International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

Seasonal Fluctuations in the Pollution Indicators, Microorganisms and Aquatic Insects in the Vettiyar Segment of River Achankovil

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Abstract: ***Achencovil River with a length of 128 kms is a major river of Kerala. Physico-chemical parameters, microbiological and pollution indicators of the River Achencovil, Kerala, India was determined during summer season. The physico-chemical parameters like Turbidity, Temperature, p^H, Total Dissolved solids (TDS), Conductivity, Dissolved Oxygen, Biological Oxygen Demand, Nitrate, Phosphate; microbiological analysis like Total Coliform Count were studied and analyzed during summer season, 2012 using standard procedures. The water samples were collected from three different sites of mid stream Vettiyar segment during summer season. All most all parameters showed significant ($p<0.05$) variation between sites and was determined by analysis of variance (Anova). Water Quality Index and microbiological characteristic like Total Coliform Count (TC) were also analyzed. The aqatic insects ordrer like Odonata, Hemiptera were obtained during the study period. Overall water quality index of Vettiyar segment in river Achenkovil during summer season was 59.***

Keywords: Achencovil river water, Physico-chemical parameters, Water quality index, Microbiological analysis.

1. Introduction

The Achenkovil River is one of the important rivers in Kerala, formed from the streams of Rishimala River, Pasukidamettu River and Ramakkalteri River. This river enriches the Pathanamthitta district of Kerala State. It joins the Pamba River at veeyapuram in the Alappuzha district of Kerala in South India.

Water Pollution is a phenomenon that is characterized by the deterioration of the quality of land water (rivers, lakes, marsh and ground water) or sea water as a result of various human activities (Triveni and Guru Deep, 1996). Pollution represents wastage of world resources, an economic burden on a nation and a financial loss to an enterprise. The pollution can be reduced and minimised by reducing the inefficiencies.

Rivers contains waste materials these include sewage, garbage and liquid waste from factories and homes. Wastages from chemical factories contain many toxic or poisonous chemicals, these are discharged into rivers. The river water becomes poisonous for fish other aquatic animals and plants (Agarwal, 1995). Anthropogenic activities such as the river valley projects have drastically transformed the riverine ecosystems all over the world. In addition to the river valley project the landscape transformations are probably responsible for the most widespread damage to the rivers and streams (Allan, 1995; Dudgeon, 2000 and Allan, 2004). It is apparent that an assessment of water quality cannot focus on chemical indicators alone, but must instead focus on indicators alone, but instead focus on indicators that integrate the effects of physical, chemical and biological contaminations (Genet and Chirhart, 2004).

There are few studies conducted in river Achenkovil. Ever increasing issues of water pollution and its consequences on rivers like Achenkovil needs urgent attention in order to cease or lower the threatening problem faced by the laymen for their survival. Physico-chemical and microbiological analysis is the most effective way to monitor the water quality of rivers. When you submit your paper print it in two-column format, including figures and tables [1]. In addition, designate one author as the “corresponding author”. This is the author to whom proofs of the paper will be sent. Proofs are sent to the corresponding author only [2].

2. Methodology

2.1 Study area

The study area was Vettiyar mid stream segment of River Achankovil. Four study sites were selected in this segment and samples are collected from each site. They were Site I. Muttumpattu Kadavu it located at latitude 09^0 14’ 46.2’N and longitude 076^0 35’42.9’E, Site II. Kanjirathummoodu is located at latitude 09^0 14’ 44.0’N and longitude 076^0 35’ 38.9’E with elevation, Site III. Sanchayakadavu is located at latitude 09^0 14’ 55.5’N 076^0 35’ 24.6’ E with elevation and longitude Site IV. Pattenkadavu is located at latitude 09^0 14’ 57.0’N and longitude 076^0 35’ 22.4’ E with elevation

2.2 Collection and Transportation of sample

Monthly samples were collected from Vettiyar segment during summer (February, March, April, 2012) seasons. Three samples were taken from each site with an average distance of 500 metres. Samples were collected in pre-sterilized containers and transported to the laboratory within shortest possible time to avoid erroneous data variation due to physical and bacteriological change.

