are single cells, motile found swimming with the help of usually one prominent flagellum and in some cases with two flagella. These are widely distributed in all types of water bodies specifically in organically rich aquatic ecosystems. Bacillariophyceae: The members belonging to this class are popularly known as diatoms. All are basically unicellular, in some cases become pseudo filamentous or aggregated into colonies. Dinophyceae: The members are unicellular motile cells with two flagella one located in the transversely aligned groove or furrow and other in a longitudinally arranged furrow (Anand, 1998).

The development of a phytoplankton community in a river depends directly upon the physical factors of flow and turbidity, and when either or both of these are too great, no appreciable populations can be formed. Day length and temperature, particularly the former, seem also to be important, and the highest numbers of algae occur during prolonged periods of bright dry weather, when the rate of flow and silt are also at a minimum. In most lowland rivers nitrates and phosphates, derived from agriculture and from sewage, are present in abundance for algal growth. Deficiency of silica, however, may lead to the end of vigorous populations of diatoms in spring, which are then often succeeded by mixed plankton, mainly of green algae, throughout the summer (Eggs and Aksnes, 1992; Chellappa *et al.,* 2008).

The growth and attrition of phytoplankton populations in rivers are thought to be subject to the same general environmental factors as those in lakes- chemical factors (inorganic nutrient concentrations, primarily phosphorus and nitrogen), physical factors (light, temperature), and biotic factors (competition, grazing) (Wetzel 1983, Reynolds 1988). In contrast to lakes, however, phytoplankton in rivers may also be affected by hydrological factors such as river discharge and water residence time. An inverse correlation between phytoplankton biomass and river discharge has been observed (Jones 1984, Jones and Barrington 1985, Reynolds 1988). Increases in river discharge are believed to decrease phytoplankton biomass by shortening residence time and, consequently, the available for potamoplankton to develop (Baker and Baker 1979, Reynolds 1988).

High cost of complex chemical analysis, complicated and time consuming procedures of sample preparation, analysts search for quicker and more specific methods. Biological assessment or Bio- monitoring is a valuable assessment tool that is receiving increased use in water quality monitoring programs of all types and is a useful alternative for assessing the ecological quality of aquatic ecosystems since biological communities integrate the environmental effects of water chemistry, in addition to the physical and geomorphologic characteristics of Rivers and lakes (Stevenson and Pan, 1999). The use of biological material combined with analytical techniques, allows improvement of the sensitivity and accuracy of conventional chemical methods. A great deal of work has been done on using algae as bio -indicators of pollution (Mohapatra and Mohanty, 1992). In order to address this topic, the present research concerns the development, regulation, and trophic interactions of planktonic communities within large, temperate, lowland rivers.

Very little information is available on the phytoplankton status of River Cauvery and its tributary Arasalar and in order to fill up this lacuna, the present study was undertaken. In this study an attempt has been made to assess the diversity status of phytoplankton of River Cauvery and its tributary Arasalar at Kumbakonam region.

5.2 MATERIALS AND METHODS

5.2.2 Phytoplankton Analysis

5.2.2.1 Phytoplankton collection:

Water was collected from the surface with minimal disturbance and filtered in a No. 25 bolting silk cloth net of mesh size 63 mm and 30 cm diameter. The final volume of the filtered sample was 125ml. The sample was transferred to another 125ml plastic bottle and labeled mentioning the time, date and place of sampling.

5.2.2.2 Preservation:

The samples collected in 125 ml plastic bottles were preserved by adding 5 ml of 4% formalin.

5.2.2.3 Concentration:

The preserved samples were kept for 24 hours undisturbed to allow the sedimentation of plankton suspended in the water. After 24 hours, the supernatant was discarded carefully without disturbing the sediments and the final volume of concentrated sample was 50 ml.

5.2.3 Qualitative and quantitative analysis of phytoplankton:

The qualitative and quantitative analysis of phytoplankton was done by Lackey's drop method. In Lackey's drop method, the cover slip was placed over a drop of water in the slide and whole of the cover slip was examined by parallel overlapping strips to count all the organisms in the drop. About 20 strips were examined in each drop. Number of subsamples to be taken was dependent on the examining 2 to 3 successive subsamples without any addition of un encountered species when compared to the already examined subsamples in the same sample (APHA, 1985).

The species belonging to each group were noted down and number of individuals in each species was counted. The number of organisms was expressed in Total organisms per liter using the formula,

CALCULATION:

For Lackey's drop method:

$$\text{Organisms per liter (N)} = \frac{R * A_t * 10^3}{A_s * S * V}$$

Where R = Number of organisms counted per subsample

A_t = Area of cover slip, mm^2

A_s = Area of one strip, mm^2

S = Number of strips counted, and

V = Volume of sample under the cover slip, ml

Therefore, Total organisms per liter = N * 1/C

$$\text{Were concentration factor, } C = \frac{\text{Volume of concentrate (ml)}}{\text{Volume of sample (ml)}}$$

5.3 RESULTS

The phytoplankton in the six stations of both the river showed variations because of the diverse physico-chemical conditions. The algal (phytoplankton) component of Cauvery River and Arasalar River consisted of the members of Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae. The total number of phytoplankton and monthly average phytoplankton organism per L were shown in the table 59 and 60 while monthly percentage composition of plankton components has been shown in table 61 and 62. It was noted that the total number of phytoplankton in the river Cauvery recorded was 3050-5813 org/L, 3155-6055 org/L and 3224-5858 org/L, for S1, S2 and S3 respectively. Similarly in the river Arasalar recorded were 3050-5813 org/L, 3155-6055 org/L and 3224- 5858 org/L for S1, S2 and S3 respectively.

Table 59. Monthly variations in phytoplankton count org/L in River Cauvery.

Components		Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010	Annual Total
Station 1	Chlorophyceae	1636	1026	1334	2447	1808	1805	1210	1274	1018	775	1544	1403	17280
	Bacillariophyceae	1096	1194	876	1386	1708	1200	1124	1074	1320	1054	945	1298	14275
	Cyanophyceae	1165	1675	1386	1864	1478	2056	1364	1786	1046	874	781	1056	16531
	Euglenophyceae	140	216	188	116	578	426	114	248	148	347	106	376	3003
Monthly Total		**4037**	**4111**	**3784**	**5813**	**5572**	**5484**	**3812**	**4382**	**3532**	**3050**	**3376**	**4133**	**51089**
Station 2	Chlorophyceae	1680	1020	1328	2438	1802	1799	1204	1268	1012	869	1538	1397	17355
	Bacillariophyceae	1107	1199	881	1320	1713	1205	1129	1079	955	1059	1390	1303	14340
	Cyanophyceae	1171	1681	1392	1870	1484	2062	1370	1790	1052	879	792	1062	16605
	Euglenophyceae	142	217	189	427	499	188	117	249	149	348	118	377	3020
Monthly Total		**4100**	**4117**	**3790**	**6055**	**5498**	**5254**	**3820**	**4386**	**3168**	**3155**	**3838**	**4134**	**51315**
Station 3	Chlorophyceae	1690	1030	1338	2448	1812	1809	1214	1278	1022	904	1548	1407	17500
	Bacillariophyceae	1117	1209	891	1400	1723	1215	1135	1089	1300	1063	1005	1313	14460
	Cyanophyceae	1181	1691	1402	1880	1494	2072	1380	1780	1062	904	822	1072	16740
	Euglenophyceae	144	219	201	130	502	141	429	251	167	353	129	379	3045
Monthly Total		**4132**	**4149**	**3832**	**5858**	**5531**	**5237**	**4158**	**4398**	**3551**	**3224**	**3504**	**4171**	**51745**

Table 60. Monthly variations in phytoplankton count number/ml in River Arasalar.

Components		Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010	Annual Total
Station I	Cyanophyceae	1303	1390	1059	1320	1713	1129	1205	1079	965	881	1199	1107	14350
	Bacillariophyceae	946	994	708	1186	1244	1000	924	874	1120	854	795	1098	11743
	Chlorophyceae	1007	1099	781	1220	1518	1105	1029	1069	855	959	1200	1203	13045
	Euglenophyceae	140	106	188	247	227	154	226	110	148	116	114	176	1952
Monthly Total		**3396**	**3589**	**2736**	**3973**	**4702**	**3388**	**3384**	**3132**	**3088**	**2810**	**3308**	**3584**	**41090**
Station 2	Cyanophyceae	1308	1395	1064	1325	1718	1134	1210	1084	970	901	1204	1112	14425
	Bacillariophyceae	951	999	713	1191	1249	1005	929	879	1125	859	800	1100	11800
	Chlorophyceae	1012	1104	793	1225	1523	1110	1034	1074	860	964	1205	1208	13112
	Euglenophyceae	141	107	189	248	228	155	221	117	149	117	115	176	1963
Monthly Total		**3412**	**3605**	**2759**	**3989**	**4718**	**3404**	**3394**	**3154**	**3105**	**2841**	**3324**	**3596**	**41300**
Station 3	Cyanophyceae	1323	1410	1079	1340	1733	1149	1225	1099	985	901	1219	1117	14580
	Bacillariophyceae	965	1009	726	1135	1259	1015	939	889	800	869	1201	1113	11930
	Chlorophyceae	1027	1119	1001	1240	1538	1125	1049	1089	875	979	1104	1107	13253
	Euglenophyceae	143	109	191	250	226	157	220	117	151	119	117	182	1982
Monthly Total		**3458**	**3647**	**2997**	**3965**	**4756**	**3446**	**3433**	**3194**	**2811**	**2868**	**3641**	**3519**	**41745**

Table 61. Monthly % composition of phytoplankton at 3 stations of Cauvery River (2010).

Components		**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
Station 1	Chlorophyceae	40.52	24.95	35.25	42.09	32.44	32.91	31.74	29.07	28.82	25.40	45.73	33.94
	Bacillariophy	27.14	29.04	23.15	23.84	30.65	21.88	29.48	24.50	37.37	34.55	27.99	31.40
	Cyanophyceae	28. 5	40.74	36.62	32.06	26.52	37.49	35.74	40.72	29.61	28.65	23.13	25.55
	Euglenophyc	3.46	5.25	4.96	1.99	10.37	7.76	2.99	5.65	4.19	11.37	3.13	9.09
Station 2	Chlorophyceae	40.97	24.77	35.03	40.26	32.77	34.24	31.51	28.91	31.94	27.54	40.07	33.79
	Bacillariophyc	27	29.12	23.24	21.80	31.15	22.93	29.55	24.53	30.14	33.56	36.21	31.51
	Cyanophyceae	28.56	40.83	36.72	30.88	26.99	39.24	35.86	40.81	33.20	27.86	20.63	25.68
	Euglenophyce	3.46	5.27	4.98	7.05	9.07	3.57	3.06	5.67	4.70	11.03	3.07	9.11
Station 3	Chlorophyceae	40.90	24.82	34.31	41.78	32.6	34.54	29.19	29.05	28.78	28.03	44.17	33.73
	Bacillariophyc	27.03	29.13	23.25	23.89	31.15	23.20	27.29	24.76	36.60	32.97	28.68	31.47
	Cyanophyceae	28.58	40.75	36.38	32.09	27.01	39.56	33.38	40.47	29.90	28.03	23.45	25.70
	Euglenophyce	30.48	5.27	5.24	2.21	9.07	2.69	10.31	5.70	4.70	10.94	3.68	9.08

Table 62. Monthly % composition of phytoplankton at 3 stations of Arasalar River (2010).

Components	**Jan** 2010	**Feb** 2010	**Mar** 2010	**Apr** 2010	**May** 2010	**June** 2010	**Jul** 2010	**Aug** 2010	**Sept** 2010	**Oct** 2010	**Nov** 2010	**Dec** 2010
Station I Cyanophyceae	38.36	38.72	38.7	33.22	36.43	33.36	35.60	34.45	31.25	31.35	36.24	30.88
Bacillariophyc	27.85	27.69	25.57	29.85	26.45	29.51	27.30	27.90	36.26	30.39	24.03	30.63
Chlorophyceae	29.65	30.62	28.54	30.70	32.28	32.61	30.40	34.13	27.68	34.12	36.27	33.56
Euglenophyce	4.12	2.95	6.87	6.21	4.82	4.54	6.67	3.51	4.79	4.12	3.44	4.91
Station 2 Cyanophyceae	38.33	38.69	38.56	33.21	36.41	33.31	35.65	34.36	31.23	31.71	36.22	30.92
Bacillariophyc	27.87	27.71	25.84	29.85	26.47	29.52	27.37	27.86	36.23	30.23	24.06	30.58
Chlorophyceae	29.66	30.62	28.74	30.70	32.28	32.60	30.46	34.05	27.69	33.93	36.25	33.59
Euglenophyce	4.13	2.96	6.85	6.21	4.83	4.55	6.51	4.11	4.79	4.11	3.45	4.89
Station 3 Cyanophyceae	38.25	38.69	36.00	33.79	36.43	33.34	35.68	34.40	35.04	31.41	33.47	31.74
Bacillariophyc	27.90	26.67	24.24	28.69	26.47	29.45	27.35	27.83	28.45	30.29	32.98	31.62
Chlorophyceae	29.69	30.68	33.40	31.67	32.33	32.64	30.55	34.09	31.11	34.13	30.32	31.45
Euglenophyce	4.13	2.98	6.37	6.30	4.75	4.55	6.40	3.66	5.37	4.14	3.21	5.17

Table 63. Seasonal variations of phytoplankton groups of river Cauvery.

