

POLLUTION MONITORING IN THAZHKKARA SEGMENT OF RIVER ACHENKOVIŁ BASED ON ENTAMOLOGICAL AND PHYSICO-CHEMICAL PARAMETERS

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Abstract- Present work was designed to study the water quality of Thazhakkara segment of Achenkovil River based on physico-chemical, entomological and microbiological aspect following Water Quality Index and Family Biotic Index of aquatic insects. Sampling was done during summer season 2012. Three study sites were selected from the study segment as Vazhuvadi, Pottamelkadavu and Kunnam. Physico-chemical parameters like TDS (Total Dissolved Solids), Conductivity, Salinity, P^H , Temperature, Turbidity, Dissolved Oxygen, BOD, Nitrate, Phosphate were analyzed. Mean with standard deviation and ANOVA were taken. Water Quality Index was also analyzed. It has been observed that overall water quality index of Thazhkkara segment of river Achenkovil during summer season was 53, that is some of the parameters substantially exceeded the limit. Microbiological analysis showed that the level of fecal coli form was moderate during summer season. An average of 7.9 Family biotic index of aquatic insects were obtained during the study period. The results showed that the Achenkovil river water at Thazhkkara segment was polluted with numerous organic pollutants.

Index Terms- Achenkovil River, Physico-chemical parameters, Water Quality Index, Family Biotic Index

I. INTRODUCTION

Achenkovil River is one of the major rivers in Kerala. The river originates from Pasikidamedu of Thoovalmala of Achenkovil mount as two streams namely "Kallar" and "Kanayar". Both streams unite near Kulathuppuzha and form the river Achenkovil and join river Pampa at Veeyapuram in Alappuzha district which later joins Arabic sea through Vembanadu Lake. River Achenkovil flows through three districts of Kerala Kollam, Alappuzha and Pathanamthitta. Most of this river flows through Pathanamthitta and Alappuzha districts. The recent trend of

planting rubber trees on the sides of river and paddy fields have caused severe problems to the portability of water.

Biological assessment of the fresh water habitats aims at characterizing and monitoring the conditions of the aquatic resources (Sivaramakrishnan *et al.*, 1996). The temperature is one of the important physical factors, which affects the chemical and biological reactions in water. It regulates the rate of photosynthesis in aquatic ecosystem. The temperature variation is one of the factors in the swamp and estuarine system, which may influence the physico-chemical characteristics and also influence the distribution and abundance of flora and fauna (Soundarapandian, *et al.*, 2009). The fluctuation in river water temperature usually depends on the season, geographic location, sampling time and temperature of effluents entering the stream (Ahipathi, 2006). Dissolved oxygen values were found maximum during winter and minimum during summer, which might be due to natural turbulences and higher algal productivity produces oxygen by photosynthesis in rainy period and active utilization in bacterial decomposition of organic matter (Rajkumar, 2004).

Phosphate and Nitrate determinations are important in assessing the potential, biological productivity of surface water. Increasing concentration of phosphorus and nitrogen compounds in lakes and reservoirs leads to eutrophication. Phosphates and nitrates were maximum in monsoon and minimum in summer, this could be due to agricultural runoff during rainy season and utilization as nutrients by algae and other aquatic plants (Ahipathi, 2006). The maintenance of healthy aquatic ecosystem is depended on the physico-chemical properties and biological diversity. A regular monitoring of water bodies with required number of parameters with reference to the quality of water not only prevents the outbreak of diseases and occurrence of hazards but checks the water from further deterioration. Bacteriological assessment, particularly for coli forms – the indicators of contamination by faecal matters is therefore routinely carried out to ascertain the quality and potability of water to ensure prevention of further dissemination of

pathogens through agency of under investigation (Venkatesharaju *et al.*, 2010).

An effort has been made in this study to monitoring the water quality of river Achenkovil, at selected sites using entomological indicators, physico- chemical and biological analysis. This is relevant as a quick assessment method. Insects are particularly suited for using environmental impact assessment because of their high species diversity, ubiquitous occurrence and important functioning of natural ecosystem (Rosenberg *et al.*, 1986). The presence of aquatic insects often provides the best indication of the condition of a stream. Most groups of aquatic insects have been suggested as valuable indicator species, all groups have merits (Goodnight, 1973).