2.3 Physico – Chemical analysis of samples

In the laboratory P^H, Dissolved oxygen, Total Dissolved solids (TDS) and conductivity was measured using water quality analyzer. Temperature was measured in the site itself using a thermometer. Nitrate, phosphate and Biological Oxygen Demand were determined as per the procedures of APHA (APHA, 2005). Turbidity was measured using sechi disc in the site itself. For microbiological analysis culture technique was adopted (APHA, 2005) water samples were serially diluted to 10^{-3} and standardized the same for the convenience of colony counting. Adopting pour plate method, the bacterial population in different sample was calculated on Mc Conkey agar for Total Coliform count (TC).

2.4 Water Quality Index

The overall water quality index of Vettiyar segment determined by using National Sanitation Foundation (NSF) water quality index calculator (NSF, 2010).

2.5 Collection and identification of Aquatic Insects and Larvae

All insects and other larvae collected were identified up to family level with the help of the suitable key (Morse *et al.,* 1994). All tax were sorted and kept in separate vials with proper labelling. The benthic metrices calculated during this study.

2.6 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.

3. Result

1. Total Dissolved Solids (TDS)
The average TDS of all Sampling Site were 0.03 with standard deviation (SD) of 0.002, 0.001, 0.003, 0.003 respectively. The overall TDS of Vettiyar segment was 0.03 during the summer season.(Table 1). Two way Anova showed less difference in the TDS between sites no significant difference between sites (P = 0.04368; P <0.05) and significant difference observed between samples (P = 0.008; P < 0.05). (Table 11)

Table 1: TDS (mg/L) in samples from different sites during Summer season

Site	Sample 1	Sample 2	Sample 3	Mean± SD	Average TDS
1	0.039	0.035	0.034	0.03 ±0.002	
2	0.032	0.032	0.035	0.03 ±0.001	0.03
3	0.035	0.039	0.032	0.03 ±0.003	
4	0.036	0.031	0.037	0.03 ±0.003	

2. Biological Oxygen Demand (BOD)
The average BOD of site I was 5.46 and SD of 0.20. Site II was 5.36 and SD of 0.12. The average BOD of site III 5.43 and SD of 0.12and that of average BOD of site IV was 5.42 with SD of 0.07. The overall BOD of Vettiyar segment was formed to be 5.42. (Table 2). Two way Anova showed no significant difference in the BOD between sites (P =0.358349; P >0.05) and significant difference observed between samples (P =0.000191; P < 0.05). (Table 11)

Table 2: Mean and SD of BOD (mg/L) in samples from different sites during Summer season

Site	Sample 1	Sample 2	Sample 3	Mean ± SD	Average BOD
1	5.2	5.7	5.5	5.46±020	5.42
2	5.2	5.5	5.4	5.36±0.12	
3	5.3	5.4	5.6	5.43±0.12	
4	5.5	5.5	5.6	5.42±0.07	

3. P^H
The P^H Value was highest in the site IV (6.68). The average P^H of site II and site III was 6.58. The average P^H of site I was 6.59 with a SD of 0.07. The overall P^H of Vettiyar segment was 6.61 (Table 3). The two way Anova of P^H showed no significant difference between site (P = 0.3538; P > 0.05) and have a great significant difference between the samples (P = 1.2 E^{-05}; P < 0.05). (Table 11)

Table 3: Mean and SD of p^H in samples from different sites during Summer season

Site	Sample 1	Sample 2	Sample 3	Mean±SD	**Average p^H**
1	6.53	6.67	6.58	6.59±0.07	6.61
2	6.53	6.59	6.64	6.58±0.05	
3	6.58	6.59	6.59	6.58±0.005	
4	6.67	6.68	6.69	6.68±0.01	

4. Turbidity
The average turbidity of site I was 0.46 with SD of 0.20, site II was 0.46 with SD of 0.15, site III was 0.46 with SD of 0.11, site IV was 0.5 with SD 0.1. The overall turbidity of Vettiyar segment was 0.475 (Table 4). The two way ANOVA of turbidity showed no significant difference between sites (P = 0.4125; P > 0.05) and have a great significant difference in the turbidity between samples (P = 0.0032; P < 0.05) (Table 11).