Seasons	Chlorophyceae	Bacillariophyceae	Cyanophyceae	Euglenophyceae	Total
Summer	21796	16258	20374	3667	62095
Winter	16289	13484	15934	2796	48503
Rainy	14050	13333	13628	2613	43624

Table 64. Seasonal variations of phytoplankton groups of river Arasalar.

Seasons	Cyanophyceae	Bacillariophyceae	Chlorophyceae	Euglenophycea	Total
Summer	16201	13056	14716	2559	45992
Winter	14667	11322	12461	1848	40298
Rainy	12487	11075	12253	1490	37305

Table 65. Annual average and Percentage of phytoplankton in River Cauvery.

Groups	**No. of genera**	**Annual Average**	**Annual Percentage**
Chlorophyceae	24	1448.19	33.82
Bacillariophyceae	14	1196.52	27.94
Cyanophyceae	26	1385.44	32.35
Euglenophyceae	3	251.88	5.88

Table 66. Annual average and percentage of phytoplankton in River Arasalar.

Groups	No. of genera	Annual Average	Annual Percentage
Cyanophyceae	23	12034.30	34.92
Bacillariophyceae	13	985.36	28.57
Chlorophyceae	25	1094.72	31.74
Euglenophyceae	2	163.8	4.76

Table 67. Seasonal Averages of phytoplankton (org/L) in River Cauvery

Groups	Summer	winter	Rainy
Chlorophyceae	1816.33	1357.41	1170.83
Bacillariophyceae	1354.83	1123.66	1111.08
Cyanophyceae	1697.83	1327.83	1135.66
Euglenophyceae	305.58	232.5	217.75

Table 68. Seasonal Averages of phytoplankton (org/L) in River Arasalar.

Groups	Summer	winter	Rainy
Chlorophyceae	1226.83	1038.41	1021.08
Bacillariophyceae	1088	943.5	922.91
Cyanophyceae	1350.83	1222.25	1040.58
Euglenophyceae	213.25	154	124.16

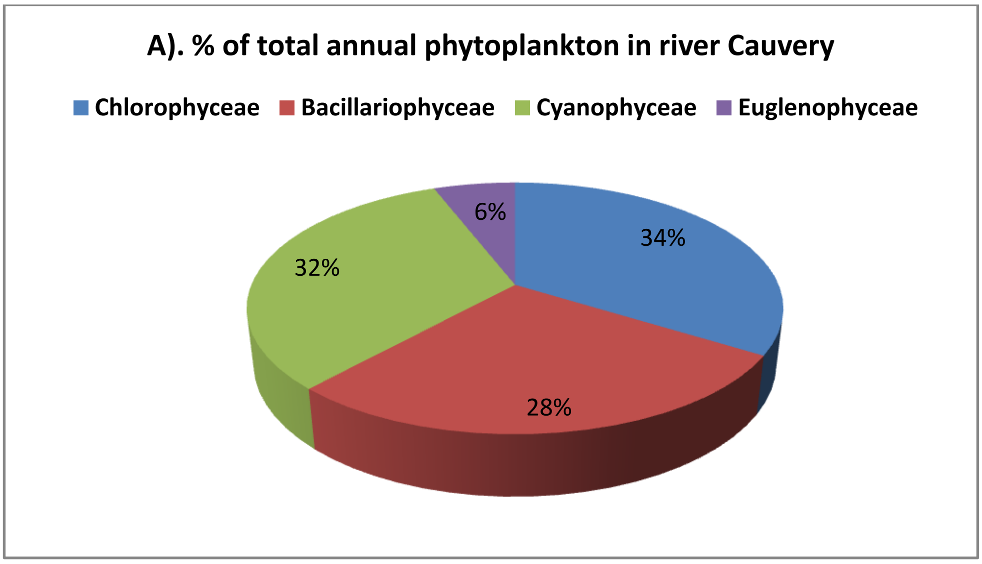


Figure 21. % of Annual phytoplankton in river Cauvery.

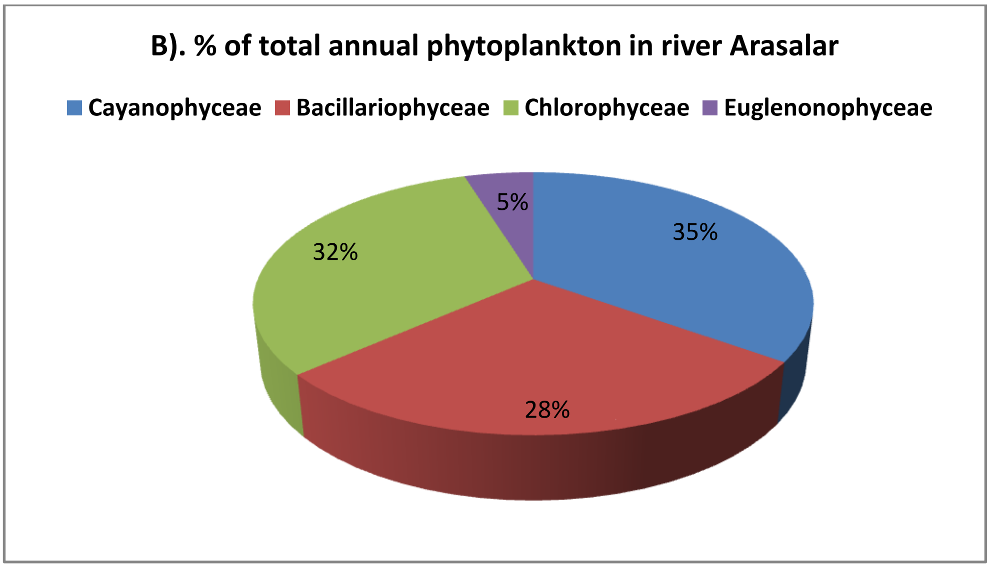


Figure 22. % of Annual phytoplankton in river Arasalar.

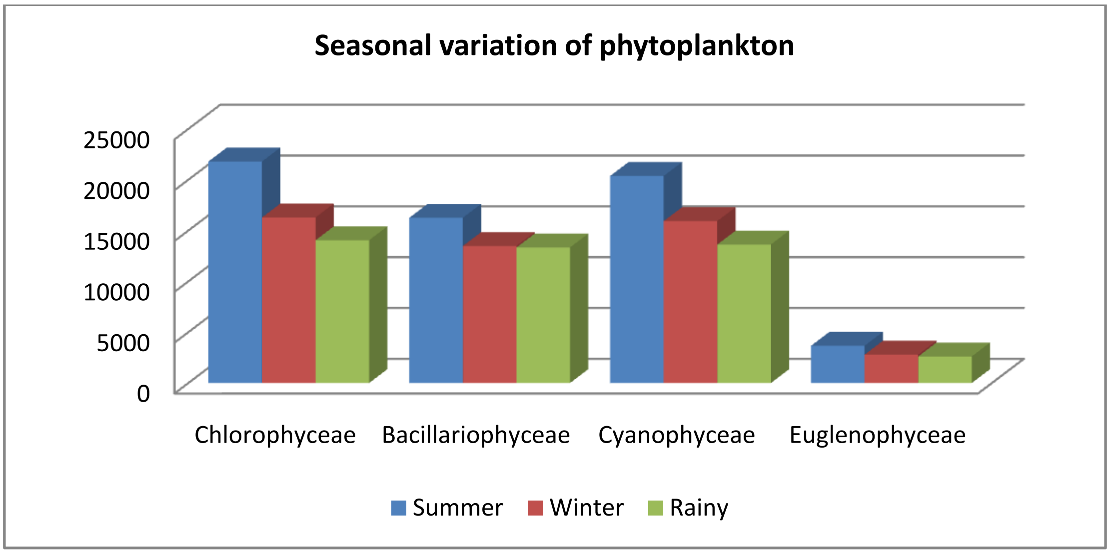


Figure 23. Seasonal variations of phytoplankton in River Cauvery.

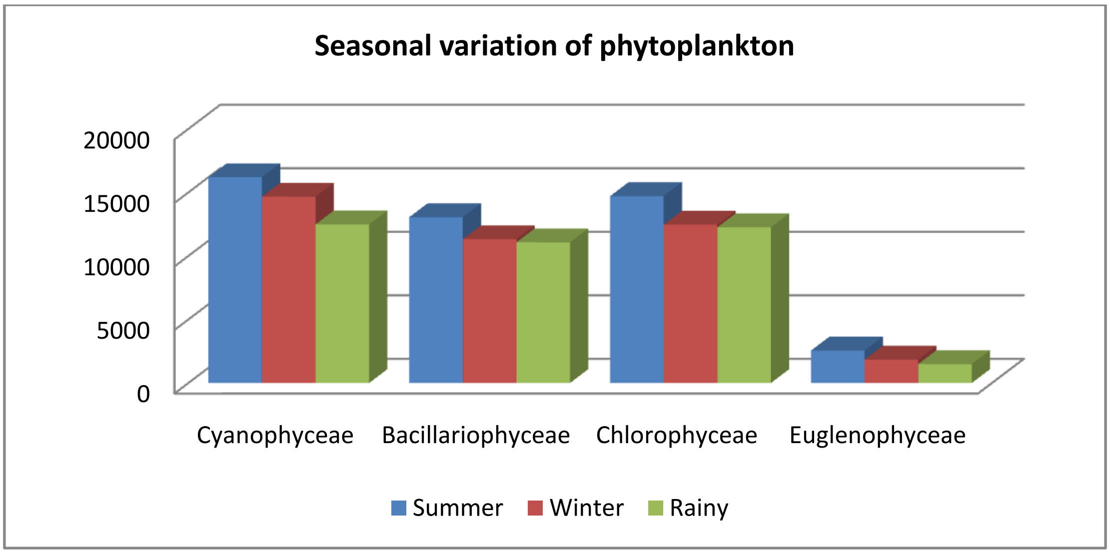


Figure 24. Seasonal variations of phytoplankton in River Arasalar.

