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ASSESSMENT OF WATER QUALITY OF NEYYAR RIVER, KERALA, INDIA

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Abstract: Neyyar is popularly known as the southernmost river of Kerala, which is under the verge of destruction due to indiscriminate pollution activities. In order to understand the river water quality, the physico-chemical characteristics are analyzed on monthly basis from May 2015 to April 2016. Six sampling sites namely Neyyar Dam, Kallikkadu, Mandapathinkadavu, Aruvippuram, Neyyattinkara and Poovar are fixed considering physiography as well as pollution. The parameters such as Water temperature, Total alkalinity, TDS, Salinity, Dissolved oxygen, Sodium, Nitrate and Phosphate are analyzed for this study. The river water seemed to be of poor quality in downstream stretches probably due to the high anthropogenic activities associated with the region together with the cumulative effect of all the contaminants emerging from highland portion onwards and salt water intrusion from the sea.

Keywords: Physico chemical parameters, Physiography, Saline intrusion, Correlation

INTRODUCTION

Rivers are very important in human progress by providing drinking water, making the earth fertile and serving as a medium for transportation. For centuries, humans have been enjoying the ecosystem services provided by rivers without understanding how the river ecosystem functions and maintains its vitality (Naiman, 1992). Man has changed the nature of rivers by controlling their floods, by constructing large impoundments, by overexploiting their living and non-living resources and by using rivers for disposal of wastes. Such taming of rivers and exploitation of riverine resources have often led to serious decline and causing serious implications on human health and the environment (Carpenter *et al.*, 1998). Global concern for the quality of river water in addition to quantity has been on the increase, in recent years. In India, the river water quality problems are intensified during the last few decades and now the situation has become alarming. Studies on the river ecosystems indicate that the major Indian rivers are grossly polluted, especially beside the cities (Srivastava, 1992). Rivers in Kerala face the problem of pollution caused by municipal wastes which include liquid, solid, industrial effluents and agricultural runoffs. Significance of water as a potent ecological factor can be appreciated only by studying its physico-chemical characteristics.

Neyyar River is one of the important small catchment rivers in the south-western coast of India, where the demand of water is increasing exponentially over the years in tune with increase in population and economic development. The River is extensively used for domestic, recreational, drinking and irrigation purposes in the area. But different municipal, chemical and domestic wastes are being disposed in to the river and people use this river for extensive sand mining without any concern for the life of the river. Therefore there is an urgent need for continuous monitoring of the river water quality so as to safeguard public health threats from using this water. Each water source should be monitored with utmost care and precision for laying down strategies for the effective conservation and management of the pristine water resources. In this perspective, the present study tries to focus on the water quality status along the course of Neyyar River from the upstream stretch to the downstream.

MATERIALS AND METHODS

Study area

Neyyar, the southern-most river of Kerala having a total basin area of 483sq. km, lies between 8°15’ to 8°40’N latitudes and 77°00’ to 77°20’E longitudes. The river’s main tributaries are Kallar, Karavaliar and Chittar. A network of six sampling stations is fixed along the Neyyar River such as Neyyar Dam (S-1), Kallikadu (S-2), Mandapathinkadavu (S-3), Aruvippuram (S-4), Neyyattinkara (S-5) and Poovar-Bund (S-6) considering the physiography (Fig. 1). The physiographic features of the sampling locations are provided in table. 1. While, considering pollution, the surface water is more polluted in the low land.