Table 4: Mean and SD of Turbidity in samples from different sites during summer season

Site	Sample 1	Sample 2	Sample 3	Mean±SD	Average Turbidity
1	0.3	0.4	0.7	0.46±0.20	0.47
2	0.3	0.5	0.6	0.46±0.15	
3	0.4	0.6	0.4	0.46±0.11	
4	0.4	0.5	0.6	0.5±0.1	

5. Temperature
The temperature was highest in site I, and site IV 34^0 C. The average temperature of site I is 34^0 C with SD of 0, site II is 32.66 with SD of 0.57, that of site III is 32.333with SD of 0.57 and that of site IV is 33.66 with SD of 0.57. The overall temperature of Vettiyar segment during summer season was 33.16 (Table 5). The two way ANOVA of temperature

showed no difference in site P = 0.2385; P > 0.05 and great significant between samples P = 8.8 E^{-12}; P < 0.05. (Table 11).

Table 5: Mean and SD of Temperature in samples from different sites during Summer season

Site	Sample 1	Sample 2	Sample 3	Mean±SD	*Average Temperature*
1	34	34	34	34±0	33.16
2	32	33	33	32.66±0.57	
3	33	32	32	32.33±0.57	
4	34	34	33	33.66±0.57	

6. Dissolved Oxygen (DO)

The Dissolved Oxygen was highest in site IV 6.4 and lowest in site II 5.1. The average Dissolved Oxygen of site I was 6.26 with SD of 0.05, that of site II is 5.43 with SD of 0.30, that of site III is 5.46 with SD of 0.30 and that of site IV is 6.23 with SD of 0.15. The overall Dissolved Oxygen in the Vettiyar segment is 5.85 during summer (Table 6). The two way ANOVA of Dissolved Oxygen showed no significant difference between sites P = 0.23018; P > 0.05 and great significant difference between samples P = 0.00017; P < 0.05 (Table 11).

Table 6: Mean and SD of DO in samples different sites during Summer season

Site	Sample 1	Sample 2	Sample 3	Mean± SD	Average DO
1	6.2	6.3	6.3	6.26± 0.05	5.85
2	5.1	5.5	5.7	5.43± 0.30	
3	5.2	5.4	5.8	5.46± 0.30	
4	6.4	6.2	6.1	6.23± 0.15	

7. Conductivity

The average conductivity of site I was 0.11 with SD of 0.06, that of site II was 0.10 with SD of 0.05, that of site III was 0.10 with SD of 0.05 and that of site IV was 0.10 with SD of 0.05. The overall conductivity of Vettiyar segment is 0.10 (Table 7). The two way ANOVA showed no significant difference in conductivity between site P = 0.4394; P > 0.05; and great significant difference between samples P = 0.0010; P < 0.05 (Table 11).

Table 7: Mean and SD of Conductivity in samples from different sites during Summer season

Site	Sample 1	Sample 2	Sample 3	Mean±SD	Average conductivity
1	0.1	0.18	0.051	0.11±0.06	0.10
2	0.1	0.17	0.051	0.10±0.05	
3	0.1	0.17	0.051	0.10±0.05	
4	0.1	0.17	0.051	0.10±0.05	

8. Nitrate

The Nitrate showed highest concentration in site I, II and lowest in site III. The average Nitrate value of site I was 0.6 with SD 0.1, that of site II is 0.5 with SD of 0.1 that of site III is 0.56 with SD of 0.15 and that of site IV 0.533 with SD of 0.05. The overall Nitrates in the Vettiyar segment is 0.55 during summer (Table 8). The two way ANOVA of Nitrates showed no significant difference between sites P = 0483; P > 0.05 and great significant difference between samples P = 0.004; P < 0.05.

Table 8: Mean and SD of Nitrate in samples from different sites during Summer season

Site	Sample 1	Sample 2	Sample 3	Mean±SD	Average Nitrate
1	0.5	0.6	0.7	0.6±0.1	
2	0.4	0.5	0.6	0.5±0.1	0.55
3	0.6	0.7	0.4	0.56±0.15	
4	0.5	0.6	0.5	0.53±0.05	

9. Phosphate

The average phosphate level in site I is 0.83 with SD is 0.20, that of site II is 1.16 with SD of 0.23, that of site III is 1.1 with SD is 0.1 and that of site IV is 1.03 with SD of 0.20. The overall phosphate of study area is 1.008 (Table 9). Two way ANOVA showed no significant different in phosphate between the site P = 0.2893; P > 0.05 and great significant difference between samples P = 0.0160; P < 0.05. (Table 11)