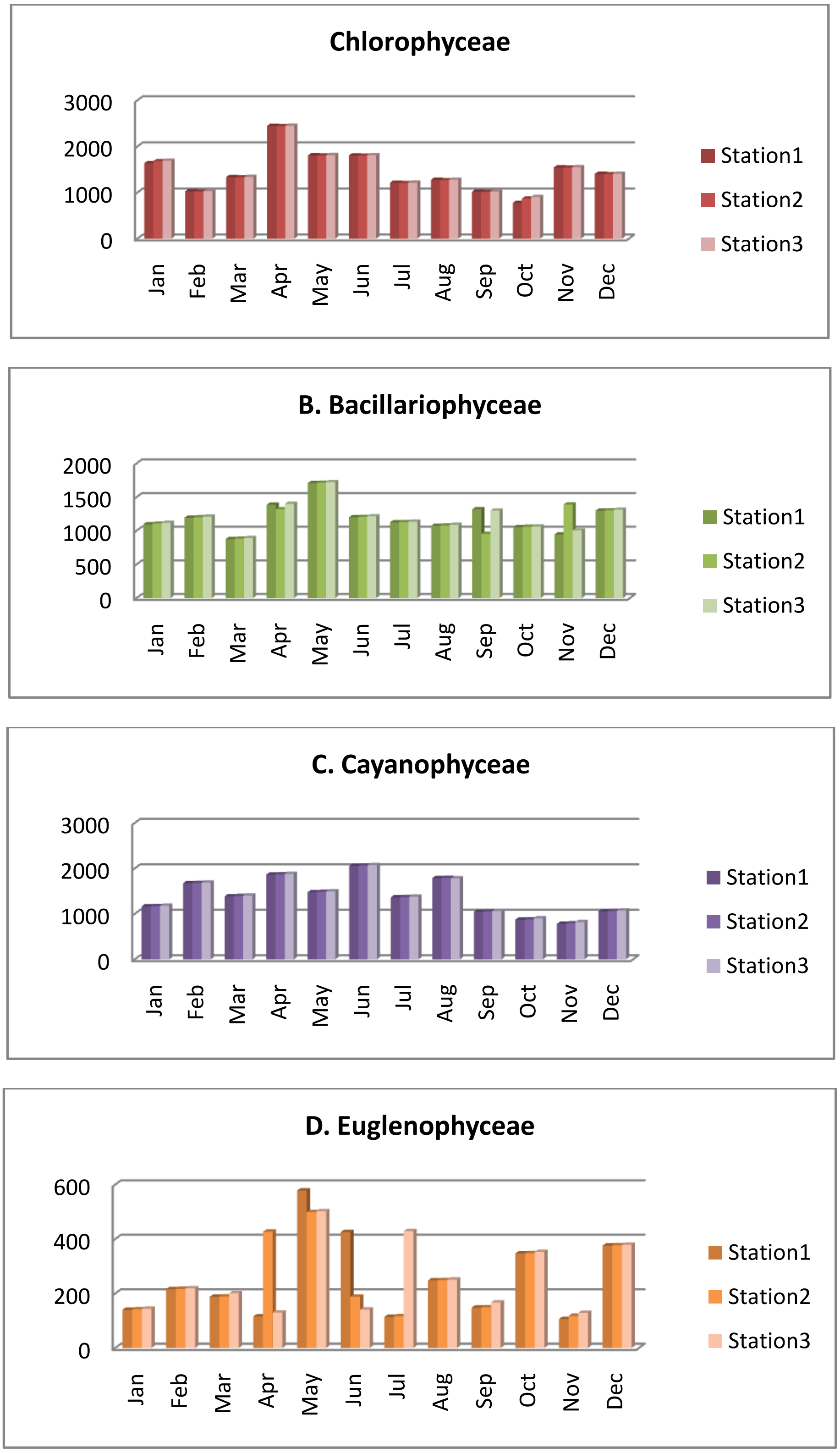


Figure 25. Monthly fluctuations of phytoplankton (Org/L) at 3 stations of Cauvery River.

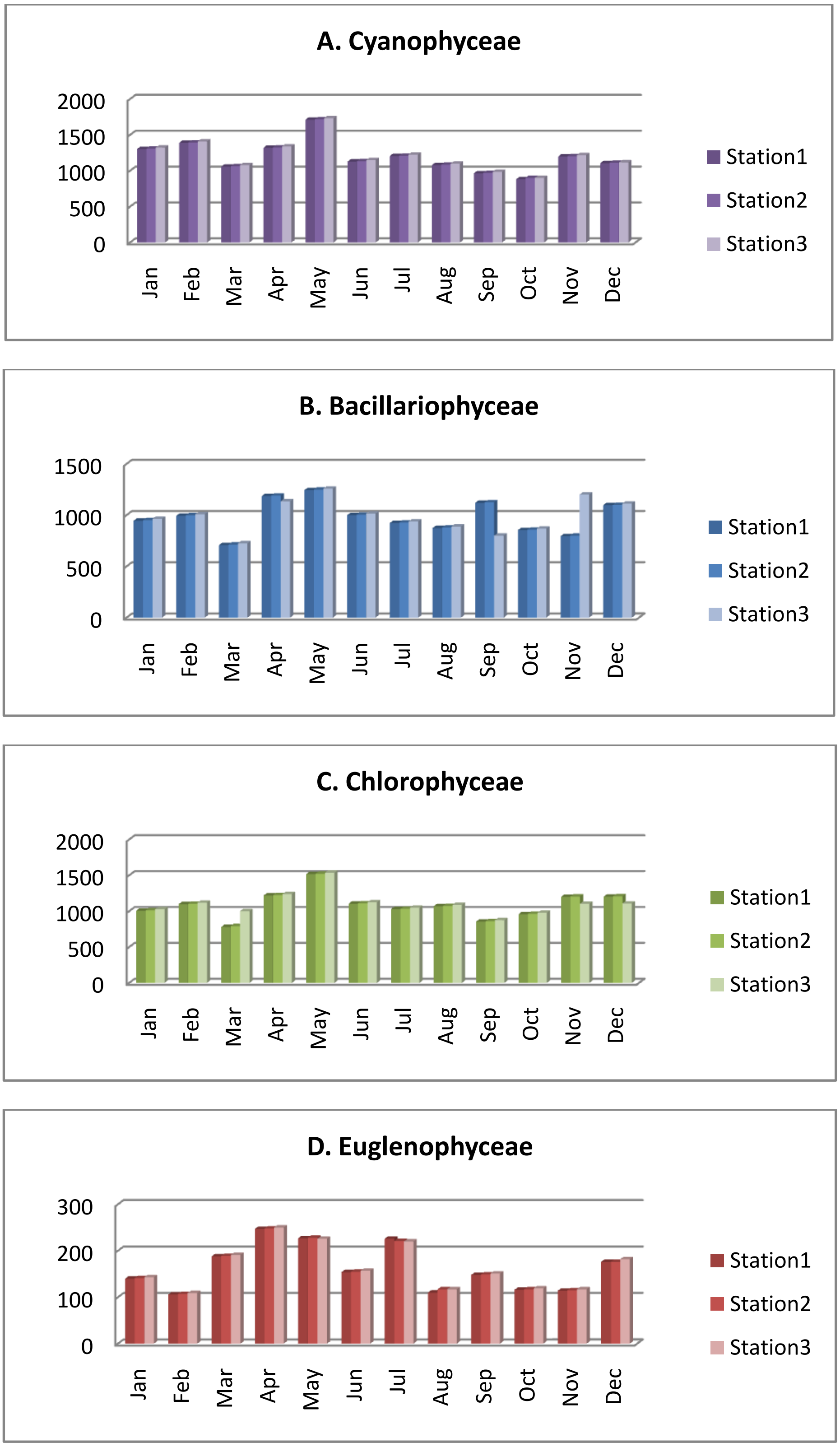


Figure 26. Monthly fluctuations of phytoplankton (Org/L) at 3 stations of Arasalar River.

Table 69. Phytoplankton diversity of river Cauvery and Arasalar (2010 Jan - Dec).

Collected Phytoplankton	CS 1	CS2	CS3	AS1	AS2	AS3
Chlorophyceae						
Actinastrum hantzschi	+	+	+	-	+	-
Closterium calosporum	-	-	-	+	-	+
C.parvulum	-	-	+	+	+	+
Characium angustum	+	-	-	-	-	-
Coelastrum microsporum	+	-	-	+	+	-
Cosmarium sp.	+	+	-	-	+	-
Crucigenia crucifera	-	+	-	-	+	++
Hydrodictyon reticulatum	+	-	-	+	+	+
Lyngbya sp.	-	-	-	+	+	-
Monoraphidium sp.	++	+	-	++	-	-
Microspora amoena	+	+	+	+	-	-
Mougeotia sp.	-	+	+	+	-	+
Oedogonium sp.	+	+	+	+	-	-
Pediastrum boryanum	-	+	-	-	-	-
P.tetras	-	-	-	+	++	+
P.duplex	+	+	-	+	+	-
P. simplex	+	+	+	+	++	+
Scenedesmus dimorphus	-	+	-	-	+	+
S. quadricauda	-	-	-	+	+	+
S. acuminatus	-	+	-	-	+	+
S. armatus	-	-	-	+	-	-
S.obliques	-	-	-	-	+	-
S. protuberance	-	-	-	+	-	-
S. abundans	-	-	-	+	+	+
Spirogyra hyalina	-	-	-	+	+	-
Staurastrum sp.	+	+	+	+	+	-
Stigeoclonium tenuae	-	-	-	+	++	+
Tetraedron sp.	+	+	-	+	+	+
Tetraedron tribobulatum	+	+	-	+	+	-
Trebauria sp.	+	+	+	-	-	-
Ulothrix zonata	-	-	+	+	-	-
Uronema sp.	+	-	-	-	-	-
Cyanophyceae						
Anabaena la						
Anabaena sp.	-	+	+	+	+	-
Aphanocapsa sp.	+	+	-	+	+	-
Chroococcus turgidis	-	-	-	+	+	-
Chroococcus disperses	-	+	+	+	+	-

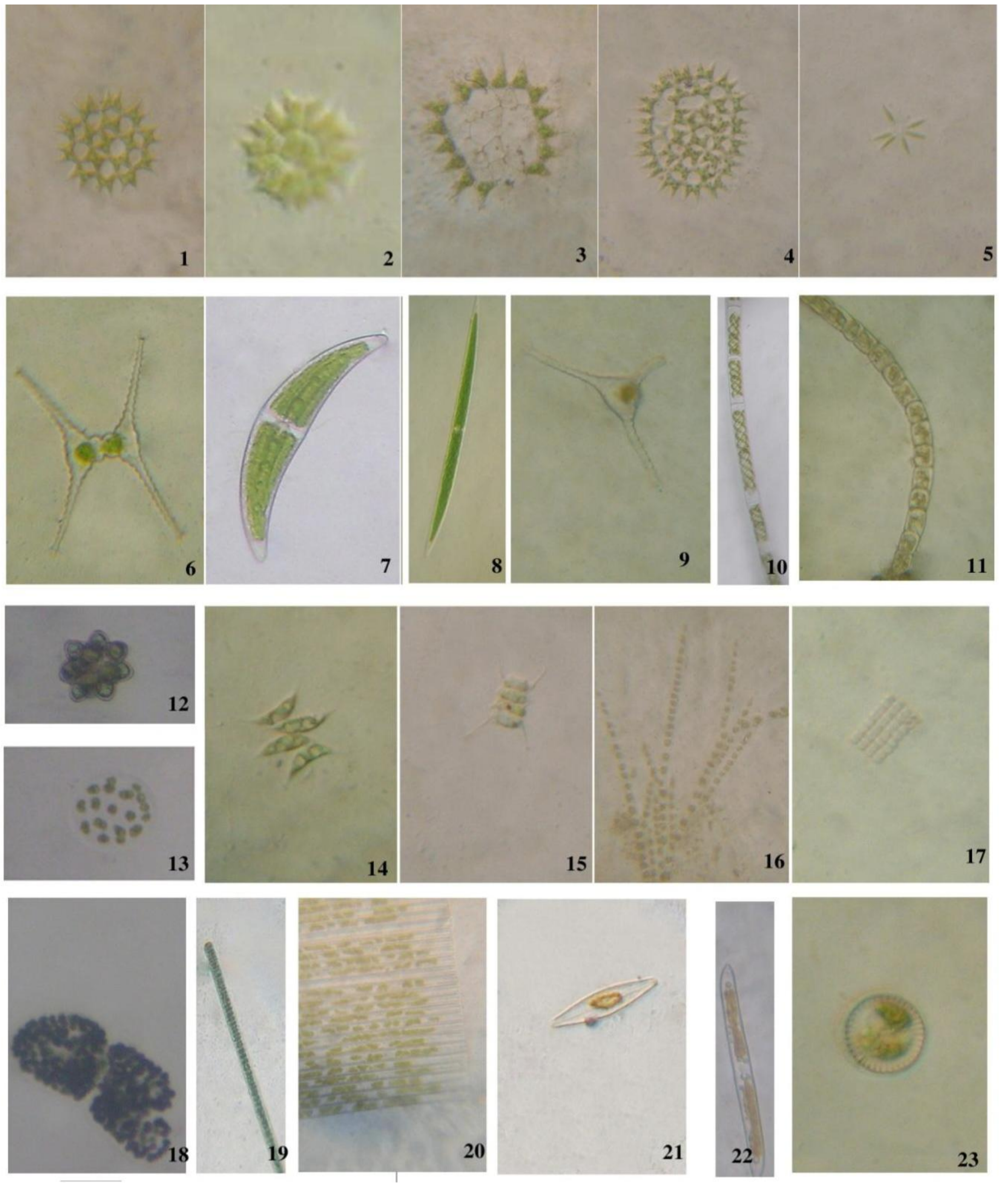
Conti…

Phytoplankton diversity of river Cauvery and Arasalar (2010 Jan - Dec)

Collected Phytoplankton	CS 1	CS2	CS3	AS1	AS2	AS3
Gloeocapsa sp.	+	+	-	+	+	-
Merismopedia tenuissima	+	+	+	++	+	-
M. elegans	+	+	-	+	-	-
M. glauca	+	+	+	+	+	-
Microcystis aeruginosa	-	-	-	+	++	-
M. lamelliformis	-	-	-	-	+	-
M. robusta	-	-	-	-	+	+
Nostoc sp.	+	-	-	+	+	-
Oscillatoria proboscida	-	-	-	-	-	+
O. princeps	-	-	+	-	+	+
O.tenuis	-	-	-	-	+	-
Phormidium sp.	-	-	-	+	+	-
Arthrospira sp.	-	+	+	-	-	-
Bacillariophyceae						
Anomoneis	-	-	-	+	-	-
Cyclotella	+	+	-	+	++	+
Cymbella tumida	-	-	-	+	-	+
Fragilaria sp.	-	+	-	+	++	-
Gomphonema	-	-	-	++	++	-
Melosira sp.	+	+	+	-	-	-
Navicula	-	-	-	++	+	-
Nitzschia palea	-	-	-	+	+	+
Pinnularia	-	+	-	+	+	+
Rhopalodia	-	-	-	-	+	-
Synedra ulna	-	-	-	+	+	+
S. gracilis	+	+	+	+	-	-
Euglenophyceae						
Euglena sp.	-	+	+	+	+	+
Phacus	-	+	-	+	-	-
Trachelomonas sp.	-	+	-	+	+	-

+ Present; - Absent; ++ Rare; +++ Dominant*;* CS1- Cauvery station 1, CS2- Cauvery station 2, CS3 - Cauvery station 3, AS1- Arasalar station 1, AS2- Arasalar station 2, AS3- Arasalar station 3.