Water samples are collected from six sampling stations of the river monthly for 12 months from May 2015 to April 2016 and subjected to various physicochemical analyses. Water sample is analyzed for physicochemical parameters such as Water temperature (WT), Total alkalinity (TALK), Total dissolved solids (TDS), Salinity (SAL), Dissolved oxygen (DO), Sodium (Na), Nitrate (NO_3) and Phosphate (PO_4). In-situ determination is done for parameters such as Temperature and Alkalinity and samples of DO is chemically fixed in site itself. All the analyses are carried out following standard methods (APHA, 2012). Two-way analysis of variance (ANOVA) for each parameter between stations and months and simple correlation matrices between various water quality parameters for each station are analyzed using SPSS 16 software. Mean and standard deviation of the different water quality parameters for the six stations were also worked out

RESULTS AND DISCUSSION

According to rainfall pattern, the year has been divided into three sections viz., February to May (pre-monsoon), June to September (Monsoon) and October to January (Post-monsoon). Maximum rainfall generally occurs in Kerala during South-West

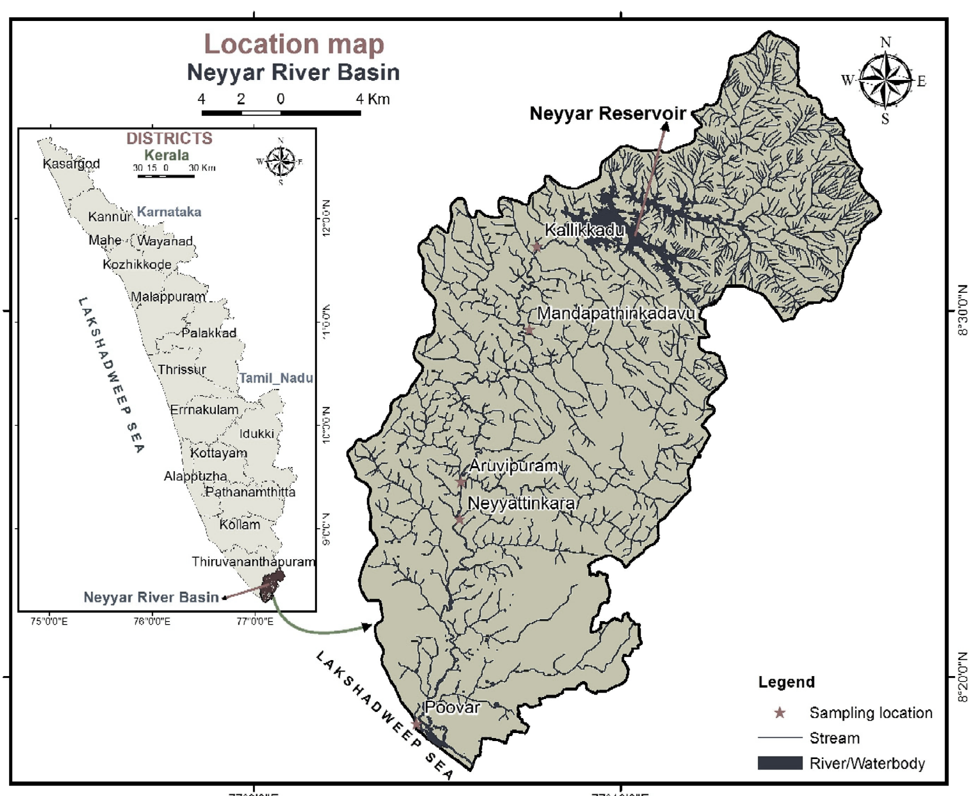

Fig. 1. Water sampling locations in Neyyar River

Table. 1. Physiographic features of sampling sites

Location	Latitude &Longitude	General Physiography
Neyyar Dam (S1)	N-08°32′6.3″ E-77°08′44.0″	Highland
Kallikadu (S2)	N-08°31′46.4″ E-77°07′39.4″	Highland
Mandapathinkadavu (S3)	N-08°29′27.9″ E-77°07′27.6″	Transition area
Aruvippuram (S4)	N-08°25′16.0″ E-77°05′34.1″	Midland
Neyyattinkara (S5)	N-08°24′9.6″ E-77°05′19.6″	Lowland
Poovar (S6)	N-08°19′22.9″ E-77°04′31.7″	Lowland

monsoon but there is also a considerable influence of the North-East monsoon during October and November. According to Abdul Aziz and Nair (1978) the southwest monsoon period, representing the principal rainy season in Kerala accounts for 60% of the total rainfall in the state. In the present study, rainfall indicates astonishingly lower southwest monsoon than the north east monsoon (Fig. 2), which has been observed in the southern districts of Kerala during the last 2-3 years. Such a shift in the rainfall pattern may have tremendous influence on the water availability and cropping pattern which needs to be investigated.