Table 9: Mean and SD of Phosphate in samples from different sites during Summer season

Site	Sample 1	Sample 2	Sample 3	Mean±SD	*Average Phosphate*
1	0.6	0.9	1	0.83±0.20	1.008
2	0.9	1.3	1.3	1.16±0.23	
3	0.9	1	1.1	1±0.1	
4	0.8	1.1	1.2	1.03±0.20	

9. Faecal Coliform

The average faecal coliform count was found to be site I was 6 x 10^{-2} with SD is 3.46 x 10^{-2}, that of site II is 12.66 x 10^{-2} with SD is 0.57 x 10^{-2}, that of site III is 17.66 x 10^{-2} with SD is 5.50 x 10^{-2} and that of site IV is 13.33 x 10^{-2} with SD is 5.77 x 10^{-2}. The overall FC count 12.41 x 10^{-2} during summer in the study area (Table 10). The two way ANOVA showed no significant difference between site P = 0.3740; P > 0.05 and great significant difference between samples P = 0.0008; P < 0.05. (Table 11)

Table 10: Mean and SD of Faecal Coliform in samples from different sites during Summer season

Site	Sample 1	Sample 2	Sample 3	Mean±SD	Average Faecal coliform
1	4	10	4	6±3.46	12.41
2	12	13	13	12.66±0.57	
3	15	24	14	17.66±5.50	
4	10	20	10	13.33±5.77	

Table11: Anova showing physico-chemical and microbiological parameters during summer season at Vettiyar segment

Parameter analyzed	Comparison aspects	F value	F critical value 5% level	P value
TDS	Between habitats	0.998659	3.862548	0.436825
	Between season	14.58079	3.862548	0.00084
BOD	Between habitats	1.217659	3.862548	0.358349
	Between season	21.55441	3.862548	0.000191
P^H	Between habitats	1.231974	3.862548	0.353799
	Between season	42.73793	3.862548	$1.19 X10^{-5}$
Turbidity	Between habitats	1.061323	3.862548	0.412575
	Between season	9.923846	3.862548	0.003256
Temperature	Between habitats	1.6875	0.238495	3.862548
	Between season	1058.063	$8.78X10^{-12}$	3.862548
DO	Between habitats	1.729951	3.862548	0.23018
	Between season	22.12275	3.86248	0.000173
Conductivity	Between habitats	0.992016	0.439486	3.862548
	Between season	13.73016	0.001046	3.862548
Nitrate	Between habitats	0.887969	0.483543	3.862548
	Between season	8.728835	0.004978	3.862548
Phosphate	Between habitats	1.460576	0.289385	3.862548
	Between season	5.961917	0.016005	3.862548
Faecal coliform	Between habitats	1.169708	0.37408	3.862548
	Between season	14.34247	0.000893	3.862548

Table 12: Water Quality Index obtained from 3 different sites of Achenkovil River

Parameter	Index value
Nitrate	96
Phosphate	40
P^H	76
Turbidity	98
Dissolved Oxygen (DO)	5
Faecal Coliform	69
Biological Oxygen Demand(BOD)	54
Total Dissolved Solids (TDS)	79
Overall index	59

The water quality index of Vettiyar segment of Achankovil River was found to be 59 for summer. The purity of water in the Vettiyar segment of Achankovil River of medium water quality.

Family wise tolerance value indices of insects and family biotic index

Table 13: Number and tolerance value of aquatic insects based on their taxa at siteI

Sl. No.	Taxa		Number	Tolerance value	X n XTV
	Order	Family			
1	Odonata	Libellulidae	8	9	72
		Caenogrionidae	6	9	54
		Gomphidae	5	1	5
2	Hemiptera	Corixidae	8	0	0
3	Coleoptera	Hydrodrophilidae	5	5	25
	Total		32		156

Hilsenhoff Biotic family index

$$\frac{\sum n\,X\,TV}{N} = \frac{156}{32} = 4.87$$

Table 14: Number and tolerance value of aquatic insects based on their taxa at Site II