PLATE –II PHYTOPLANKTON



1. Pediastrum duplex 2. P.tetras 3. P. simplex 4. P.boryanum 5.Actinastrum hantzschi 6.Staurastrum sp. 7.Closterium tumida 8.C.parvulum 9.Trebauria sp. 10.Spirogyra hyaline 11.Ulothrix zonata 12.Coelastrum microsporum 13 .Aphanocapsa sp. 14.*Scenedesmus dimorphus 15.S.quadricauda 16.Stigeoclonium tenuae 17.Merismopedia Sp 18. Microcystis aeruginosa 19. Oscillatoria proboscida 20. Fragilaria sp. 21. Pinnularia 22. Nitzschia palea 23. Cyclotella*

River Cauvery

The percentage of total annual phytoplankton of the river Cauvery consisted of 33.82% Chlorophyceae (Green algae), 27.94% Bacillariophyceae (Diatoms), 32.35% Cyanophyceae (Blue green algae), and 5.88% of Euglenophyceae (Fig.21). Annual average of Chlorophyceae was 1448.19 org/L, Bacillariophyceae was 1196.52 org/L, Cyanophyceae was 1385.44 org/L and Euglenophyceae was 251.44 org/L (Table.65). Annual averages revealed that Chlorophyceae were the dominant group.

Monthly fluctuation of phytoplankton showed four peaks in April (9.66 %), May (11.44 %), June (10.73%) and August (8.57 %) (Table 61). Four peaks of Chlorophyceae (Green algae) were observed in January (40.52 % - 1636 org/L), March (35.25 % - 1334 org/L), April (42.09 % - 2447 org/L) and November (45.73 % - 1544 org/L). The Bacillariophyceae (diatoms) showed two peaks, one in September (37.37% - 1320 org/L) and another in October (34.55% -1054 org/L). Four peaks of Cyanophyceae (Blue Green algae) were observed in February (40.74 % - 1675 org/L), March (36.62 % -1386 org/L), June (37.49 % - 2056 org/L) and August (40.72 % - 1786 org/L) (Fig.25). During the twelve months of collection the Chlorophyceae were the dominant forms. Cyanophyceae and Bacillariophyceae were seen throughout the year.

Seasonal averages of summer season showed that Chlrophyceae was 1816.33 org/L, Bacillariophyceae was 1354.83 org/L, Cyanophyceae was 1697.83 org/L and Euglenophyceae was 305.58 org/L. Seasonal averages of winter season showed that Chlrophyceae was 1354.83 org/L, Bacillariophyceae was 1123.66 org/L, Cyanophyceae was 1327.83 org/L and Euglenophyceae was 232.50 org/L. Seasonal averages of rainy season showed that Chlrophyceae was 1170.83 org/L, Bacillariophyceae was 1111.08 org/L, Cyanophyceae was 1135.66 org/L, and Euglenophyceae was 217.75 org/L, (Table.67 and Fig.23). In dry season Chlorophyceae and Cyanophyceae were the dominating group. Phytoplankton was remarkably abundant during dry season.

During the twelve months of collection the diatoms were the dominant forms. Chlorophyceae and Bacillariophyceae were seen throughout the year. In Cyanophyceae, *Oscillatoria* was the dominant genus. *Oscillatoria* showed two peaks, one in April and another in May. *Merismopedia* was seen only in April and May. *Phormidium* was abundant in May and was seen in April, May and August. In the case of *Chlorophyceae* (Green algae*)* *Closterium sp.* was the dominant genus. *Closterium sp.* was found in the plankton throughout the year, their number was high in October. *Mougeotia* and *Spirogyra* were found during seven months. Their number was high in March, *Oedogonium* was frequent forms and their number was high in May. *Rhizoclonium, Euastrum, Micrasterias Hyalotheca, Sphaerozosma* was very frequent forms. In the case of diatoms *Navicula* was found in all the months except in March and June. *Navicula* was abundant in February, April and in May. *Fragillaria* was seen during eight months. Two peaks of *Fragillaria* were observed, one in February and another in March *Pinnularia* was found during seven months.

Two peaks were observed, one in April and another in May *Gophonema*, which was found during five months and a peak was observed in February. *Suniella* was found during February, March and April .The peak was in April Synedra was found in February, March. July and November, The peak was in February. *Nitzschia* was found in March, May and July. The peak was in March. *Melosira, Cyclotella*, Pleurosigma and Cymbella were very rare forms. In Englenophyceae, *Euglena* was seen only in March and in *Rhodophyceae, Audouinella* was seen in September only. They were also very rare in the plankton. In station I, *Closterium* was only species seen throughout the year (Table 69).

River Arasalar

The percentage of total annual phytoplankton of the river Arasalar consisted of 34.92 % Cyanophyceae (Blue green algae), 28.57 % Bacillariophyceae (Diatoms) 31.74 %, Chlorophyceae (Green algae), and 4.76 % of Euglenophyceae (Fig.22). Annual averages of Cyanophyceae were 1204.30 org/L, Bacillariophyceae was 985.36 org/L, Chlorophyceae was 1094.72 org/L, and Euglenophyceae was 163.80 org/L. Annual averages revealed that Cyanophyceae were the most dominant group in this river.

Monthly fluctuation of phytoplankton showed three peaks, in February (8.73 %), April (9.66%) and May (11.44 %) (Table 62). Four peaks of Cyanophyceae (Blue green algae) were observed in January (38.36 % - 1303 org/L), February (38.32 % - 1390 org/L), March (38.70 % -1059 org/L) and November (36.24 % - 1199 org/L). The Bacillariophyceae (diatoms) showed two peaks, one in September (37.37 % - 1120 org/L) and another in December (34.55 % - 1098 org/L). Three peaks of Chlorophyceae (Green algae) were observed in August (34.13 % - 1069 org/L), October (34.12 % - 959 org/L) and November (36.27 % - 1200 org/L). During the twelve months of collection the Cyanophyceae were the dominant forms. Chlorophyceae and Bacillariophyceae were seen throughout the year.

Seasonal averages of summer season showed that Cyanophyceae was 1350.83 org/L, Bacillariophyceae was 1088 org/L, Chlorophyceae was 1226.33 org/L, and Euglenophyceae was 213.25 org/L, Seasonal averages of winter season showed that Cyanophyceae was 1222.25 org/L Bacillariophyceae was 943.5 org/L, Chlorophyceae was 1038.41 org/L, and Euglenophyceae was 154.41 org/L. Seasonal averages of rainy season showed that Cyanophyceae was 1040.58 org/L, Bacillariophyceae was 922.91, Chlorophyceae was 1021.08 org/L, and Euglenophyceae was 124.16 org/L, (Table.68 and Fig.24). In dry season Cyanophyceae and Chlorophyceae were the dominating group. Phytoplankton was remarkably abundant during dry season.

Among Cyanophyceae *Oscillatoria* was the dominated genus. It was found throughout the year, except in August, and was abundant in April. *Merismopedia* was abundant in April and was found only in March, April and May. *Phormidium* was a frequent form. *Aphanocapsa, Spirulina* and *Lyngbya* were rarely seen. Among Chlorophyceae, Closterium and Spirogyra were the dominated genera. They were obser*ved throughout the year. Oedogonium, Pediastrum, Mougeotia, Micrasterias, Cosmarium* and *Hyalotheca* were sub dominant forms. *Penium, Pleurotaenium and Xanthidium* was found frequently. *Stigeoconium, Dictyosphaerium, Ankistrodesmus, Kirchneriella, Pediastrum, Tetradron, Scenedesmus. Crucigenia, Zgynema, Cylindrocystis, Treubaria, Netrium, Gonotozygon, Euastrum. Staurastrum,and Spondylosium* were rarely seen.

In the case of Bacillariophyceae, *Fragillaria, Navicula* and *Surirella* were the dominant forms. *Synedra, Gophonema* and *Pinnularia* were subdominant forms. *Diatorna, Pleurosigma* and *Nitzschia* were frequently seen and *Melosira, Achnanthes, Diploneis, Gyrosigma, Cymbella* and *Amphora* were rarely found in this station. Among Rhodophyceae *Audouinella sp* was the only form and It was very rare. From the analysis of phytoplankton in this station *Clostenum* was the only genera seen throughout the entire period of collection (Table 69).

DISCUSSION

The seasonal dynamics of the phytoplankton is influenced by the climatic conditions as well as the physico-chemical characteristics of the river. Maximum number of total phytoplankton during summer and winter indicates good physicochemical conditions (Kant and Kachroo 1977). A marked difference in the composition and in the relative abundance of various algal groups was observed in both the rivers. The settled volume and the individual numbers of phytoplankton were very weak during the wet season while many fold increase in phytoplankton populations was noted during the dry season. The turbidity and the heavy water current will prevent the growth of phytoplankton during the wet season. During dry season, the river water turns to more lacustrine and the addition of nutrients will favor the growth of planktons. Hydrological factors such as discharge or water residence time are thought to be of greater importance to planktonic development in rivers.

In the present investigation, Chlorophyceae population was the most abundant group in the river Cauvery followed by Cyanophyceae, Bacillariophyceae and Euglenophyceae. Similar finding was also reported by Suresh et al (2011) in Tungabhadra River. Whereas, in the river Arasalar Cyanophyceae were most dominant followed by Chlorophyceae, Bacillariophyceae, and Euglenophyceae.

Sarojini (1996) and Tarar and Bodhke (2002) have observed that high turbidity, pH, bicarbonate, orthophosphate, alkalinity, chloride may be responsible for the Cyanophycean growth and bloom. Jarousha (2002) have reported that higher diversity of the blue-green algae may be attributed to high nitrate values during the rainy season. In the present study Bacillariophyceae were more in summer than in winters and least in rainy season. Kaur et al. (2001) have recorded minimum population of diatoms during moderate temperature. As compared to other classes of algae, the members of Euglenophyceae were recorded least in number. Its percentage was very less as compared to other groups.

In water body, there usually occur seasonal qualitative and quantitative fluctuations in the planktonic population in temperate and tropical climate. The reports of some workers suggest that the maximum development of phytoplankton occur during summer and minimum in winter (Philipose, 1960; Anjana and kanhera., 1980). While Kumar estimated that the density of phytoplankton is greater during summer, post monsoon and winter and is lowest in monsoon. In the present investigation also peak of the phytoplankton was observed during summer followed by winter Saha and Choudhary (1985). Phytoplankton count also registered higher value during non-rainy months. This result gains support from the similar observations of Kamat (2000) and Singh et al. (2002). It is reported that excessive growth of certain algal genera, viz., *Scenedesmus, Anabaena, Oscillatoria and Melosira* indicate nutrient enrichment of aquatic bodies (Kumar, 1990; Zargar and Ghosh, 2006). Although these plankters were present in both the rivers but their density varied. Nandan and Aher (2005) has showed the algal genera, *Euglena, Oscillatoria, Scenedesmus, Navicula, Nitzschia and Microcystis* which are the species found in organically polluted waters. Similar genera were also recorded in the present study.

