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Seasonal patterns and behaviour of water quality parameters of Achenkovil River

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Abstract
The Achenkovil River, a freshwater perennial lotic system of the southern Western Ghats. As a part of the investigation, three stations were selected for the study for water quality analysis of the river. pH in all stations was recorded as acidic and also parameters such as turbidity, free carbon dioxide, salinity, dissolved oxygen, primary productivity, biological oxygen demand and total dissolved solids showed variations with seasons. Station 2 exhibited a highly acidic state compared to others. Station 1 has low concentration of dissolved oxygen in pre-monsoon with a range of 1.84mg/l. Gross productivity was high in station 3 and Station 1 has high net productivity. Turbidity has a maximum range in station 1 on pre-monsoon season of 698 NTU (Nephelometric Turbidity Unit) and a minimum range of 560 NTU in station 2. Maximum salinity was observed in the pre-monsoon in station 2 of nearly 102.40mg/l. This study gives an idea on the degrading water quality of Achenkovil River and immediate protection of the water body is necessary.

Keywords: Dissolved oxygen, turbidity, carbon dioxide, net productivity, NTU (Nephelometric Turbidity Unit)

1. Introduction
Water is one of the most important and basic natural resource which is found around 75% in the earth's crust. Presently water has become a precious commodity because of human induced development activities and its quality is threatened due to pollution. Analysis of water quality and monitoring for physico-chemical parameters are essential to preserve and protect the natural ecosystem. The study of different water quality parameters help in understanding the metabolic events of the aquatic system. Certain parameters such as Turbidity, pH, Temperature, Hardness, Total dissolved solids, Free CO_2, Dissolved O_2, Primary productivity, Biological oxygen demand, Salinity are necessary for the understanding of flora and fauna abundance and distribution with time. The Achenkovil, a river in Kerala, India, created towards the southern tip of the peninsula by the confluence of the Rishimala, Pasukidamettu, and Ramakkalteri rivers (Sanal Kumar *et al*, 2014) [11]. The Achenkovil enriches the Pathanamthitta district of Kerala state. It joins with the Pampa River at Veeyapuram, in the Alappuzha district of Kerala. Achenkovil is also the name of the forest area, which is the catchment area for this river, and of a small town situated in the Achenkovil forest area.
Water quality of aquatic body is determined by many physical, chemical and biological characteristics (Sargaonkar & Deshpande, 2003) [12]. 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 water quality management for the beneficial uses, analysis of physic-chemical parameters is needed.
Out of many freshwater sources, rivers are the lifelines of our culture and economy and severe water pollution is increasingly making them dead. Pollution of a river first affects its chemical quality and then systematically destroys the community disrupting the delicate food web. 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% of the waste water. Industrial waste water comprised 8 to 16%. (WHO, 2003) [14]. 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. The domestic sewage discharged from a population of about 2 million gives rise to numerous water-borne diseases like typhoid, cholera, dysentery,

poliomyelitis and cysticercosis, thereby affecting the human health and deterioration of the water quality (Dhirendra *et al*; 2009) [4].

The present study deals with the assessment of water quality of Achenkovil River. Water samples were collected from three different sites of Achenkovil River. These three regions are facing high degree of anthropogenic activities and also rich in flora and fauna. The regions selected for study are Mudiyoorkonam, Shargakavu temple and Thottakonam. The present investigation will create a conscientization among the common people regarding the need for conservation of this biodiversity rich area that forms a branch of the holy pilgrim Pamba River.

2. Materials and Methods

Water samples were collected during the year 2016 from the study area and the physico-chemical parameters were analyzed with respect to the seasons following standard methods of APHA (1998) [1]. The three selected sites were Station 1 (Mudiyoorkonam), Station 2 (Shargakavu temple) and Station 3 (Thottakonam). Fishes were collected and identification of the fish fauna in the study area was carried out by following the methods adopted by Day (1994) [2] and Jayaram (1999) [7].