II. METHODOLOGY

1. Study area:

The study area was Thazhakkara segment of River Achenkovil. It is located at latitude 9° 15' 20.9"N and longitude 76° 34' 51.6"E with an elevation of 6 ft above mean sea level. Three study sites were selected in this segment; they were Vazhuvadi, Pottamelkadavu and Kunnam.

2. Collection and Transportation of Sample:

Monthly samples were collected from three study sites during summer season (February, March and April 2012). Three samples were taken from each site with an average distance of 100 meters. Samples were collected in pre-sterilised containers and transported to the laboratory in ice boxes within shortest possible time to avoid errors on data variation due to physical and bacteriological change.

3. Physico- Chemical Analysis of Samples:

In the laboratory pH, salinity, Dissolved Oxygen, TDS (Total Dissolved Solids) and Conductivity was measured using digital water- soil quality analyser kit. Temperature was measured in the site itself using thermometer. Nitrate, Phosphate and Biological Oxygen Demand (BOD) was determined as per the procedures of APHA (APHA, 2005) Turbidity was measured using a sechi disc in the site itself. For microbiological analysis, culture technique was adopted (APHA 2005). Water samples were serially diluted to 10⁻³ and standardised the same for the convenience of colony counting. Adopting pour plate method, the bacterial population in different samples were calculated on MC Conkey agar for Total Coliform count (TC).

4. Water Quality Index:

The overall water quality of Thazhakkara segment was calculated using National Sanitation Foundation (NSF) water quality index calculator (NSF, 2010).

5. Entomological Indicators:

Two types of gears were used for sampling aquatic insects. Kick net - Dimensions of kick net were 1mX1m attached to two poles. D-frame dip net -Dimensions of D-frame dip net were 0.3m width and 0.3m height and shaped as a "D" where frame attaches to long pole . The collected

insects were picked up using brush or forceps and transferred to sample containers containing 95% ethanol for preservation. All samples were brought to laboratory for identification

6. Statistical analysis

Mean and standard deviation for each parameter were determined using Microsoft excel software. Two way analysis of variance (ANOVA) was conducted to determine any significance difference in the value of each parameter between samples and between sites using SPSS package.

III. RESULTS

1. Total Dissolved Oxygen.

The TDS was found to be more in Vazhuvadi site (0.039) and lowest in Kunnam (0.032) during summer. The average TDS of Vazhuvadi site was 0.035 with a standard deviation (SD) of 0.003; Pottamelkadavu site having 0.034 with a SD of 0.001 and Kunnam with 0.034 and SD 0.002. The overall TDS of Thazhakkara segment was 0.034 during summer season (Table 1, Figure 1). The two way ANOVA conducted showed no difference in the values of TDS between sites (P=0.5; P>0.05) and between samples (P=0.09; P>0.05).

Table 1: TDS values obtained from 3 different sites of Achenkovil River.

SITES	Sample 1	Sample 2	Sample 3	Mean ±SD	Average TDS
	February	March	April		
Vazhuvadi	0.039	0.032	0.035	0.035±0.003	0.034
Pottamelkadavu	0.034	0.033	0.035	0.034±0.001	
Kunnam	0.036	0.032	0.034	0.034±0.002	

2. Conductivity.

Conductivity was found highest in Vazhuvadi site (59.6) and lowest in Kunnam (49.8). The average conductivity of Vazhuvadi sample was 55.23 with a SD of 4.62 that of Pottamelkadavu 51.23 with a SD of 0.93 and Kunnam was 53.2 with a SD of 3.26. The overall conductivity of the study area during summer is 53.22. (Table 2, Figure 2). The two way ANOVA showed no significant difference in the conductivity values between sites (P=0.2811; P>0.05) and between samples (P=0.1703; P>0.05)

Table 2: Conductivity values obtained from 3 different Sites of Achenkovil River

SITES	Sample 1	Sample 2	Sample 3	Mean±SD	Average
	February	March	April		
Vazhuvadi	59.6	49.8	55.23	55.23±4.62	53.22
Pottamelkadavu	51.23	53.2	53.2	51.23±0.93	
Kunnam	49.8	53.2	53.2	53.2±3.26	