The fluctuations in the water quality parameters have a great deal of influence with this pattern of rainfall. Data of monthly variations in physico-chemical parameters recorded from six stations are illustrated in Table 2. The annual mean and SD of various water quality parameters are depicted in Table 3. The two way analysis of variance of different water quality parameters are showed in Table 4. The correlation co-efficient between the parameters of S-1, S-2 and S-3, S-4, S-5 and S-6 are presented in Table 5.

Temperature is an important water quality parameter that affects the physico-chemical and biological characteristics of aquatic environments. In the present study water temperature broadly fluctuates between 26^{0}C in June-2015 and 33.5^{0}C in March-2016 (Table 2). The annual mean values of water temperature revealed that among the six stations, the lowest value recorded in S-1 and highest in S-6 (Table 3). Two way anova showed significant variations for the water temperature between stations and between months at 5% level ($P<0.05$) (Table. 4). From February onwards water temperature recoded gradual increase with corresponding decrease in rainfall as well. So the study indicates that the fluctuation in water temperature has a relative influence of rainfall. Murugan and Ayyankkavu (1991a) have explained that such low temperature recorded during monsoon can be attributed to the monsoonal rain and cloudy sky while the high temperature observed during premonsoon months may be due to the high solar radiation. In the present study low water temperature observed during the months of october to november may be due to the heavy N-E monsoon and also due to the atmospheric temperature. Alkalinity is important in determining the ability of a stream to neutralize acidic pollution from rainfall or wastewater. Present study indicates that alkalinity values are very less all along the river during all the months (Table 2). The annual mean values of total alkalinity revealed that among the six stations, the lowest value recorded in S-1 and highest in S-6 (Table 3). Two way anova showed significant variations for the alkalinity between stations and between months at 5% level ($P<0.05$) (Table. 4). All samples show alkalinity values below the range prescribed by BIS (2004) for drinking purpose (120mg/l).

TDS refers to all solid materials present in solution either in ionised state or in non-ionised state and excludes suspended colloids or dissolved gases. The dissolved solids found commonly in rivers include chloride, sulphate, nitrate, bicarbonate and phosphates of sodium, potassium, calcium, magnesium, iron and manganese (EPA, 1976). In the present study total dissolved solids varied broadly between 17.86 mg/l in November-2015 to 7638.72mg/l in March-2016 (Table. 2). The annual mean values of TDS revealed that among the six stations, the lowest value recorded in S-1 and highest in S-6 (Table 3). Two way anova showed significant variations for the TDS between stations at 5% level ($P<0.05$) and no significant variation observed between months ($P>0.05$) (Table. 4). The abnormal rise in TDS observed at S-6, which may be due to salt water intrusion from the sea. A sudden rise in

Table. 2. Monthly distributions of Physico-chemical parameters of Neyyar River water