2.1 Photographs showing the study stations in Achenkovil River

Station 1 **Station 2** **Station 3**

3. Results

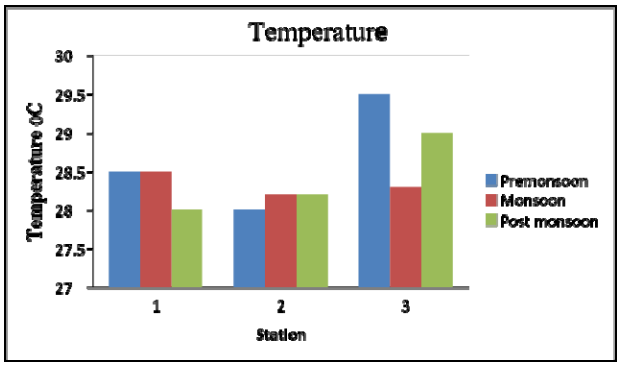
The study of three stations of Achenkovil River, Station 1 (Mudiyoorkonam), Station 2 (Shargakavu temple), Thottakonam (Station 3) of Pre-monsoon, Monsoon, Post-monsoon were analysed and compared. The physico-chemical parameters of each station showed difference in each seasons. Based on it, the temperature in station 3 has maximum temper of 29 ^{0}C and minimum range was 28 ^{0}C. All these stations show an average temperature of 28.3 ^{0}C-28.6 ^{0}C in all seasons. There was only slight variations in temperature in pre-monsoon, monsoon and post monsoon seasons (Table 1, Fig 1). pH range was acidic in nature in all stations in all seasons. From the study, station 2 was highly acidic with a range of 5.92 in pre monsoon period and station 1 showed maximum range of acidic pH of 5.83 and 5.92 during monsoon season and post-monsoon season (Table 1, Fig 2). Dissolved oxygen was found to be 1.8mg/L in minimum range in Station 1 and maximum range in Station 2 of 12.32mg/l during pre-monsoon season. During monsoon season, station 3 has maximum range of dissolved oxygen i.e. 9.04mg/l and minimum range in station 2 of 7.28mg/l on monsoon season. Station 3 has maximum range of 4 mg/L dissolved oxygen and minimum range of 3.04 in station 1 in post–monsoon seasons. Dissolved oxygen has high concentration in premonsoon with an average value of 8.63mg/l and minimum range in post-monsoon season of 3.62mg/l (Table 1, Fig 3). Maximum range of net primary productivity and gross primary productivity was recorded in station 2 of 0.6mg C/l/hr and 2.73mgC/l/hr and a minimum range of net and gross primary productivity was seen in station 1 on pre-monsoon season. Maximum range was shown in net primary productivity and gross primary productivity in station 3 and minimum in station 2 with a range of 0.05 and 0.13mgC/l/hr. on monsoon season. Maximum range of net primary productivity and gross primary productivity was shown in station 3 with a range of 2.28mgC/l/hr. and 3.88 mg C/l/hr. The average net primary productivity and gross primary productivity was maximum in post monsoon season and minimum in monsoon season (Table 1, Fig 4 and 5).

Free carbon dioxide value was high in station 1 with a range of 9.68ppm and low range in station 2 of pre-monsoon season. The maximum range and minimum range of CO_2 was shown by the station 1 and station 2 of 13.2ppm and 6.16ppm on monsoon season and in post monsoon maximum range was shown in station 2 and minimum in station 3. The overall concentration of free carbon dioxide was maximum in monsoon season and minimum in post monsoon season (Table 1, Fig 6). The Biological Oxygen Demand was maximum in station 1 i.e. 7.09 mg/l and minimum in station 3. In pre-monsoon season the maximum and minimum range of biological oxygen demand was shown in station 3 i.e.3.44mg/l and 0.4mg/l in monsoon the maximum and minimum range in post monsoon period was 7.84mg/l in station 1 and 4.48mg/l. The overall Biological oxygen demand was maximum in 4.48mg/l in post monsoon season and minimum in 2.72 mg/l in pre-monsoon season (Table 1, Fig 7). The Maximum and minimum range of turbidity was seen in pre-monsoon season was seen on station 1 i.e.698 NTU and 557 NTU minimum in station 3. The Maximum and minimum range of turbidity was seen station 2 and station 3 in monsoon season (Table 1, Fig 8). The Maximum and minimum range of turbidity in post monsoon was at station 3 and station 2. The overall range of turbidity was maximum in 4.48mg/l in post monsoon season and minimum in 2.72mg/l in pre-monsoon season. The Maximum and minimum range of hardness was seen in pre-monsoon season was seen on station 1 i.e. 18mg/l and minimum in station 3. The Maximum and minimum range of hardness was seen station 2.i.e.36mg/l and station 1 in monsoon season. The Maximum and minimum range of hardness in post monsoon was at station 2 and station 2. The overall range of hardness was maximum in station 2 of monsoon season with 15.33mg/l and minimum in 10.5mg/l in pre-monsoon season. The Maximum and minimum range of Total dissolved solids was seen in pre-