Sl. No.	*Taxa*		*Number*	*Tolerance value*	*X n xTV*
	Order	Family			
1		Libellulidae	8	9	72
		Caenogrionidae	6	9	54
	Odonata	Gomphidae	9	1	9
2	Hemiptera	Corixidae	6	0	0
	Total		29		135

Hilsenhoff Biotic family index

$$\frac{\sum n\,X\,TV}{N} = \frac{135}{29} = 4.65$$

Table 15: Number and tolerance value of aquatic insects based on their taxa at Site III

Sl. No.	*Taxa*		*Number*	*Tolerance value*	*X n xTV*
	Order	Family			
1		Libellulidae	10	9	90
		Caenogrionidae	5	9	45
	Odonata	Gomphidae	9	1	9
2	Hemiptera	Corixidae	8	0	0
	Total		32		144

Hilsenhoff Biotic family index

$$= \frac{\sum n\,X\,TV}{N} = \frac{144}{32} = 4.5$$

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

Sl. No.	*Taxa*		*Number*	*Tolerance value*	*X n xTV*
	Order	Family			
1		Libellulidae	7	9	63
		Caenogrionidae	7	9	63
	Odonata	Gomphidae	6	1	6
2	Hemiptera	Corixidae	6	0	0
	Total		26		132

Hilsenhoff Biotic family index $= \frac{\sum n\,X\,TV}{N} = \frac{132}{26} = 5.076$

4. Discussion

Rivers, streams and lakes are the important surface water resources through which water supplies are managed. Water pollution indices are commonly used for the detection and evaluation of water pollution. The indices are broadly characterized into two parts; the physico – chemical indices and biological indices.

The physico-chemical factors of Vettiyar segment of Achankovil River showed medium water quality index. Faecal coliform, Dissolved Oxygen, P^H, BOD, Nitrate, Phosphate, Total Dissolved Solids are mainly responsible for the determination of water quality of a water body. Turbidity and TDS are also play crucial factors in determining the water quality. BOD is the amount of oxygen utilized by microorganisms in stabilizing the organic matter. In summer the value of BOD is 5.42. The high BOD value in summer indicates less flow, more plantation growth, more temperature and less Dissolved Oxygen content.

Turbidity is another parameter of water quality. Turbidity in waters is due to the clay, silt, organic matter and phytoplankton, turbidity makes the water unfit for domestic purposes, food and beverage industries and many other industrial uses. Turbidity values showed variation with season in most of the fresh water quality studies like Sanal Kumar, 2011. The water was acidic to neutral in nature. So P^H has no direct adverse effects on health; however, a lower value below 4 will produce sour taste and higher value above 8.5, an alkaline taste.

Temperature is basically important for its effects on the chemistry and biological reactions in the organisms in water. Temperature may be varying with difference in the atmospheric temperature. A rise in temperature of the water leads to the speeding up of the chemical reactions in water reduces the solubility of gases and amplifies the tastes and odours. Dissolved oxygen is one of the most important parameter in water quality assessment and reflects the physical and biological processes prevailing in the waters. The amount of DO in study area was 5.85mg/L. The Conductivity has a direct relationship with turbidity and TDS. When TDS and turbidity is more there will be corresponding to the conductivity also (Abbasi, 1997).

The Nitrate level of study area was moderate. This indicates the low level of river bank agriculture during summer reason. High amounts of nitrate are generally indicating pollution. The phosphate values also showed moderate level which is an indication of low level agricultural practices in the banks of the rivers. The major sources of phosphorus are domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste waters. The higher concentration of phosphorus therefore is indicative of pollution. Faecal coliform numbers is almost similar in all sites. The amount of fecal coliform is increased due to the various anthropogenic activities domestic sewage, faecal water etc. (Vaisakh *et al.,* 2014). The pollution tolerance insects were obtained from study area indicated that the Vettiyar segment has organic pollution also.

5. Summary and Conclusions

Most of the physico-chemical parameters and biological indicators of Achencovil river water from Vettiyar segment were within the range of moderately polluted general fluvial ecosystem. Presence of faecal coliforms and pollution tolerant aquatic insects were the key points towards the assessment that the river part is subjected to moderate or high anthropogenic activities and facing gradual quality degradation. Hence it can be suggested to have timely assessment of river pollution levels and imparting suitable controlling measures to prevent further quality degradation of river water, since it support its biotic inhabitants and other indirect consumers.

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