Vazhuvadi	59.6	50.4	55.7	55.23±4.62	53.22
Pottamelkadavu	51.5	52	50.2	51.23±0.93	
Kunnam	56.3	49.8	53.5	53.2±3.26	

3. Dissolved Oxygen (DO) (mg/L)

The Dissolved Oxygen was highest in Pottamelkadavu (8.4) and lowest in Vazhuvadi (5.4). The average DO of Vazhuvadi site was 5.6 with a SD of 0.2 that of Pottamelkadavu was 8.03 with a SD of 0.32 and Kunnam was 7.1 with a SD of 0.2. The overall DO of study area was found to be 6.91 in summer season. (Table 3, Figure 3). The two way ANOVA showed great significant difference in the DO between sites (P=6.09X10⁻⁰⁵; P<0.05) between samples (P=0.0376; P<0.05)

Table 3: Dissolved Oxygen values obtained from 3 different sites of Achenkovil River.

SITES	Sample 1	Sample 2	Sample 3	Mean±SD	Average
	February	March	April		
Vazhuvadi	5.8	5.4	5.6	5.6±0.2	6.91
Pottamelkadavu	8.4	7.9	7.8	8.03±0.32	
Kunnam	7.3	7.1	6.9	7.1±0.2	

4. Biological Oxygen Demand (BOD) (mg/L)

The BOD value was highest Kunnam site (5.9) and lowest in Vazhuvadi site (5.1). The average BOD of Vazhuvadi site was 5.2 with a SD of 0.1, that of Pottamelkadavu was 5.53 with a SD of 0.15 and Kunnam was 5.73 with a SD of 0.15. The overall BOD of Thazhakkara segment was 5.49 during summer. (Table 4, Figure 4). Two way ANOVA conducted showed an F-value 10.3157 between sites and 0.6842 between samples. It showed there is a great significant difference in the BOD between sites. (P=0.0263; P<0.05) and no difference in the BOD between samples. (P=0.551; P>0.05)

Table 4: BOD values obtained from 3 different sites of Achenkovil River.

SITES	Sample 1	Sample 2	Sample 3	Mean±SD	Average
	February	March	April		
Vazhuvadi	5.2	5.3	5.1	5.2±0.1	5.49
Pottamelkadavu	5.4	5.5	5.7	5.53±0.15	
Kunnam	5.7	5.6	5.9	5.73±0.15	

5. Salinity.

The salinity is highest in Pottamelkadavu site (1.3) and lowest in Vazhuvadi was (0.2). The average salinity of Vazhuvadi was (0.43) with a SD of 0.21, that of Pottamelkadavu site was 0.87 with a SD of 0.4 and Kunnam was 0.97 with a SD of 0.32. The overall salinity of Thazhakkara segment during summer was 0.75. (Table 5, Figure 5). The two way ANOVA showed a great significant difference in the salinity between sites (P=0.0350; P<0.05) and between samples (P=0.0321; P<0.05).

Table 5: Salinity values obtained from 3 different sites of Achenkovil River

SITES	Sample 1	Sample 2	Sample 3	Mean±SD	Average
	February	March	April		
Vazhuvadi	0.5	0.2	0.6	0.43±0.21	0.75
Pottamelkadavu	1.3	0.5	0.8	0.87±0.40	
Kunnam	1.2	0.6	1.1	0.97±0.32	

6. pH

The pH value was highest in the Pottamelkadavu site (6.51) and lowest in Vazhuvadi (6.3). The average pH of Vazhuvadi site was 6.3 with a SD of 0.02, that of Pottamelkadavu was 6.48 with a SD of 0.03 and Kunnam was 6.25 with a SD of 0.04. The overall pH of Thazhakkara segment was during summer. (Table 6, Figure 6). The two way ANOVA showed a great significant difference in samples (P=0.7991; P>0.05) and no difference in the pH between sites (P=0.0032; P<0.05).