monsoon season was recorded on station 1 of value 5.2mg/l and minimum in station 2 of value 0.2 mg/l. The Maximum and minimum range of Total dissolved solids was seen station 3 of value 1.40mg/l and station 1 of value 1mg/l in monsoon season. The Maximum and minimum range of total dissolved solids in post monsoon was at station 1 with a value of 0.8 mg/l and station3 with a value of 0.4mg/l. The overall range of total dissolved solids was maximum in pre-monsoon season with 2.4 mg/l and 0.8mg/l minimum in monsoon and post-monsoon season. The salinity showed a maximum and minimum range of salinity was seen in pre-monsoon season was seen on station 2 of value 102.4mg/l and minimum in station 3 of value 53.17mg/l. The Maximum and minimum range of salinity was seen in station 3 of value 140mg/l and station 2 of value 115.2mg/l in monsoon season. The Maximum and minimum range of salinity in post monsoon was at station 2 with a value of 134.4mg/l and station3 with a value of 102.4mg/l. The overall range of salinity was maximum in post-monsoon season with 128.0mg/l in monsoon season and minimum in pre- monsoon season. Collected fishes were identified to be *Systomus sarana, Pristolepis marginata, Parambassis thomassi, Puntius filamentosis, Heteropneustes fossilis, Hyporhamphus limbatus, Nandus nandus, Puntius amphibious, Mystus malabaricus, Etroplus malabaricus* etc.

Table 1: Seasonal Variations of Physico-Chemical Parameters

Sl. no	Parameters	Season	Station 1	Station 2	Station 3	Average	Std. deviation
1	Temperature (^{0}C)	Pre monsoon	28.5	28	29.5	28.667	0.76
		Monsoon	28.5	28.2	28.3	28.333	0.152
		Post monsoon	28	28.2	29	28.4	0.52915
2	pH	Pre monsoon	6.25	5.35	6.43	6.01	8.73
		Monsoon	5.83	6.59	6.73	6.38	8.25
		Post monsoon	5.92	6.30	6.60	6.273	3.62
3	Dissolved oxygen(mg/l)	Pre monsoon	1.84	12.32	12.16	8.733	6.0049
		Monsoon	8.43	7.28	9.04	8.25	0.89
		Post monsoon	4.04	4	3	3.68	0.58
4	Primary productivity Gross productivity (mgC/l/hr)	Pre monsoon	0.950	2.73	2.125	1.935	0.90
		Monsoon	0.478	0.13	1.145	0.584	0.515
		Post monsoon	3.11	1.69	3.88	2.893	1.110961
	Net primary productivity (mgC/l/hr)	Pre monsoon	0.508	0.6	0.375	0.494333	0.113121
		Monsoon	0.158	0.053	0.025	0.078667	0.070117
		Post monsoon	1.72	1.16	2.28	1.72	0.56
5	Free carbon dioxide (mg/l)	Pre monsoon	9.68	4.4	5.28	6.453333	2.828804
		Monsoon	13.2	6.16	9.68	9.68	3.52
		Post monsoon	7.04	7.92	3.52	6.16	2.328261
6	Biological oxygen demand(mg/l)	Pre monsoon	7.90	3.52	2.72	4.713333	2.788572
		Monsoon	.8	0.4	3.44	1.546667	1.651827
		Post monsoon	3.44	4	4.84	4.093	0.704651
7	Turbidity (NTU)	Pre monsoon	698	560	557	605	80.55433
		Monsoon	533	561	524	539.3333	19.29594
		Post monsoon	899	672	908	826.3333	133.7323
8	Hardness (mg/l)	Pre monsoon	18	14	12	14.66667	3.05505
		Monsoon	6	36	4	15.33333	17.92577
		Post monsoon	3	18	2	10.5	8.962886
9	Total dissolved solids (Mg/l)	Pre monsoon	5.2	0.2	1.8	2.4	2.553429
		Monsoon	1	0.2	1.40	0.8	0.611010093
		Post monsoon	.8	0.6	0.4	0.866667	0.61101
10	Salinity (mg/l)	Pre monsoon	89.61	102.4	53.17	81.72667	25.54424
		Monsoon	128.04	115.20	140.8	128.0133	12.80002
		Post monsoon	128.0	134.4	102.4	121.6	16.93281