						Water Temperature (°C)						
Stations	**MAY**	**JUNE**	**JULY**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**
S1	28.00	26.50	28.00	27.00	26.50	27.00	27.00	27.50	30.00	30.00	31.00	30.50
S2	28.00	26.00	27.50	28.00	27.50	28.00	28.00	29.00	30.00	30.50	31.00	31.00
S3	28.50	26.50	26.50	30.00	29.50	29.00	29.00	29.00	31.00	31.00	31.50	32.00
S4	29.00	27.50	27.00	30.00	29.50	29.50	29.50	29.50	31.50	31.00	32.50	32.00
S5	30.50	29.50	28.50	30.50	30.00	30.00	30.00	31.00	32.00	32.00	33.50	32.50
S6	31.00	30.00	29.00	31.50	31.00	29.00	29.00	30.50	31.00	32.00	33.50	33.00
						Total Alkalinity (mg/l)						
Stations	**MAY**	**JUNE**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**
S1	17.26	14.84	18.67	15.41	16.15	12.26	13.83	15.55	18.47	19.62	21.18	21.24
S2	20.33	18.56	20.82	21.50	20.20	16.25	18.29	19.32	21.73	22.57	24.56	25.69
S3	19.29	17.64	21.75	22.79	22.54	16.62	17.76	20.80	24.91	22.49	23.92	26.53
S4	25.45	22.19	26.40	24.63	22.80	20.92	20.60	25.86	26.29	25.90	27.34	27.10
S5	33.79	30.26	31.82	31.36	30.46	28.39	27.25	29.46	32.30	34.16	36.09	35.43
S6	40.02	43.16	45.28	48.93	42.36	38.06	36.28	44.57	49.60	53.82	56.55	54.43
						TDS (mg/l)						
Stations	**MAY**	**JUNE**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**
S1	21.40	19.76	21.14	20.51	20.34	18.52	17.35	23.74	25.17	26.47	29.36	25.82
S2	31.54	28.43	35.32	30.32	29.58	27.30	24.56	30.86	36.46	39.34	41.38	40.69
S3	35.71	32.92	37.44	33.16	30.92	28.36	27.17	34.25	36.95	38.65	43.47	41.37
S4	39.20	37.80	42.06	40.44	40.25	30.10	28.42	35.91	39.27	41.35	44.56	47.74
S5	51.84	43.41	50.36	45.52	42.41	33.43	31.64	46.22	48.35	53.06	54.11	53.48
S6	5615.16	4391.53	5141.28	4564.96	3910.55	1853.86	1105.93	2741.72	4828.84	6180.69	7638.72	6980.87
						Salinity (ppt)						
Stations	**MAY**	**JUNE**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**
S1	0.10	0.04	0.06	0.07	0.05	0.03	0.02	0.06	0.08	0.16	0.23	0.14
S2	0.47	0.21	0.34	0.27	0.14	0.06	0.04	0.32	1.01	1.15	1.21	1.23
S3	0.49	0.14	0.45	0.42	0.23	0.17	0.12	0.46	0.59	0.72	0.89	0.81
S4	1.18	0.45	0.51	0.47	0.37	0.20	0.11	0.64	1.06	1.22	1.41	1.34
S5	2.08	0.67	1.25	0.83	0.87	0.42	0.35	1.06	1.48	1.97	2.47	2.06
S6	10.43	7.15	10.38	9.77	5.30	3.66	2.72	5.02	9.30	11.84	12.26	11.47
						DO (mg/l)						
Stations	**MAY**	**JUNE**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**
S1	5.60	6.27	5.33	5.45	5.66	6.26	5.94	6.05	5.47	5.22	5.04	5.37
S2	4.75	5.21	4.38	4.41	4.70	5.23	4.81	5.31	5.03	4.27	4.21	4.63
S3	5.02	5.62	4.58	4.64	5.40	5.91	5.27	5.39	4.93	4.44	4.26	4.71
S4	5.53	6.08	5.66	5.79	5.84	6.22	5.74	6.04	5.38	5.16	4.96	5.21
S5	4.45	5.01	4.16	4.20	4.36	5.13	4.93	4.71	4.25	4.17	4.10	4.23
S6	4.39	4.68	4.20	4.28	4.33	4.75	4.63	4.59	4.35	4.26	4.18	4.25
						Na (mg/l)						
Stations	**MAY**	**JUNE**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**
S1	3.01	2.50	3.40	3.13	2.80	2.64	2.43	2.75	3.11	3.61	4.24	3.84
S2	5.19	4.70	5.01	4.78	4.35	4.14	3.97	4.63	5.20	5.66	5.89	5.62
S3	6.80	5.70	6.12	6.01	5.24	4.53	4.30	5.80	6.72	6.84	7.30	7.04
S4	8.25	7.13	8.32	8.16	6.58	5.30	5.21	6.20	7.57	8.34	9.08	8.53
S5	13.70	10.70	14.40	12.72	10.17	7.26	7.13	10.40	13.62	15.45	16.70	15.60
S6	328.26	280.19	345.08	331.42	288.36	204.55	170.28	253.18	296.03	323.84	355.63	340.28
						Nitrate (mg/l)						
Stations	**MAY**	**JUNE**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**
S1	0.20	0.39	0.11	0.24	0.33	0.43	0.40	0.34	0.31	0.27	0.09	0.18
S2	0.37	0.45	0.23	0.32	0.36	0.47	0.41	0.36	0.32	0.28	0.25	0.36
S3	0.46	0.49	0.32	0.37	0.45	0.56	0.49	0.43	0.36	0.38	0.41	0.44
S4	0.39	0.47	0.31	0.32	0.43	0.51	0.48	0.41	0.34	0.29	0.27	0.35
S5	2.47	2.53	1.56	1.61	1.67	2.64	2.56	1.09	1.54	1.91	2.27	2.44
S6	2.53	3.24	2.03	2.19	2.34	3.36	3.05	1.41	1.82	2.06	2.38	2.49
						Phosphate (mg/l)						
Stations	**MAY**	**JUNE**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**
S1	0.030	0.040	0.010	0.020	0.030	0.050	0.040	0.030	0.020	0.020	0.010	0.020
S2	0.050	0.065	0.040	0.045	0.062	0.090	0.072	0.053	0.030	0.025	0.020	0.040
S3	0.060	0.070	0.040	0.050	0.070	0.100	0.080	0.060	0.040	0.045	0.050	0.056
S4	0.053	0.060	0.030	0.040	0.060	0.090	0.070	0.050	0.040	0.034	0.030	0.050
S5	0.064	0.080	0.060	0.063	0.075	0.120	0.090	0.060	0.050	0.056	0.060	0.060
S6	0.065	0.160	0.070	0.080	0.100	0.160	0.130	0.070	0.054	0.060	0.060	0.063