Table 6: pH values obtained from 3 different sites of Achenkovil River

SITES	Sample 1	Sample 2	Sample 3	Mean±SD	Average
	February	March	April		
Vazhuvadi	6.29	6.33	6.3	6.3±0.02	6.3455
Pottamelkadavu	6.51	6.45	6.48	6.48±0.03	
Kunnam	6.21	6.29	6.25	6.25±0.04	

7. Temperature.

The highest temperature was recorded from Kunnam site (32°C) and lowest from Vazhuvadi (28°C). The average temperature of Vazhuvadi was 28.66°C with a SD of 0.58, that of Pottamelkadavu site was 29.66°C with a SD of 0.58 and Kunnam was 31°C with a SD of 1. The average temperature of the segment was 29.8°C. (Table 7, Figure 7). The two way ANOVA showed a great significant difference in the temperature between sites (P=0.0026; P<0.05) and between samples (P=0.0177; P<0.05).

Table 7: Temperature obtained from 3 different sites of Achenkovil River

SITES	Sample 1	Sample 2	Sample 3	Mean±SD	Average
	February	March	April		
Vazhuvadi	28	29	29	28.66±0.58	29.77
Pottamelkadavu	29	30	30	29.66±0.58	
Kunnam	30	31	32	31±1	

8. Turbidity.

The turbidity value was highest Kunnam site (0.7) and lowest in Vazhuvadi site (0.3). The average turbidity of Vazhuvadi site was found to be 0.33 with a SD of 0.05, that of Pottamelkadavu was 0.53 with a SD of 0.05 and Kunnam was 0.66 with a SD of 0.05. The overall turbidity of Thazhakkara segment was 0.5 during summer. (Table 8, Figure 8). The two way ANOVA showed a great significant difference in the turbidity between sites (P=0.0006; P<0.05) and between samples (P=0.0439; P<0.05).

Table 8: Turbidity values obtained from 3 different sites of Achenkovil River

SITES	Sample 1	Sample 2	Sample 3	Mean ±SD	Average
	February	March	April		
Vazhuvadi	0.3	0.4	0.3	0.33±0.05	0.51
Pottamelkadavu	0.5	0.6	0.5	0.53±0.05	
Kunnam	0.6	0.7	0.7	0.66±0.05	

9. Nitrate.

The highest nitrate level was found in Kunnam site (0.7) and lowest in Vazhuvadi (0.4). The average nitrate level 0.43 in Vazhuvadi site with a SD of 0.05, that of Pottamelkadavu site was 0.53 with a SD of 0.05 and Kunnam was 0.67 with a SD of 0.05. The overall nitrate level in the study area was 0.54 in the summer season. The two way ANOVA showed a great significant difference in the nitrate level between sites (P=0.0026; P<0.05) and between samples (P=0.0493; P<0.05)

Table 9: Nitrate values obtained from 3 different sites of Achenkovil River

SITES	Sample 1	Sample 2	Sample 3	Mean ±SD	Average
	February	March	April		
Vazhuvadi	0.4	0.4	0.5	0.43±0.05	0.54
Pottamelkadavu	0.5	0.5	0.6	0.53±0.05	

Kunnam	0.6	0.7	0.7	0.67±0.05	
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10. Phosphate.

The Phosphate content was highest in Kunnam (1.3) and lowest in Vazhuvadi (0.8). The mean phosphate content of Vazhuvadi was 0.83, 1.06 for Pottamelkadavu and 1.26 for Kunnam with a SD of 0.05, 0.15 and 0.05 respectively. The overall phosphate level in the summer was 1.055 in the study area. The two way ANOVA showed a great significant difference in the Phosphate level between sites (P=0.0063; P<0.05) and no difference in the phosphate level between samples (P=0.1659; P>0.05)

Table 10: Phosphate values obtained from 3 different sites of Achenkovil River

SITES	Sample 1	Sample 2	Sample 3	Mean ±SD	Average
	February	March	April		
Vazhuvadi	0.8	0.9	0.8	0.83±0.05	1.055
Pottamelkadavu	0.9	1.1	1.2	1.06±0.15	
Kunnam	1.2	1.3	1.3	1.26±0.05	

11. Faecal Coliform (No./100ml)

Kunnam showed high Faecal Coliform count (14x10³) and Vazhuvadi showed low FC count (8x10³). The average FC count was found to be 9.3x10³ at Vazhuvadi, 11.3x10³ and 12x10³ at Kunnam with SD of 1.5, 2.08 and 2 respectively. The overall FC count was 10.89x10³ during summer in the study area. The two way ANOVA showed no difference in the FC count between sites (P=0.0940; P>0.05) and between samples (P=0.0574; P<0.05).