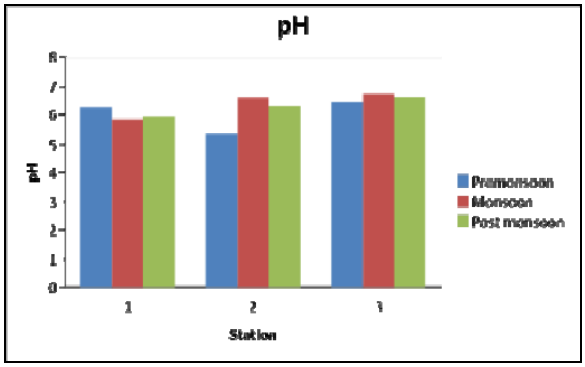


Fig 1 and 2: Graph showing the seasonal variations of temperature and pH.

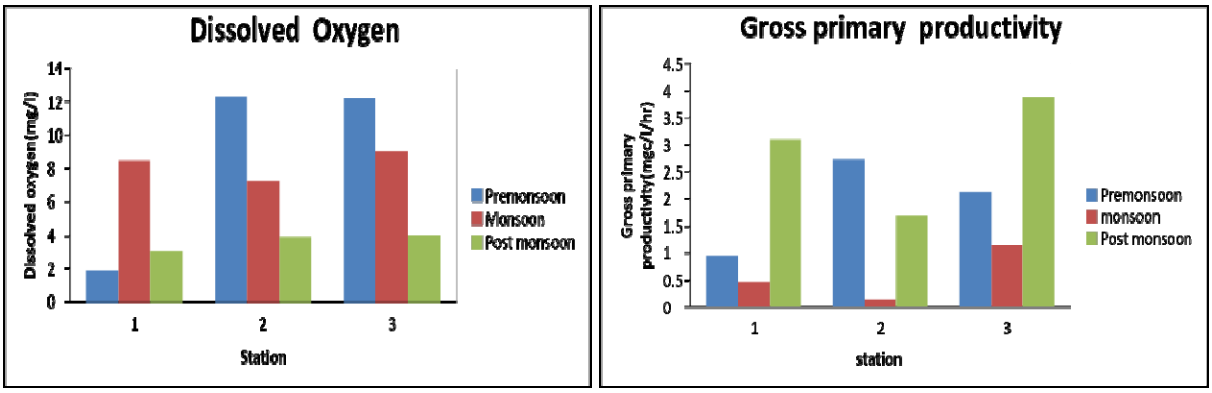


Fig 3 and 4: Graph showing the seasonal variations of Dissolved oxygen and Gross productivity.