Table. 3. Annual Mean and SD of various Physico chemical parameters

S-1	Mean	Std. Deviation	N	S-2	Mean	Std. Deviation	N	S-3	Mean	Std. Deviation	N
WT	28.25	1.65831	12	WT	28.7083	1.58771	12	WT	29.4583	1.77685	12
TALK	17.04	2.85797	12	TALK	20.8183	2.65134	12	TALK	21.42	3.08328	12
TDS	22.465	3.61877	12	TDS	32.9817	5.53587	12	TDS	35.0308	4.91943	12
SAL	0.0867	0.06169	12	SAL	0.5375	0.47034	12	SAL	0.4575	0.26102	12
DO	5.6383	0.40584	12	DO	4.745	0.38479	12	DO	5.0142	0.50916	12
Na	3.1217	0.55871	12	Na	4.9283	0.61237	12	Na	6.0333	0.97212	12
NO3	0.2742	0.11229	12	NO3	0.3483	0.07371	12	NO3	0.43	0.06674	12
PO4	0.02667	0.012309	12	PO4	0.04933	0.020464	12	PO4	0.06008	0.017686	12
S-4	Mean	Std. Deviation	N	**S-5**	Mean	Std. Deviation	N	**S-6**	Mean	Std. Deviation	N
WT	29.875	1.66686	12	WT	30.8333	1.41956	12	WT	30.875	1.49431	12
TALK	24.6233	2.38249	12	TALK	31.7308	2.75468	12	TALK	46.0883	6.62044	12
TDS	38.925	5.46063	12	TDS	46.1525	7.47124	12	TDS	4579.51	1965.4944	12
SAL	0.7467	0.46516	12	SAL	1.2925	0.71193	12	SAL	8.275	3.35784	12
DO	5.6342	0.39542	12	DO	4.475	0.37056	12	DO	4.4075	0.20037	12
Na	7.3892	1.29854	12	Na	12.3208	3.18082	12	Na	293.09	58.15704	12
NO3	0.3808	0.0796	12	NO3	2.0242	0.52109	12	NO3	2.4083	0.57926	12
PO4	0.05058	0.017738	12	PO4	0.06983	0.019319	12	PO4	0.08933	0.039132	12