Table 11: Faecal Coliform values obtained from 3 different sites of Achenkovil River

SITES	Sample 1	Sample 2	Sample 3	Mean ±SD	Average
	February	March	April		
Vazhuvadi	8 x 10 ³	11 x 10 ³	9 x 10 ³	9.3±1.5	10.89
Pottamelkadavu	9 x 10 ³	13 x 10 ³	12 x 10 ³	11.3±2.08	
Kunnam	10 x 10 ³	12 x 10 ³	14 x 10 ³	12±2	

Table 12: Anova showing the physicochemical and microbiological parameters obtained from 3 different sites of river Achenkovil

Parameter analyzed	Comparison aspects	F value	F critical value 5% level	P value
TDS	Between habitats	0.6808	6.9442	0.5565

	Between season	4.638 2	6.944 2	0.0907
Conductivity	Between habitats	1.771 9	6.944 2	0.2811
	Between season	2.845 3	6.944 2	0.1703
DO	Between habitats	254.3 125	6.09 $\times 10^5$	6.9442
	Between season	8.312 5	0.037 6	6.9442
BOD	Between habitats	10.31 57	6.944 2	0.0263
	Between season	0.684 2	6.944 2	0.5551.
Salinity	Between habitats	8.68	6.944 2	0.035
	Between season	9.16	6.944 2	0.0321
p H	Between habitats	32.85 59	6.944 2	0.0032
	Between season	0.237 2	6.944 2	0.7991
Temperature	Between habitats	37	6.944 2	0.0026
	Between season	13	6.944 2	0.0177
Turbidity	Between habitats	76	6.944 2	0.0006
	Between season	7	6.944 2	0.0493
Nitrate	Between habitats	37	6.944 2	0.0026
	Between season	7	6.944 2	0.0493
Phosphate	Between habitats	23.09 09	6.944 2	0.0063
	Between season	2.909	6.944 2	0.1659
Faecal coliform	Between habitats	4.521 7	6.944 2	0.094
	Between season	6.347 8	6.944 2	0.0574

Table 13: Water Quality Index obtained from 3 different sites of Achenkovil River

Sl. No.	Parameters	Average	WQI
1	Faecal coli form	10.89	70
2	TDS	0.034	79
3	Dissolved Oxygen	6.91	5
4	p ^H	6.34	65
5	Turbidity	0.51	97
6	BOD	5.4	54

7	Nitrate	0.54	96
8	Phosphate	1.05	39
9	Temperature	29.77	10

Table 14: Water Quality Factors and Weights obtained from 3 different sites of Achenkovil River

Parameters	Quality Index	Weight
Faecal Coliform	70	0.16
TDS	79	0.07
Dissolved Oxygen	5	0.17
p ^H	65	0.11
Turbidity	97	0.08
BOD	54	0.11
Nitrate	96	0.10
Phosphate	39	0.10
Temperature	10	1

Based on 9 factors entered the overall water quality index of Thazhakkara segment of river Achenkovil in summer season was 53 (Table 13, 14).

Family wise tolerance value indices of insects and family biotic index

Table 15: Number and tolerance value of aquatic insects based on their taxa at Vazhuvadi site

SL.No:	TAXA		No (ni)	Tolerance Value (TV)	X=TV X ni
	Order	Family			
1	Odonata	Coenagrionidae	6	9	54
2		Libellulidae	12	9	72
3	Ephemeroptera	Leptophlebiidae	2	4	8
4	Hemiptera	Corixidae	13	0	0

Family Biotic Index = $\sum (TVX ni)/N = 134/20 = 6.7$

Table 16: Number and tolerance value of aquatic insects based on their taxa at Pottamelkadavu

$$\text{Family Biotic Index} = \frac{\sum (TVX ni)}{N} = \frac{122}{18} = 6.7$$

Sl. No:	TAXA		No	Tolerance Value	X=TV X ni
	Order	Family			
1	Hemiptera	Corixidae	7	0	0
2	Odonata	Coenagrionidae	5	9	45
3		Libellulidae	8	9	72
4		Gomphidae	5	1	5

The factors (weight in bracket) fecal coli form (0.16), Dissolved oxygen (0.17), pH (0.11), BOD (0.11), nitrate (0.1) and phosphate (0.1), Turbidity (0.08) and TDS (0.07) plays crucial role in determining the water quality. Entomological indicators also play a major role in pollution monitoring.