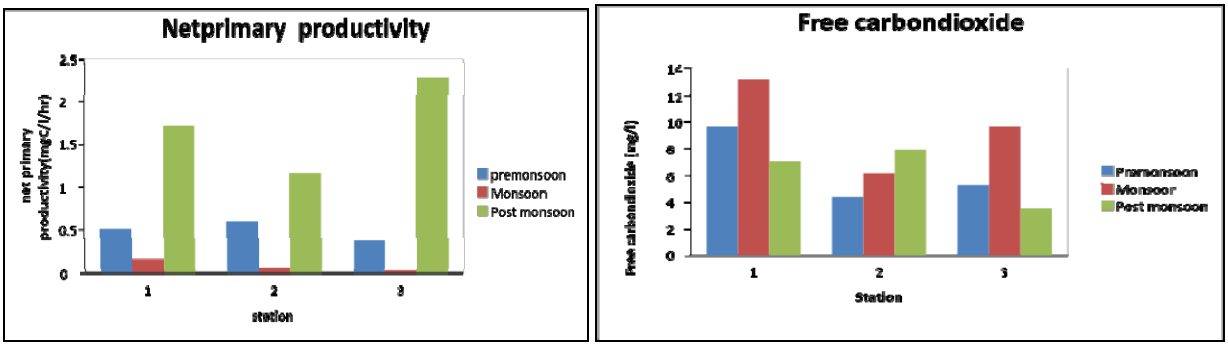


Fig 5 and 6: Graph showing showing the seasonal variations of net primary productivity and free carbon dioxide.

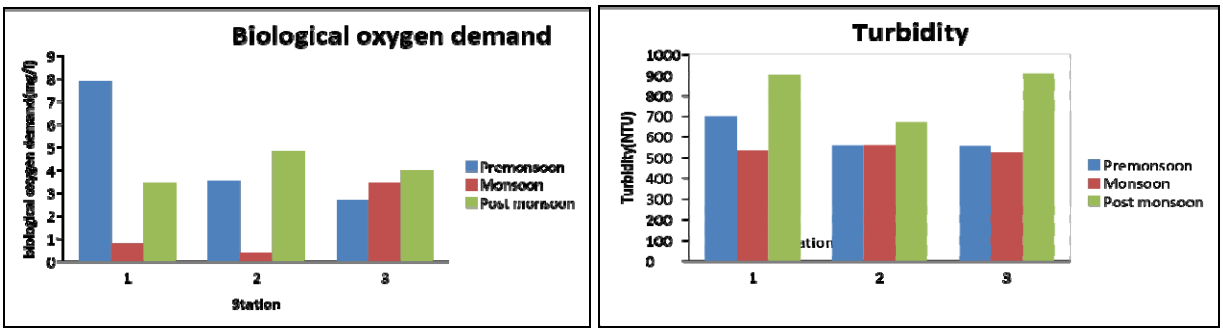


Fig 7 and 8: Graph showing the seasonal variations of Biological oxygen demand and turbidity.

4. Discussion

Temperature plays a vital role in physical, chemical and biological properties of water and has direct influence on aquatic biota. Effects of changes in temperature would adversely affect the water quality. Many physiological factors depend on the temperature, pH, productivity, solubility of gases like Carbon dioxide, Dissolved oxygen etc. will be adversely affected. In the present study in all stations, temperature has no specific seasonal variation. The range of temperature in station has a range of between 28.5 ^{0}C-28 ^{0}C and that of station 2 has range of temperature between 28 ^{0}C-28.2 ^{0}C and station 3 has a range of temperature between 29.5 ^{0}C (Fig 1). Minimum temperature was recorded at two seasons of Pallickal river due to the presence of rich vegetation which can reduce the water temperature (Sanalkumar, 2014) [11]. pH is one of the physical property of water. A slight change in pH can change the acidity or basicity of the water. Normal pH range of the water should be between 6.2-8.5 according to the WHO (2003) [14] standard limits. In the present study, station 1 and station 3 has the value of 6.25 and 6.43.But station 2 was highly acidic i.e. 5.35. (Fig 2) pH become low in the winter and high in summer due to the metabolic activity of autotrophs. Acidic pH affects the photosynthetic activity (Zahid *et al*., 2016) [15]. Based on the studies of Karamana river, (Sujitha *et al*., 2012) [13] mentioned that Karamana river has acidic pH. This is due to the high organic content will tend to decrease the pH. Most metals will become more soluble in acidic pH which negatively affect the health of the organism.