In this study, the peak of phytoplankton was observed during April, May, and June while lowest peak was found in September followed October and November in 3 stations of river Cauvery. Similarly, the peak of phytoplankton was observed during February, April, and May while lowest peak was found in March followed September and October in 3 stations of river Arasalar. Sreenivasan (1964) have observed that the peaks of phytoplankton occurred at different period in different years. Margalef (1968) suggested that phytoplankton population in fertile water is more diverse than those in infertile water.

In the present investigation, the phytoplankton fluctuates monthly and its productivity was high during summer and low during rainy seasons as evidenced earlier by Sadguru *et al.* (2002). The low productivity of phytoplankton might be due to the grazing effect by zooplankton and fishes as evidenced earlier by Mathivanan and Jayakumar (1995), Biswas and Konar

(2001). Low density phytoplankton recorded during rainy season may be possibility is due to dilution by the rainy water coupled with other unfavorable environmental conditions.

A variety of ecological factors influence and control the seasonal distribution and composition of algal communities. Algal population is influenced by various factors such as pH, temperature, heavy metal content, organic matter content and other pollutants that are added by anthropogenic activities in the basin. The overall temperature range required for the survival of freshwater algal is -40 to 75ºC. Optimum temperature ranges for several major freshwater algal taxa are 15 to 25ºC for diatoms, 25 to 35ºC for green algae and 30 to 40ºC for blue green algae (Hawkes, 1969). Typically, an increase in productivity in the winter season and a decrease in the summer season is the most commonly observed effect, but decrease in the species number and diversity also has been reported. Blue green algae are more generally more heat tolerant than other species. Patrick et al., (1969) reported a reduction in diatoms when the water temperature was between 35 and 40ºC.

The effect of aquatic plants on pH is dependent upon the buffering capacity of the water and plants productivity. Changes in the plants community composition have been reported on numerous occasions in streams recently acidified and having pH values less than 6. However, community biomass is not always reduced because of the increase in the acid tolerant species. (Stokes *et al.,* 1989). When the pH decreases below 5.0 in streams, an increase in algal biomass and primary productivity often has been observed. These changes have been attributable to reduced grazing pressure by macro invertebrates, reduced microbial decomposition, increased micronutrient availability and the low pH preference of some natural periphyton (Elwood and Mulholland, 1989). Green algae often comprise a greater portion of the algal community in acid streams. The relative abundance of diatoms and blue-green species decreases as the pH decreases (Stokes *et al.,* 1989). These algal species are more sensitive to pH changes than dinoflagellates. An increase in green filamentous form is often observed for Lake Periphyton in low pH waters.

Palmer (1969) made the first major attempt to identify and prepare a list of genera and species of algae tolerant to organic pollution. Palmer's (1969) has shown that the genera like *Oscillatoria, Euglena, Scenedesmus, Chlamydomonas, Navicula, Nitzschia, Stigeoclonium* and *Ankistrodesmus* are the most tolerant species found in organically polluted waters. Patrick (1965) concluded that Euglena and *Oscillatoria* are highly pollution tolerant genera and, therefore, reliable indicators of Eutrophication similar of these genera with very high grade points of Palmer's scale are like *Euglena viridis, Euglena gracilis, Oscillatoria limosa, Oscillatoria chlorine and Oscillatoria tenuis.* The pollution tolerance of *Stigeoclonium tenue* is also well documented.

Pearsal (1932) was the first to show a clear correlation between organic pollution and blue-green algae and the centric diatoms namely *Pandorina, Scenedesmus, Navicula, Chlorella, Spirulina, Anabaena, Eudorina, Melosira, Closterium, Cosmarium* which are the indicators of the organically pollution tolerant species. *Bacillariophyceae like, Navicula, Nitzschia, Gomphonema, Synedra and Fragilaria* is being used as indicators of water quality Cholonky (1968). Abundance of green algal flora like, *Zygnema, Spirogira, Mougeotia, Euastrum, Staurastrum,* etc. are found in less polluted spots (Venkateswarlu and Reddy, 1985). Similar genera were also recorded in the present study.

Biological monitoring using algae is a useful alternative tool for assessing the water quality of any aquatic ecosystem, as it can help in evaluation of environmental changes in the water bodies. The most convincing reason for including algal indicators in environmental monitoring programs is that changes in both algal production and taxonomic composition can greatly affect food web interactions and ecosystem dynamics and also biomonitoring using algae is less expensive, more informative and convincing. Biomonitoring results can be used to identify the water body ecology problems and establish priorities for pollution control efforts. Among taxonomic analysis of algal assemblage, Community study are capable of measuring ecosystem changes in response to broad range of impact scenario, but require a suitable reference condition to be set up. Analysis and interpretation that considers both levels of biological organization derive the greatest amount of information from taxonomic data sets and should allow for a more complete and reliable assessment of environmental changes than if either approaches is used alone.

Based on our results, it can be concluded that the river Cauvery which is one of the most productive riverine system of Tamilnadu. In kumbakonam area, the river Cauvery and its tributaries Arasalar were polluted at downstream stations. The present findings show that there are certain members of species in the Chlorophyceae and Cyanophyceae which are tolerant to organic pollution and resist the stress caused by pollutants. Abundance of such taxa in the polluted habitats suggests their possible use an “indicator organism”. The study emphasizes the necessity of using phytoplankton as effective and appropriate method of biomonitoring for evaluation of river water quality.

CHAPTER 6

BIODIVERSITY OF RIVER CAUVERY AND ITS TRIBUTARIES ARASALAR

6.1 INTRODUCTION

The term biological diversity or biodiversity refers to all plants, animals, microorganisms, the ecosystems of which they are part, and the diversity within species, between species, and of ecosystems. Biodiversity underlies the goods and services provided by ecosystems that are crucial for human survival and well being. These include among others: nutrient cycling; primary production; regulation of air quality, climate, floods, soil erosion; provision of food, fuel wood, fiber, biochemical, natural medicines, genetic resources, spiritual and religious values, educational values and recreation. The physic-chemical characteristics of a water body are altered by disposal of sewage, drainage, anthropogenic activities like bathing, washing etc. and other wastes. As per Goswami (2012) the first step towards the conservation of an aquatic system should be on the identification and assessment of biodiversity composition of a river.

Aquatic ecosystems are affected by several health stressors that significantly deplete biodiversity. In the future, the loss of biodiversity and its effects are predicted to be greater for aquatic ecosystems than for terrestrial ecosystems (Sala *et al.*, 2000). Rivers are subjected to various natural processes taking place in the environment, such as the hydrological cycle. As a consequence of unprecedented development, human beings are responsible for choking several lakes to death. Storm water runoff and discharge of sewage into rivers are two common ways that various nutrients enter the aquatic ecosystems resulting in the depletion of Aquatic ecosystems (Sudhira and Kumar, 2000; Adeyemo, 2003).

In all rivers, diversity increased rapidly from upstream to downstream sections, almost entirely the result of addition of new species with little replacement of the upstream fauna. Head water diversity was lowest in rivers with the most variable head waters; the increase in diversity downstream steepest for those rivers with the steepest decrease in variability and the number of species of downstream sections was greater in rivers with more constant downstream sections. It is very important to know the structure of communities since they are basic integral and lively components of the ecosystem The structure and function of such communities has been a long debate among the global scientist for the last two three decades and hence the study of communities should be given due to importance.

Indian Rivers are some of the last global frontiers of rich freshwater diversity, endangered and threatened species. According to India's National Biodiversity Action Plan (NBAP, 2012 p 15), "Nearly 50% of the aquatic plants of the world are recorded from the Indian subcontinent but only a few have been studied in detail." India is a mega diverse country with respect to freshwater fish species (650+ species). In freshwater fish diversity, India is eighth in the world and third in Asia (Biju Kumar, 2000). At the same time, these rivers support millions of livelihoods and indigenous people. Rivers flowing through Eastern and North Eastern Himalayas and Western Ghats have been designated as global hotspots of freshwater biodiversity.

The Western Ghats hotspot is globally significant centre of diversity and endemism for freshwater species where close to 16% of the 1,146 freshwater taxa assessed are threatened with extinction, with a further 1.9% assessed as Near Threatened. While in the Eastern Himalayan Hotspot, nearly 31% species studied are data deficient and can be of very high conservation value. Thousands of indigenous, forest dwelling tribes in the North East, Himalayas and Western Ghats depend entirely on these rivers for livelihoods. Many rivers and riverine stretches are sacred and are conserved actively by local communities.

Today, India's Rivers, riverine biodiversity and river dependent communities are facing major threats: from large dams, pollution, encroachment, sand mining, deforestation and bad management practises. These factors are impacting all aspects of rivers: ecological, social, cultural, religious, aesthetic, tourism-related and economic. A considerable quantity of research has been carried out on the physicochemical parameters of riverine water and their impact on aquatic biota in India (Adebisi, 1980; Pande *et al*., 1988; Ray *et al*., 1996; Samanta and Chakrabarti, 1997; Chakraborty, 1998; Dhanapakiam *et al*., 1999; Shastri, 2000; Barat & Jha, 2002; Shahnawaz *et al*., 2009 and Sarkar *et al*., 2010).

Biodiversity is decreasing day by day. Therefore, the study on biodiversity and conservation of species from any ecosystem is essential. The richness of earth is its living wealth, which provides an abundant and essential supply of indispensable goods and services to mankind (Nirmal Kumar *et al.*, 1999). Today, India's Rivers, riverine biodiversity and river dependent communities are facing major threats: from large dams, pollution, encroachment, sand mining, deforestation and bad management practices. These factors are impacting all aspects of rivers: ecological, social, cultural, religious, aesthetic, tourism-related and economic. More than 10.8 Million people depend on riverine fisheries alone which are degrading and collapsing at an alarming rate.

Biodiversity and conservation of freshwater ecosystems has been the focus of regional assessments recently (Olsen et al. 1998, Pringle & Scatena 1999, Pringle et al. 2000) since along with their terrestrial counterparts, aquatic ecosystems have been increasingly placed under pressures to provide renewable resources while being exposed to the ravages of poor planning and pollution. Listed among the identified impacts on aquatic biodiversity are deforestation, agriculture (including pesticides and irrigation), urban and industrial development, river regulation for water and hydropower production, mining, petroleum extraction, introduction of exotic species, dumping of solid wastes, dredging and channelization, overfishing and the aquarium trade (Pringle *et al*. 2000).

In India, studies on freshwater fishes in rivers were primarily focused on the catch data of fishes of commercial value (Vishwanath *et al*. 1998, Sarkar & Bain 2007, Raghavan *et al*. 2008, Sarkar *et al*. 2010). A review of published literature shows that very few studies on fish diversity have been completed in India (Biju *et al*. 1999, Sarkar & Bain 2007, Sarkar *et al*. 2008). Besides, conservation information on the pattern of fish biodiversity, abundance of threatened and endangered fishes, and threats in the rivers and streams are very limited in India (Husain 1983, Sarkar *et al*. 2010, Lakra *et al*. 2010). Nevertheless, recently, it has been observed to decline rapidly due to environmental degradation like urbanization, damming, abstraction of waters for irrigation and power generation, and pollution. These environmental impacts have induced severe stress on freshwater fish diversity (Sarkar *et al*. 2008).

Various authors reported the ichthyofaunal diversity in Indian water bodies (Chhapgar and Manakadam, 2000; Jayaram and Dhas, 2000; Gopi, 2001; Soruba, 2002 and Anuradha Bhat, 2004). These reports highlight the faunal and floral diversity of the aquatic ecosystem and reveal the variations in the distribution of the ichthyofauna and other fauna found in the aquatic ecosystem. These reports also highlight the potential fish species found in Indian waters, their growth potential, aquaculture importance and their capture fishery dynamics. A proper understanding of the fish fauna, their seasonal abundance and habitat is of great importance in effective utilization of these resources.

According to David Dudgeon (2000), freshwater ecosystem in Asia and under grave threat conservation of freshwater biodiversity faces particular challenges because of a lack of public awareness of its magnitude and importance. Many lakes have been so modified by human activities that they function as enormous fishponds, and the introduction of exotic species or the translocation of native taxa has contributed to the extinction of endemic species in isolated drainage basins.

The spatial and temporal distribution patterns of benthic macroinvertebrates were studied in an intermittent river in Algeria (Chelif Wadi, North Africa) by using the self-organizing map (SOM) an unsupervised artificial neural network overall the study sites showed a very poor macro invertebrate fauna have been reported (Arab *et al.*, 2004). Ruggiero *et al.* (2004) observed the result of taxonomic compositions of aquatic macrophytes, zooplankton and macroinvertebrates were also determined. Inter and intra-annual variation of water chemistry and phytoplankton biomass were addressed.