Table. 4. Two way anova of various physico chemical parameters

Parameters	Comparison	F	P-value	F-crit
WT (°C)	Between stations	34.86792	6.91×10^{-16}	2.382823
	Between months	33.49057	2.02×10^{-20}	1.967547
T.Alk (mg/l)	Between stations	319.502	2.54×10^{-39}	2.382823
	Between months	14.4133	1.53×10^{-12}	1.967547
TDS (mg/l)	Between stations	52.93928	1.87×10^{-15}	2.605975
	Between months	1.028111	0.438152	2.077248
Salinity (ppt)	Between stations	74.74733	2.84×10^{-23}	2.382823
	Between months	2.723501	0.007031	1.967547
DO (mg/l)	Between stations	130.0858	3.47×10^{-29}	2.382823
	Between months	27.72537	1.56×10^{-18}	1.967547
Na (mg/l)	Between stations	302.9617	1.04×10^{-38}	2.382823
	Between months	1.269508	0.266474	1.967547
NO_3 (mg/l)	Between stations	153.5312	5.16×10^{-31}	2.382823
	Between months	3.675456	0.000604	1.967547
PO_4 (mg/l)	Between stations	40.07998	3.75×10^{-17}	2.382823
	Between months	18.15721	1.51×10^{-14}	1.967547

Table. 5. Correlation coefficient between various physico chemical parameters

S-1	WT	TALK	TDS	SAL	DO	Na	NO3	PO4	S-4	WT	TALK	TDS	SAL	DO	Na	NO3	PO4
WT	1								WT	1							
TALK	0.881**	1							TALK	0.449	1						
TDS	0.911**	0.869**	1						TDS	0.383	0.826**	1					
SAL	.866**	0.847**	0.909**	1					SAL	0.661*	0.836**	0.746**	1				
DO	-0.751**	-0.869**	-0.716**	-0.782**	1				DO	-0.707*	-0.724**	-0.683*	-0.859**	1			
Na	0.870**	0.913**	0.859**	0.922**	-0.885**	1			Na	0.33	0.836**	0.903**	0.795**	-0.759**	1		
NO3	-0.616*	-0.821**	-0.615*	-0.714**	0.853**	-0.855**	1		NO3	-0.455	-0.876**	-0.784**	-0.717**	0.800**	-0.884**	1	
PO4	-0.668*	-0.855**	-0.713**	-0.674*	0.916**	-0.829**	0.886**	1	PO4	-0.256	-0.851**	-0.744**	-0.623*	0.691*	-0.838**	0.944**	1
S-2	WT	TALK	TDS	SAL	DO	Na	NO3	PO4	**S-5**	WT	TALK	TDS	SAL	DO	Na	NO3	PO4
WT	1								WT	1							
TALK	0.764**	1							TALK	0.690*	1						
TDS	0.814**	0.898**	1						TDS	0.532	0.920**	1					
SAL	0.889**	0.874**	0.945**	1					SAL	0.726**	0.956**	0.901**	1				
DO	-0.406	-0.679*	-0.591*	-0.48	1				DO	-0.466	-0.783**	-0.809**	-0.723**	1			
Na	0.724**	0.874**	0.949**	0.925**	-0.593*	1			Na	0.585*	0.955**	0.963**	0.904**	-0.867**	1		
NO3	-0.486	-0.676*	-0.722**	-0.559	0.785**	-0.670*	1		NO3	0.028	0.029	-0.274	0.003	0.441	-0.177	1	
PO4	-0.685*	-0.855**	-0.879**	-0.840**	0.666*	-0.895**	0.865**	1	PO4	-0.44	-0.669*	-0.843**	-0.676*	0.819**	-0.803**	0.575	1
S-3	WT	TALK	TDS	SAL	DO	Na	NO3	PO4	**S-6**	WT	TALK	TDS	SAL	DO	Na	NO3	PO4
WT	1								WT	1							
TALK	0.702*	1							TALK	0.854**	1						
TDS	0.48	0.752**	1						TDS	0.818**	0.840**	1					
SAL	0.701*	0.798**	0.944**	1					SAL	0.717**	0.817**	0.954**	1				
DO	-0.475	-0.715**	-0.799**	-0.821**	1				DO	-0.660*	-0.743**	-0.808**	-0.830**	1			
Na	0.473	0.728**	0.948**	0.908**	-0.770**	1			Na	0.682*	0.751**	0.928**	0.933**	-0.864**	1		
NO3	-0.153	-0.675*	-0.582*	-0.546	0.784**	-0.594*	1		NO3	-0.328	-0.475	-0.302	-0.374	0.549	-0.453	1	
PO4	-0.253	-0.739**	-0.750**	-0.699*	0.831**	-0.794**	0.948**	1	PO4	-0.630*	-0.675*	-0.666*	-0.726**	0.823**	-0.709**	0.829**	1