Dissolved oxygen was an important limn logical parameter indicating level of water quality and organic pollution in the water body (Kataria *et al*; 1996) [8]. Dissolved oxygen is one of the most prevailing physical, chemical and biological characteristics. The generally accepted minimum amount of dissolved oxygen that will support a large population of various fishes. When the dissolved oxygen drops below 3mg/l, fishes die and badly affect the reproduction and spawning. Native species that cannot tolerate will be replaced by tolerant species. Low percentage of saturation of dissolved oxygen has direct effect on the fish community. Station 1 has low concentration of dissolved oxygen in pre-monsoon with a range of 1.84mg/l. So station 1 faces high level of pollution

on pre-monsoon season, house hold wastes may be considered as the source of pollution. In monsoon season, in station 3 the concentration of dissolved oxygen was maximum about 8.48mg/l. It indicated that photosynthetic activity and aerobic activity of organisms and an increase in the concentration of organic pollution. pH and temperature changes in the water column affects the primary productivity of the ecosystem. Drainage of agricultural fertilizers and animal feeds or discharge of poorly or untreated waste water may result in elevated nutrients such as nitrogen and phosphates that causes decline in primary productivity (Mwamuya,2016) [9].

During pre-monsoon, gross productivity was 0.950mgC/L/hr. Net productivity was 0.58mg/l. Station 1 has low primary productivity compared to other stations. In pre-monsoon period, gross productivity and net productivity become comparatively low. Gross productivity was high in station 3 and Station 1 has high net productivity. Net productivity and Gross productivity was very low concentration in monsoon in station 2. In post monsoon period, gross productivity and net productivity of each stations considerably increased. Gross productivity was 3.11mgC/l/hr. Net primary productivity of station 2 was 1.72 mg C/l/hr. Station 3 has high gross primary productivity and net primary productivity which is 2.28 and 3.88mgC/l/hr. (fig. 4 & 5). Carbon dioxide is required for the photosynthetic activity and the aquatic vegetation and phytoplankton. Carbon dioxide is the product of respiration and decomposition. Depletion in carbon dioxide adversely affects the fish diversity and aquatic biota. Goel (1997) [6] has mentioned that increase of Carbon dioxide affects the pH and resulted in the formation of carbonic acid, a weak acid which adversely affect the equilibrium of natural water. In the present study station 1 has a high concentration of carbon dioxide compared to other stations in pre- monsoon season which adversely affected the pH but in post-monsoon season, the concentration of carbon dioxide was increased to 13.2ppm and decreased to 7.04ppm in post-monsoon season. And also station 2 has the range of concentration 0f 4.4 ppm, 6.16ppm and 7.92ppm in pre-monsoon, monsoon and post-monsoon season. The range of concentration of carbon dioxide in station 3 has decreased to 5.28 ppm to 3.52 ppm from pre-monsoon to monsoon. But maximum range of carbon dioxide was seen in station 2 with a value of 9.68ppm. Carbon dioxide is the end product of almost all aquatic environments and its variation is often a measure of net ecosystem metabolism. Free carbon dioxide values were found to be maximum during summer. It may be due to decrease in productivity leading to decomposition forming more carbon dioxide in water (Fig 6).

The Biological Oxygen Demand was maximum in station 1 i.e. 7.00mg/l and minimum in station 3. In pre-monsoon season the maximum and minimum range of biological oxygen demand was shown in station 3 i.e.3.44mg/l and 0.4 mg /l in monsoon. Biological Oxygen Demand should be considered of 4mg/l in desirable limits and 6mg/l in permissible limits (WHO, 2003) [14]. So the BOD on station 1 exceeded the permissible limits which is 6 mg/l. (Fig 6). Increased organic matter results in the excess oxidation of organic matter to carbon dioxide and the water creates an atmosphere of oxygen depletion and results in high BOD levels (Divya *et al.*, 2011) [5]. Station 1 has high turbidity Turbidity is the condition resulted from suspended solids in the water including slits, clays, industrial waste sewage. These particles absorb light and increases heat in the water surface which resulted in low dissolved oxygen levels. In addition to that, it prevent the light entering into the bottom surface of the water body which affect the benthic organisms and the primary productivity also decreased. In the present study, turbidity has maximum range in station 1 on pre-monsoon season with a range of 698 NTU and minimum range in 560 NTU. In the monsoon season turbidity has maximum range in 561 NTU and minimum range of 524 NTU in station 3. Station 3 has the maximum range of turbidity i.e.908 NTU also there was considerable decrease of turbidity in post- monsoon season High content of turbidity in station due to the increased concentration of total dissolved solids or the discharge of organic waste through domestic waste or location area effluents (Deepa & Magudeswaran, 2014) [3]. The maximum permissible value of turbidity ranged from 0-10.Water quality having high turbidity is impossible to purify (Fig 7).