The TDS of study region showed no difference between sites and samples. This is due to less drainage during summer season. There was a great significant difference in the BOD between sites. The high BOD value in summer season indicates less flow, more plankton growth, more temperature and less Dissolved Oxygen content. The pH shows much variation between sites during summer and no variation between samples where as a major difference in turbidity value was noticed in between sites and samples. The turbidity value more in pre- monsoon is due to the inflow of pre-monsoon showers and input of particles from land. (Sanalkumar, 2011). Difference in the temperature during summer corresponds with difference in the atmospheric temperature. Commonly temperature is very high in summer season due to global warming. The conductivity has a direct relationship with turbidity is more there will be corresponding increase in the conductivity also (Abbasi, 1977).

The level of Fecal coli form was moderate during summer season. This level is due to the inflow of human excreta into the river. This is due to the lack of sufficient water in the house wells during summer season. The treatment of human excreta is effective before plunged into the river which showed the medium level FC value. The nitrate level of Achenkovil is moderate in summer. This indicates low levels of riverbank agriculture during summer. Phosphate also showed moderate value in summer which is an indication of low level agricultural practices in the banks of the river.

In summer season, amount of pollution increases in river water. As a result of this highly pollution tolerant insects are only seen in river during summer. In monsoon, the number of insects may be increased due to flow of water. The summer water quality is an index of overall river health. The water quality index is worst during summer in any water body. So medium range quality of water in Achenkovil during summer was a positive sign of improvement of water quality of this river, when compared with the worst situation of the river reported earlier by Medias and many newspapers.

Table 17: Number and tolerance value of aquatic insects based on their taxa at Kunnam site

Sl..No	TAXA		No	Tolerance Value	X=TV X ni
	Order	Family			
1	Hemiptera	Corixidae	9	0	0
2	Odonata	Coenagrionidae	8	9	72
3		Libellulidae	7	9	63
4		Gomphidae	4	1	4

$$\text{Family Biotic Index} = \frac{\sum (TVX ni)}{N} = \frac{39}{19} = 7.3$$

Table 18: Showing average family biotic index of 3 sites of River Achenkovil

Sl. No.	Site	Family biotic index	Average
1	Vazhuvadi	6.7	6.9
2	Pottamelkadavu	6.7	
3	Kunnam	7.3	

Average Family Biotic Index of Thazhakkara segment of River Achenkovil during summer is 6.9. It is between 5.51-6.50. So the water quality is fairly good. Fairly significant organic pollution is present. Tolerance value of Coenagrionidae and Libellulidae is 9. So they are highly tolerated in the polluted water.

DISCUSSION

The physico-chemical parameters of Thazhakkara segment of Achenkovil River showed a medium quality range.

CONCLUSION

Water quality of Thazhakkara segment of Achenkovil River was determined based on physico-chemical, entomological and microbiological aspect following Water

Quality Index and Family Biotic Index of aquatic insects. Three study sites were selected in the study segment as Vazhuvadi, Pottamelkadavu and Kunnam. Three samples were taken from each study site monthly during summer.

Physico-chemical parameters like TDS, Conductivity, Salinity, P^H , Temperature, Turbidity, Dissolved Oxygen, BOD, Nitrate and Phosphate were determined. Total Faecal Coli form bacterial count was determined adopted pour plate method. Mean with standard deviation was taken for each parameters value. Two way ANOVA was conducted to test whether the samples have variation in values between sites and between samples. Overall water quality index was calculated following NSF Method. Great variation in water quality was observed for DO, BOD, Salinity, Temperature, Turbidity, Nitrate, Phosphate between sites and samples during summer. Slight variation in water quality parameters were observed for TDS, Conductivity, pH, Faecal Coli form during summer. The overall water quality index (WQI) of summer was found to be 53. These values indicate a moderate water quality level in the Thazhakkara segment of Achenkovil River. The average Family biotic index of aquatic insects is 7.9. This value indicate a medium water quality level in the Thazhakkara segment of Achenkovil River.

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