Present study was mainly designed to study the composition of fish communities in different parts of the Cauvery river system, diversity of fish species and that of the other macro communities from upstream to downstream in the longitudinal axis of the river. The Cauvery delta is the rice bowl of Tamnilnadu. However, very little information is available on the Icthyofana and aquatic flora of this region except a few species (Sampoorani *et al.*, 2002). Earlier works on ichthyofauna of Cauvery were of Sreeja *et al* (2005) and Ravichandran *et al* (2008). The present study adds to the documentation of fish fauna of Cauvery River from Kumbakonam. The present data represented baseline information on the Icthyofauna and floral diversity in the two water bodies investigated.

6.2 MATERIALS AND METHODS

Three sampling stations were selected for river Cauvery such as station 1. Melakaveri (upstream of the river), station 2. Palakarai (midstream of the river) and station 3. Manancherry (downstream of the river), and similarly for river Arasalar such as station 1. Women's College Bridge (upstream of the river) 2. Patthadi palam (midstream of the river) and station 3. Sakkottai (downstream of the river) for sampling purpose. For the present study, both Icthyo fauna and non-icthyo fauna diversity sampling were made from these six locations on monthly basis for a period of one year (January 2010 to December 2010). The fauna and flora of the rivers were regularly and carefully recorded during the period of visit. The floral samples were collected and brought to the lab and identified using standard keys.

The fishes have been collected from different stations by various fishing nets with the help of local fishermen. Identification of fishes is based mainly on external characters such as body shape, length, depth, mouth and nature of fish spines, scales, etc. The fishes collected were segregated mainly based on the presence or absence of scales on the body. When scales are present, they were further separated based on body shape, number and length of fins. In the case of fishes without fins, they were separated according to the number of barbells present. After segregation, they were identified by the literature of Shrivastava (1980), Talwar & Jhingran, 1991 and Jayaram, 1999 & 2006.The threat status and endemism of fishes were assigned following Barman (2007). A data matrix was constructed with presence and absence of fish species for each of the sampling sites in the River Cauvery and Arasalar.

Species of zooplankton, insects, crustaceans, molluscs, fishes, birds and aquatic mammals have been identified. All the collected samples were anesthetized, washed and then stored in 10 % formalin and brought to the laboratory and identified using fauna of British India. The occurrence of different fauna and flora during the period of study was tabulated and presented. Insects were identified using the keys given in Imms (1963). Identification of turtles was based on direct sightings and from dead shells collected on the riverbanks. Information on resident and migratory birds has been recorded from various sampling sites.

6.3 RESULTS

Altogether 40 species of fishes belonging to seven orders and fourteen families were collected from various fishing spots of the River Cauvery and Arasalar during the observation period of about 12 months (Table 1). The results of icthyofauna, non- icthyofauna and floral diversity of the River Cauvery and Arasalar are presented in Table-1, 2, 3 and 4. In respect of Ichthyofauna diversity, a total of forty species belonging to seven orders and fourteen families were identified in the River Cauvery. Among the 40 species, 22 species were found under the order Cypriniformes, 8 species were found under the order Perciformes, 4 species were found under the order Siluriformes, three species were found under the order Synbranchiformes and a single species was found under the order Osteoglossiformes, Anguilliformes, and Cyprinodontiformes each.

The taxonomic composition of the fish fauna in the Arasalar includes a total 35 species, 20 species were found under the order Cypriniformes, 6 species were found under the order Perciformes, 3 species were found under the order Siluriformes, 3 species were found under the order Synbranchiformes and a single species was found under the order Osteoglossiformes, Anguilliformes, and Cyprinodontiformes each. Of these

Table 70. Systematic list of fishes and their conservation status of River Cauvery.

Orde	Family	Species	Status
1.Anguilliformes	Anguillidae	*Anguilla bengalensis* (Grey, 1831)	EN
2. Cypriniformes	Balitoridae	*Nemacheilus botia* (Hamilton, 1822)	NE
3.	Cobitidae	*Lepidocephalichthys guntea* (Hamilton, 1822)	NE
4.	Cyprinidae	*Barilius bola* (Hamilton, 1822)	NE
5.		*Catla catla* (Hamilton, 1822)	VU
6.		*Chela laubuca* (Hamilton, 1822)	LRnt
7.		*Cirrhinus reba* (Hamilton, 1822)	VU
8.		*Cirrhinus mrigala* (Hamilton, 1822)	LRnt
9.		*Cyprinus carpio* (Linnaeus, 1758)	NE
10.		*Danio devario* (Hamilton, 1822)	LRnt
11.		*Esomus danricus* (Hamilton, 1822)	LRlc
12.		*Garra mullya* (Sykes, 1839)	NE
13.		*Labeo bata* (Hamilton, 1822)	LRnt
14.		*Labeo calbasu* (Hamilton, 1822)	LRnt
15.		*Labeo rohita* (Hamilton, 1822)	LRnt
16.		*Osteobrama cotio* (Hamilton, 1822)	LRnt
17.		*Puntius sarana* (Hamilton, 1822)	VU
18.		*Puntius conchonius* (Hamilton, 1822)	VU
19.		*Puntius sophore* (Hamilton, 1822)	LRnt
20.		*Puntius ticto* (Hamilton, 1822)	LRnt

NE - Not Evaluated; LRnt - Lower Risk near threatened; LRlc - Lower Risk least concern; VU - Vulnerable; EN - Endangered.

Conti…

Systematic list of fishes and their conservation status of River Cauvery

	Order	Family	Species	Status
21.			*Rasbora daniconius* (Hamilton, 1822)	NE
22.			*Salmostoma bacaila* (Hamilton, 1822)	LRlc
23.			*Salmostoma phulo* (Hamilton, 1822)	NE
24.	Cyprinodontiformes	Poeciliidae	*Gambusia offinis* (Baird & Girard, 1853)	NE
25.	Osteoglossiformes		*Notopterus notopterus* (Pallas, 1769)	LRnt
26.	Perciformis	Anabantidae	*Anabas testudineus* (Bloch, 1792)	VU
27.		Chandidae	*Chanda nama* (Hamilton,1822)	NE
28.			*Parambassis ranga* (Hamilton, 1822)	NE
29.		Channidae	*Channa marulius* (Hamilton, 1822)	LRnt
30.			*Channa punctatus* (Bloch, 1793)	LRnt
31.			*Channa striatus* (Bloch, 1793)	LRlc
32.			*Channa gachua* (Hamilton, 1822)	NE
33.		Gobiidae	*Glossogobius giuris* (Hamilton, 1822)	LRnt
34.	Siluriformes	Bagridae	*Sperata seenghala* (Sykes, 1839)	NE
35.			*Mystus vittatus* (Bloch, 1794)	VU
36.		Siluridae	*Ompok bimaculatus* (Bloch, 1794)	EN
37.		Claridae	*Clarias batrachus* (Linnaeus, 1754)	VU
38.	Symbranchiformes	Synbranchidae	*Monopterus cuchia* (Hamilton, 1822)	LRnt
39.		Mastacembelidae	*Mastacembelus armatus* (Lacapede, 1800)	NE
40.			*Mastacembelus pancalus* (Hamilton, 1822)	NE

NE - Not Evaluated; LRnt - Lower Risk near threatened; LRlc - Lower Risk least concern; VU - Vulnerable; EN - Endangered

Table 71. Systematic list of fishes and their conservation status of River Arasalar.

Order	Family	Species	Status
1.Anguilliformes	Anguillidae	*Anguilla bengalensis* (Grey, 1831)	EN
2. Cypriniformes	Balitoridae	*Nemacheilus botia* (Hamilton, 1822)	NE
3.	Cobitidae	*Lepidocephalichthys guntea* (Hamilton, 1822)	NE
4.	Cyprinidae	*Barilius bola* (Hamilton, 1822)	NE
5.		*Catla catla* (Hamilton, 1822)	VU
6.		*Chela laubuca* (Hamilton, 1822)	LRnt
7.		*Cirrhinus reba* (Hamilton, 1822)	VU
8.		*Cirrhinus mrigala* (Hamilton, 1822)	LRnt
9.		*Cyprinus carpio* (Linnaeus, 1758)	NE
10.		*Danio devario* (Hamilton, 1822)	LRnt
11.		*Esomus danricus* (Hamilton, 1822)	LRlc
12.		*Garra mullya* (Sykes, 1839)	NE
13.		*Labeo bata* (Hamilton, 1822)	LRnt
14.		*Labeo calbasu* (Hamilton, 1822)	LRnt
15.		*Labeo rohita* (Hamilton, 1822)	LRnt
16.		*Osteobrama cotio* (Hamilton, 1822)	LRnt
17.		*Puntius sarana* (Hamilton, 1822)	VU
18.		*Puntius conchonius* (Hamilton, 1822)	VU
19.		*Puntius sophore* (Hamilton, 1822)	LRnt
20.		*Puntius ticto* (Hamilton, 1822)	LRnt

NE - Not Evaluated; LRnt - Lower Risk near threatened; LRlc - Lower Risk least concern; VU – Vulnerable; EN - Endangered.

Conti…

Systematic list of fishes and their conservation status of River Arasalar

	Order	Family	Species	Status
21.			*Rasbora daniconius* (Hamilton, 1822)	NE
22.	Cyprinodontiformes	Poeciliidae	*Gambusia offinis* (Baird & Girard, 1853)	NE
23.	Osteoglossiformes		*Notopterus notopterus* (Pallas, 1769)	LRnt
24.	Perciformis	Anabantidae	*Anabas testudineus* (Bloch, 1792)	VU
25.		Chandidae	*Chanda nama* (Hamilton,1822)	NE
26.			*Parambassis ranga* (Hamilton, 1822)	NE
27.		Channidae	*Channa marulius* (Hamilton, 1822)	LRnt
28.			*Channa punctatus* (Bloch, 1793)	LRnt
29.		Gobiidae	*Glossogobius giuris* (Hamilton, 1822)	LRnt
30.	Siluriformes	Bagridae	*Sperata seenghala* (Sykes, 1839)	NE
31.		Siluridae	*Ompok bimaculatus* (Bloch, 1794)	EN
32.		Claridae	*Clarias batrachus* (Linnaeus, 1754)	VU
33.	Symbranchiformes	Synbranchidae	*Monopterus cuchia* (Hamilton, 1822)	LRnt
34.		Mastacembelidae	*Mastacembelus armatus* (Lacapede, 1800)	NE
35.			*Mastacembelus pancalus* (Hamilton, 1822)	NE

NE - Not Evaluated; LRnt - Lower Risk near threatened; LRlc - Lower Risk least concern; VU - Vulnerable; EN – Endangered.

Table 72. Other faunal diversity of river Cauvery and Arasalar in during the period of investigation (2010).

S. No	Fauna	Cauvery river	Arasalar river
	porifera		
1.	*Spongilla*	+	+
	Crustacea		
2.	*Macrobranctrium idella*	+	+
3.	*Macrobranctium malcomsorii*	+	-
	Insecta	+	+
1.	*Chironomous larvae*	+	+
2.	*Dragonfly nymphs*	+	+
3.	*Gerris*	+	-
4.	*Notonecta*	-	+
	Mollusca		
1.	*Bellamya dissimilis*	+	+
2.	*Carbicula*	-	+
3.	*Carbicula striatella*	+	-
4.	*Llamellidans marginalis*	+	+
5.	*Lymnae*	-	+
6.	*Noravuli species*	+	+
7.	*Pila rivrns*	+	-
8.	*Planorbis*	+	+
9	*Thiara species*	+	+
10.	*Unio*	-	-
11.	*Villorite cyprinoids*	+	-
	AMPHIBIA		
1.	*Rana hexatactyla*	+	+
2.	*Rana tigrina*	+	+
	Reptiles		
1.	Tortoise species	+	+
2.	Water snakes	+	+
	Aves		
1.	Common King fisher *(Alcido atthis L.)*	+	+
3.	Crow	+	+
4.	Darter	-	+
5.	Eagle	-	+
6.	Hoopoe	+	-
7.	Little cormorant	+	-
8	Pied kingfisher	+	-
9.	White breasted kingfisher	-	-
	Mammals		
1.	*Lutra vulgaris*	-	-

Table 73. Floral diversity of river Cauvery and Arasalar in during the period of investigation (2010).