Hardness of water occurred due to the presence of sulphates and chlorides of calcium and magnesium. But in the some cases, hardness occurred due to the sulphates and chlorides of Iron, Manganese and Aluminium are responsible for permanent hardness. According to the (WHO 2003) [14] limits, the range between 0-40 considered as soft, 40-100 as moderately hard, 100-300 considered as hard,300-500 as very hard and 500-1000mg/l are considered as extremely hard. The Maximum and minimum range of hardness was seen in pre-monsoon season was seen on station 1 i.e. 18 mg/l and minimum in station 3 and station 2 has range of 14mg/l. The Maximum and minimum range of hardness was seen station 2.i.e.36 mg/l and station 1 in monsoon season. The station 1 has a range of 6mg/l. The Maximum and minimum range of hardness in post monsoon was at station 2 and station 2.station 1 has range of 3mg/l. So the water in three stations were included in the category of soft water (Fig 8).

Water with a high total dissolved solids indicated more ionic concentration, which is of inferior palatability and can induce an unfavorable physiochemical reaction in the consumers. Neilson *et al*., (2003) [10] have reported that increase in value of TDS indicated pollution by extraneous sources. The high amount of dissolved, suspended and total solids of samples adversely affects the quality of running water and it is unsuitable for any other purpose irrigation and drinking. In the present study, the Maximum and minimum range of Total dissolved solids was seen in pre-monsoon season was seen on station 1 of value 5.2mg/l and minimum in station 2 of value 0.2 mg/l. High content of turbidity in station due to the increased concentration of total dissolved solids or the discharge of organic wastes through the domestic waste or location area effluents (Deepa & Magudeswaran, 2014) [3]. The Maximum and minimum range of Total dissolved solids was seen station 3 of value 1.40mg/l and station 1 of value 1mg/l in monsoon season. The Maximum and minimum range of total dissolved solids in post monsoon was at station 1 with a value of 0.8 mg/l and station3 with a value of 0.4mg/l.

Salinity is the measure of salt concentration in the water. High levels of salt affected the taste of drinking water. Salinization adversely affect at the riparian zones where saline water was reached to the landscape. Salts also help fine materials to flocculate which allows more penetration of salt into the water. (Nielsen *et al.,* 2003) [10]. This may lead to more harmful blooms which favors an environment. In the present study, maximum salinity was noticed in the pre-monsoon with a range of 102.40mg/l in station 2. The minimum range of salinity was seen in 53.17 mg/l in station 3 during pre-monsoon season. The station 1 has concentration of 89.6mg/l. The station 3 has maximum concentration with a range of

140.8mg/l and minimum concentration in monsoon season with range 115.2 in station 2. Station 2 has maximum concentration with a range of 134 mg/l and minimum concentration in station 3on premonsoon season.

5. Conclusion

The present study indicated the seasonal variations of physico-chemical parameters of three stations of Achenkovil River. Station 2 showed high acidity in pre-monsoon season which exceeds the desirable limits and also concentration of carbon dioxide was high while the concentration of dissolved oxygen was in low range and a maximum concentration of BOD of nearly 7mg/l was observed. The concentration of total dissolved solids was also high. Turbidity exceeded the standard limits. Hardness was in a high range. Station 1 was highly polluted on pre- monsoon season. Salinity was high in station 2 which indicated the higher concentration of chlorides. During monsoon season, station 1 has high pH and also the concentration of carbon dioxide was also high. Increased concentration of Carbon dioxide affects the pH of the river which adversely affects the biota of that region and also gradual increase in salinity was also seen in all stations. Station 1 still remained in an acidic pH and also concentration of salinity increased in post-monsoon season. The degraded ecosystem would badly affect the diversity of the fish fauna. The study investigates the need for finding out some of the conservatory measures for conserving the biodiversity values of this area. The quality of water need to be evaluated thoroughly to generate the baseline information for the welfare of the society. In order to introduce the alleviation measures of water first a systematic study on the levels of pollution from the different sources in different seasons to be made.

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