S.No	Hydrophytes	Cauvery river	Arasalar river
	Floating plants		
1	*Pistia stratiotes*	+	+
2	*Azolla pinnata*	+	+
3	*Eicchornia crassipes*	+	++
4	*Lemna minor*	+	-
5	*Lemna polyrhiza*	+	+
	Emergent plants		
1	*Otellia alismoides*	+	-
2	*Vallisneria spiralis*	++	+
3	*Nymphaea*	-	
4	*Trapa*	+	+
5	*Myriophyllum*	+	-
	Submerged plants		
1	*Hydrilla*	++	+
2	*Najas*	-	+
3	*Ceratophyllum*	+	-
4	*Utricularia*	+	++
	Marginal plants		
1	*Marsilia quadrifolica*	+	-
2	*Impomoea aquatica*	-	+
3	*Jussiala repens*	+	+
4	*Limnathamcem oristatum*	+	-

+ = present; - = apsent; ++ = abundant

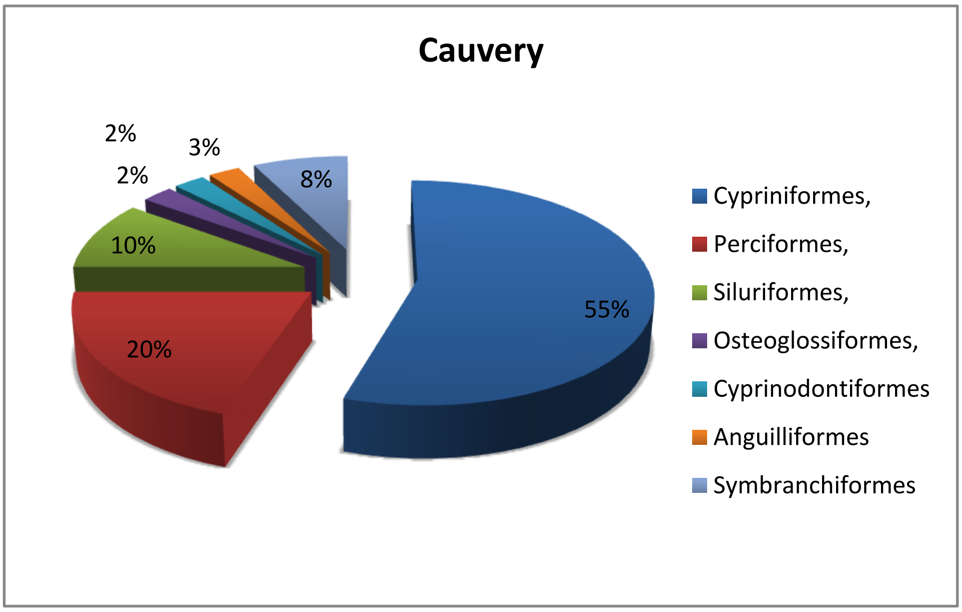


Figure 27. Percentage composition of fish population in river Cauvery.

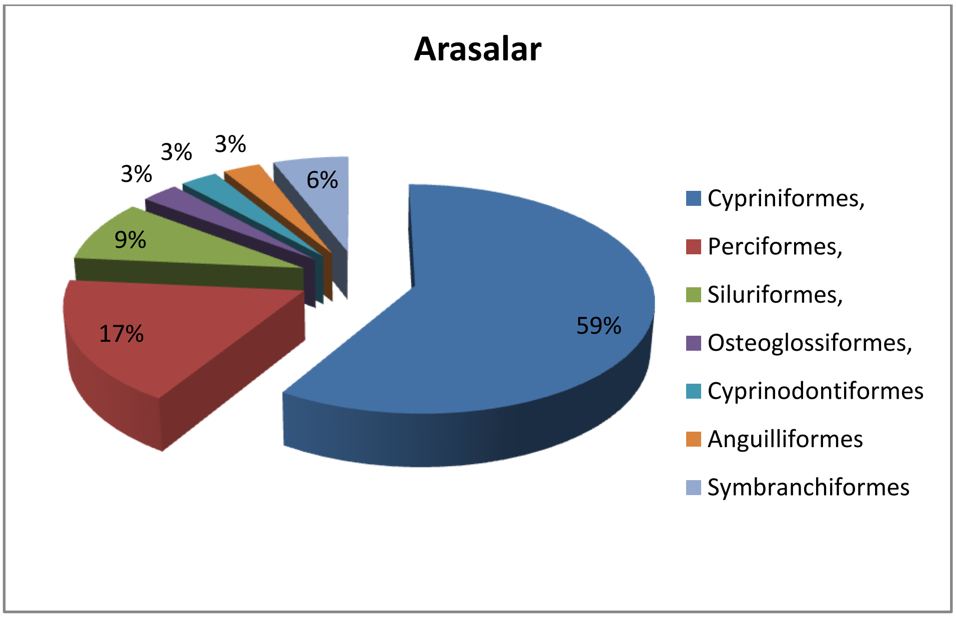


Figure 28. Percentage composition of fish population in river Arasalar.

Cyprinidae was found to be the dominant family constituting 50% of the total species observed. In the present observation, species such as *Cirrhinus mrigala, Catla catla, Labeo bata, Labeo calbasu, Labeo rohita, Cyprinus carpio, Sperata seenghala, Channa marulius, Channa punctatus, Channa striatus, Channa gachua, Clarias batrachus and Mastacembelus armatus* were of commercial value.

The Cauvery River had seven species of hydrophytes that include *Ottelia alismoides, Vallisneria spiralis, Nymphaea, Trapa, Myriophyllum,* (Emergent plants) *Hydrilla* (Submerged plants) *verticellata, Nelumbium* sp., *Chara* sp., *Comeelina* sp., *Cyperus* sp. and *Typha* sp. Similarly Arasalar River had similar flora viz. *Impomea* sp., *Cyprus* sp., *Eichornia, Salivinia, Hydrilla, Azolla, Jatropa* (Marginal plant), *Saccharum, Pistia, Marsilea quandrifolia*; *Eichorinia* was found to cover most of the surface area of the sakkottai during most of the times of the study period.

The invertebrate macro fauna consisted of aquatic insects such as Notenecta glauca, Rhagovelia sp., golden-ringed dragon fly, Cordule gaster sp., beetles like Orectochilus discifer (Whirligig beetles) and Aphelocherius sp., and Arachnids such as Argyroneta aquatica (water spider). Crustaceans represented by *Crab Macrobrachiurn idella, and Macrobranctium malcomsorii* were also found in the river Cauvery. A molluscan fauna represented by *Bellamya dissimilis, Carbicula Carbicula, striatella Lamellidans marginalis, Lymnae Noravuli species, Pila rivrns, Planorbis* and a species of frog *Rana tigrina* and *Rana hexatactyla* (adults and tadpoles) were also found in this river.

The macro fauna of Arasalar River consisted of Insects such as *Notonecta glauca. Rhagovelra sp., Laccotrephes maculatus, Ranatra elongata Gerris, Dragonfly nymphs, Chironomous larvae,* and Odonatan nymph. Crustaceans such as a *potomon crab, Macrobrachium canarae M.rosenbergis*

M.idella, a gastropod such as *Viviparus bengalensis*, bivalves such as *Lamellidens sp*. and a frog *Rana trigrina* and *Rana hexatactyla*.

6.4 DISCUSSION

The freshwater aquatic biodiversity in rivers depend on a number of variables: timing, duration, frequency, amplitude of flows and floods; temperature, nutrient content, concentration of various pollutants and dissolved gases and turbidity of the water in motion; flow pattern, chemistry, quantity and content of sediments; the physical condition, composition of the river bed, plant, animal, fish, insect biodiversity in the water and floodplains (WCD, 2000), to name only a few. All of these variables are adversely impacted when a dam, diversion or hydropower project is constructed on the river. In turn, these impacts affect the downstream livelihoods in a major way. This has been well documented by a large number of studies including by the World Commission on Dams, Food and Agriculture Organization and India's Central Inland Fisheries Research Institute.

Maintenance of a healthy aquatic ecosystem depends on the physico-chemical properties as well as biological characteristics. Physico-chemical factors of water not only affect the distribution patterns and abundances of species; they also play an important part in species richness (the number of species in any given location). Temperature is one of the most important physical parameters, which controls the physiological activities and distribution of biota. Rivers, water resources and aquatic biodiversity are intimately interrelated and interdependent. It is generally understood that water quality and habitat quality affect the composition, diversity and therefore health of aquatic ecosystems (Revenga et al. 2000).

Fish is the predominant community in freshwater ecosystem and it is a major product of aquatic ecosystem. Sandhya Jadhav and Bramhadev Bhosale

(1996) reported 12 species of fishes in the Bhima River. Vishwanath and Co workers (1998) observed 117 families from Manipur. Athayle and his Coworkers (2001) reported that crustacean constituted 11 % and fin fishes constituted 89 % in the Thane creek. Freshwater fish and decapod crustacean (crabs, freshwater shrimp or prawns) faunas are highly diverse and reflect our favourable geographical position as continental islands close to mainland sources of biodiversity. True freshwater fish diversity is estimated between 37 to 40 species (Phillip 1998).

According to the Cauvery River project report 267 species of fishes are found in the entire Cauvery river system out of which 72 per cent (206 species) belongs to estuarine zone. In the present investigation, 40 species of fishes were recorded from the kumbakonam region and this indicates lesser diversity of fishes in the delta zone of the river of Cauvery diversity of ichthyofauna decrease nowadays owing to the emergence of culture of carps which replace the indigenous fishes. This observation indicates that Cypriniformes order is the most dominating of all other seven important orders. There are 22 species which were common to all the three sampling stations and hence can be considered as migratory ichthyofauna.

In the river Cauvery 40 species of fish were identified. Cypriniformes species was dominant (55%), followed by Perciformes (20 %), Siluriformes (10 %), Synbranchiformes (8 %), Anguilliformes, (3 %), Osteoglossiformes (2 %), and Cyprinodontiformes (2 %). Similarly, in the river Arasalar 35 species of fish were identified. Cypriniformes species was dominant (59%), followed by Perciformes (17 %), Siluriformes (9%), Synbranchiformes (6%), Anguilliformes (3 %), Osteoglossiformes (3 %), and Cyprinodontiformes (3 %).

Some abiotic parameters known to influence the distribution of macroinvertebrates in streams, including substrate heterogeneity and current velocity (Hawkins et al, 1982). Cauvery River, the substracturn is often sand or mud which often support relatively low densities of macro invertebrats. Similar observations were made by Humphries et al (1998) in Australian lowland rivers. The highest densities of macro invertebrates are usually associated with microhabitats and macrophytes both of which are difficult and time consuming to sample quantitatively.

Certain groups of macro invertebrate fauna increased in number from upstream to downstream and certain other groups showed a decreasing trend. During the present study insect fauna showed decreasing trend from upstream to downstream but in the case of molluscans and prawns their number and species increased from upstream to downstream in Arasalar. Similar observations were made by Elzbieta Dumnicka (1996) in the study of River Raba. Although there was a distinct head water fauna in the Cauvery River, a sequential down stream change in species composition was observed down the whole length of the river with one species being replaced by another. This view agrees with the study of Carolyn C.Palmer (1996) in Buffalo River, South Africa.

Macro invertebrate communities decreased in number during wet season. The reduction in macro invertebrate densisty during the rainy season is attributable to the increased discharge and water turbulance and reduced food availability. Similar observations made by Anthony and Akpnand Donald. Anadu (1994) in their study of macro invertebrate fauna in the river Delimi, Jos (Nigeria). Insects and molluscans were found along the entire stretch of the river. Ramanujan (1984) also made a similar observation in his study of Kallar River.

In Arasalar River, macro invertebrate fauna was comparatively low compared to the other stations because of anthropogenic disturbances such as sand mining. Rosser & Pearson (1995) found a decline in macroinvertebrate densities with increasedd isturbance of the sediment surfaces. Riverbed mining was particularly evident in Cauvery and resulted in severe disruption of these rivers which serve as a source of construction aggregate.

Macro fauna, especially insects was abundant in Cauvery River. Where pools and large quantity of woody debris were found. Hurnphries (1998) observed that the highest densities of macro invertebrates are usually associated with microhabitats such as large woody debris (snags) and macrophytes. In Cauvery and Arasalar River crustaceans were the dominant forms. Prawns occupy the prime position in these Rivers.

Impairment of faunal communities is expressed as increased abundance and biomass when moderate nutrient enrichment occurs (Turner 2002), but decreased species richness under extreme conditions of eutrophication, organic (sewage, livestock and food wastes) or toxic (industry and oil) pollution. Since some freshwater fish and shrimp have migratory life cycles, pollution at any point on a water course can affect populations throughout that river system. This is evident in the highly polluted Caroni River where upstream communities no longer include mountain mullet or freshwater shrimp as they did in the past.

However, the increasing anthropogenic pressures on the rivers have adversely affected the fish production potentialities and they no longer support the rich biotic wealth. Extensive use of pesticides in agriculture not only kills the pests, but also adversely affects diversity of useful insects and birds. The agricultural runoff which flows into the rivers adds to river pollution. Release of untreated industrial and domestic waste into the rivers of the region is leading to a high level of water pollution.

Anthropogenic activities have brought about major changes of riverine ecosystem and consequently there have been a steady deterioration in qualitative as well as quantitative abundance of inland fishery wealth. Conservation of rivers is essential because fishes are the common protein food for the riparian people more over the maintenance of normal food web pattern. Economic potential of the ornamental fishes can be exploited; conservation is necessary. The studies reported here form the basis of a network for development of a future monitoring system for both water resources and aquatic biodiversity assessment which can be implemented by the regulatory agencies in collaboration with academic researchers.

Water resources and aquatic biodiversity are intimately interrelated and interdependent. Both provide a wide range of functions and have intrinsic value as well as provide for the sustenance of human populations. Degradation of water quality, depletion of water resources and loss of aquatic biodiversity are prominent features of the environmental landscape requiring urgent attention at global and national scales.

7. SUMMARY AND CONCLUSIONS

Water quality deterioration precedes environmental degradation. Prevention of water pollution and sustained conservation strategies for surface water bodies are inevitable to overcome various economical and ecological losses. The question of protecting and preserving surface water bodies such as rivers is a critical issue in a developing country like India as there is a great demand for quality of water for multiple uses. It is long established that the increased population, rapid industrialization, fast urbanization and modern agricultural practices (use of chemical fertilizers and biocides) are the four major environmental problems endangering the surface water bodies all over the world. As a consequence of this, the water bodies have been put under severe ecological stress and are being threatened. This is due to dumping of solid and liquid wastes into the river ecosystem. It is very much true in case of the river Cauvery, one of the perennial rivers of the Peninsular India. With this background, the present work was undertaken to study the physico-chemical and biological characteristics, pertaining to their nature, quantity, composition and variations.

Three sampling stations were selected for river Cauvery such as station 1. Melakaveri (upstream of the river) station 2. Palakarai (midstream of the river) and station 3. Manancherry (downstream of the river) and similarly for river Arasalar such as station 1. Women's College Bridge (upstream of the river) 2. Patthadi palam (midstream of the river) and station 3. Sakkottai (downstream of the river) for sampling purpose. The water samples were collected from six stations on monthly basis using a standard water sampler for a period of one year (from Jan 2010 to Dec 2010).

The physico-chemical composition of the water and sediment at all the six stations has been analyzed by following the established procedures. The inter-relationship among the various physico-chemical components in the river has been evaluated. The occurrence and distribution of the planktons have been recorded at all the stations. One time investigation on aquatic mycoflora, aquatic zooplankton, fishes and macrophytic vegetation has been carried out and the results are documented.

Studies on physico-chemical parameters clearly indicate that there was a seasonal variation in both atmospheric and water temperature. The result showed that there was no significant difference in the air and water temperature between the two rivers. In the river Arasalar the transparency was found more when compare to the river Cauvery. The value of electrical conductivity was greatest in the river Arasalar due to more concentration of the TDS. The reason for decrease in the values of the electrical conductivity of the river Cauvery was due to poor irrigation management, minerals from rain water runoff and other discharges.

In the present study the value of total solids (suspended solids and dissolved solids) was ranging from 370 mg/l to 680 mg/l in Cauvery and 480 mg/l to 780 mg/l in Arasalar. The total dissolved solids values in the river Arasalar exceed the maximum permissible limits of WHO (600 mg/l). River Cauvery show a lower TDS value than Arasalar. The reason for the minimum total solids in the river Cauvery due to the dilution of the sewage and effluents, and also the water flow is more when compare to the river Arasalar. The pH of the river water showed alkaline range throughout the study period. The values of free carbon dioxide were inversely proportional to dissolved oxygen at the sampling station. The total alkalinity showed a marked seasonal variation. The values are high during winter and low during monsoon.

Concentrations of dissolved oxygen in unpolluted waters are usually about 8-10 mg/l. In the present study dissolved oxygen level ranges between 4.3(mg/l) to 7.8 mg/l in the river Cauvery and 5.1 (mg/l) to 7.7 (mg/l) in the river Arasalar. The high value of BOD encountered in both rivers, above the permissible limit of WHO (<2 mg/l), indicates the pollution by biochemically degradable organic wastes from various sources. Nevertheless, BOD values are found to be high as compared to the ISI and WHO limits indicating the fact that the river water is slightly polluted. COD values varied from 0.5 mg/1 to 52 mg/1. On a general consideration the values recorded are very low indicating that the water is less polluted.

In the present study, value of total hardness ranged from 300-778 mg/l in the river Cauvery and 1.3 to 3.6 in the river Arasalar. Downstream station showed higher hardness when compared to upstream stations. The calcium and magnesium concentration in the present study was found to be well within the permissible limits of WHO. Calcium and magnesium do not show inverse relationship but they go hand in hand. Nevertheless, concentration of calcium was always higher than magnesium. Chlorides were present in higher concentrations during summer and their concentrations were reduced in monsoon. Anthropogenic activities appear to influence the concentration of chlorides. The concentration of sodium is found to be higher than potassium. The sodium and potassium values lie within the safe range of WHO limit of 200 and 12 ppm respectively and is suitable for irrigation and domestic purposes.

The concentrations of ammonia in the Cauvery River for the duration of the study were not alarming due to low anthropogenic activities reaching the river. The sodium and potassium values lie within the safe range of WHO limit of 200 and 12 ppm respectively and is suitable for irrigation and domestic purposes. Nitrite levels were higher than 1 mg/L during the present study. This increase of nitrite indicates the river receives very rich amount of organic matter. In the present study the nitrate content is found to be above the permissible limit (45 mg/l). The WHO safe limit for nitrate for life time use is 10 mg/L as N (WHO, 1984). This limit was exceeded in the river water; thus, nitrate is not considered to pose a problem for the domestic use of water from the river. Phosphates occurred as sub-optimum element which was subjected to variation. Nevertheless, a maximum of 2.2 mg/ of phosphate were observed at Arasalar. The high concentration of phosphate is, therefore, indicative of pollution. The mean concentration of sulphate was found in the range of 11.8 mg/L to 14.2 mg/L in river Cauvery and 33.93 to 132 mg/l in river Arasalar which is within the range of prescribed drinking water standards (200 mg/l). The occurrence of silicate was fairly detectable in all the stations of the river stretch studied; it varied between 2.7mg/L and 7.8mg/L in river Cauvery and 9.1mg/L and 41.2mg/L in river Arasalar. It was high during summer and low during rainy season. In the current study, the iron concentration in the river Arasalar varying from 0.22-1.48 mg/l which is slightly below the permissible limit set by WHO (1993).

The result of physicochemical analyses carried out on the soil sediment samples collected from the selected rivers within the studied area showed various concentrations of the parameters studied. The sediment-associated parameters considered in the present study were pH, Conductivity, Moisture, Alkalinity TA, Carbonates, Bicarbonates, Phosphorus, Sulfate, Chloride, Calcium Magnesium, Nitrogen, Organic carbon and Organic matter of the river Cauvery and its tributary Arasalar. In the river Cauvery, sediment physico-chemical parameters such as pH (7.4-8.5), Conductivity (560-820), Moisture (25.7-39.88), Alkalinity TA (1.2-2.4), Bicarbonates (35.7-170.8), Phosphorus (0.005-0211), Sulfate (0.3199-0.943) Chloride (7.1-21.2) Calcium (49.2-217.22) Magnesium (36.56-164.45) Nitrogen (0.05-4.89) Organic carbon (0.128-2.257) and Organic matter (0.221-3.892) were determined variation between the samples collected from different stations during different seasons was also recorded. Statistical analysis revealed that there is no significant correlation between the physico-chemical parameters of sediment sample. The representative soil sediment samples collected from the

Cauvery and Arasalar sub-basin subjected to physico-chemical analysis revealed that the soil is alkaline and high organic content. The presence of high levels of TOM and TOC indicate organic pollution in the river Arasalar. Therefore, environmental surveillance of these parts of the area is advocated.

In the present study, the distribution and abundance of phytoplankton and zooplankton were season dependent. The phytoplankton propagated more rapidly owing to its short turn over period whereas zooplankton was simple in composition and distribution. In the river Cauvery 45 species of zooplankton were identified. Rotifera species was dominant (34.97%); followed by Cladocera (29.92%), Copepoda (18.27%), Protozoa (12.2%) and Ostracoda (8.72%). Throughout the study, six species of Protozoa, 13 species of Rotifera, 12 species of Cladocera, 11 species of Copepoda and two species of Ostacoda were identified in the river Cauvery. Similarly, in the river Arasalar 38 species of zooplankton were identified. Rotifera species was dominant (37.87%); followed by Cladocera (26.32%), Copepoda (19.74%), Protozoa (9.17%) and Ostracoda (6.43%). During the study period, 5 species of Protozoa, 12 species of Rotifera, 11 species of Cladocera, 9 species of Copepoda and one species of Ostacoda were identified in the river Arasalar. The percentage of total annual phytoplankton of the river Cauvery consisted of 33.82% Chlorophyceae (Green algae), 27.94% Bacillariophyceae (Diatoms), 32.35% Cyanophyceae (Blue green algae), and 5.88% of Euglenophyceae. Annual averages revealed that Chlorophyceae were the dominant group. The percentage of total annual phytoplankton of the river Arasalar consisted of 34.92% Cyanophyceae (Blue green algae), 28.57% Bacillariophyceae (Diatoms) 31.74%, Chlorophyceae (Green algae), and 4.76% of Euglenophyceae. Annual averages revealed that Cyanophyceae were the most dominant group in this river.

In respect of Ichthyofauna diversity, a total of forty species belonging to seven orders and fourteen families were identified in the River Cauvery.

Among the 40 species, 22 species were found under the order Cypriniformes, 8 species were found under the order Perciformes, 4 species were found under the order Siluriformes, three species were found under the order Synbranchiformes and a single species was found under the order Osteoglossiformes, Anguilliformes, Beloniformes and Tetraodontiformes each. In respect of Ichthyofauna diversity, a total of 35 belonging to seven orders and fourteen families were identified in the River Arasalar. In the present observation, species such as *Cirrhinus mrigala, Catla catla, Labeo bata*, *Labeo calbasu*, *Labeo rohita*, *Cyprinus carpio, Sperata seenghala, Channa marulius*, *Channa punctatus*, *Channa striatus*, *Channa gachua, Clarias batrachus and Mastacembelus armatus* were of commercial value.

CONCLUSIONS

The results indicated that most of the physico-chemical quality parameters of River Cauvery were within the WHO limits for drinking water and, therefore, may be suitable for domestic purposes. In contrast, however, nutrient levels were low during the study period and did not give any clear seasonal variation. Even though the nutrient concentrations were low, care must be taken by the inhabitants. Water quality assessment of delta regions of Cauvery River revealed slightly contamination from anthropogenic activities. Since Cauvery River is predominantly monsoon fed, the physicochemical characteristics changes according to the flow intensity.

In river Arasalar, the sampling stations recorded comparatively higher pollutants such as total solids and BOD whereas in the river Cauvery the sampling stations recorded comparatively less pollutants such as BOD. BOD values were not compiling with WHO guide lines in the River Cauvery and total solids and BOD values were not compiling with WHO guide lines in the River Arasalar.

The presence of high levels of sediment organic carbon and organic matter indicate organic pollution in the river Cauvery and Arasalar. Therefore, environmental surveillance of these parts of the area is advocated.

Research focusing on river plankton has clear management implications. Abundances and processes of plauktonic organisms at the base level of river food webs have effects on water quality parameters as well as higher trophic levels. Results indicating which environmental factors may regulate planktonic development in rivers are important to organization involved in the maintenance of a high level of river water quality.

Higher nutrient concentrations may be utilized to increase the phytoplankton and zooplankton productivity in rivers. This planktonic production may be a food source directly available to fish. Alternatively, high autotrophic and heterotrophic plankton production may support high levels of benthic secondary production, which in turn may be a major food source for fishes. Therefore, either directly or indirectly, planktonic abundances and processes in rivers may have management implications for fisheries production.

Water resources and aquatic biodiversity are intimately interrelated and interdependent. Both provide a wide range of functions and have intrinsic value as well as provide for the sustenance of human populations. Degradation of water quality, depletion of water resources and loss of aquatic biodiversity are prominent features of the environmental landscape requiring urgent attention at global and national scales.

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