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

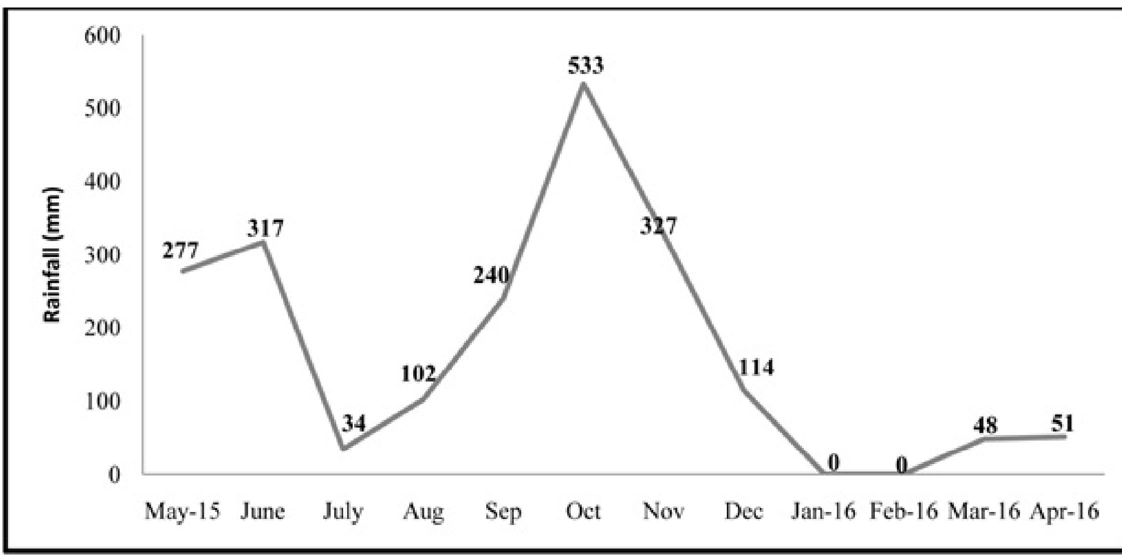

Fig. 2. Rainfall of Neyyattinkara gauging station (2015-16) (Source: IMD, Thiruvananthapuram).

content of TDS can often indicate pollution by an extraneous source (Aboo and Mandal 1967). Highest concentration of TDS in the month of March may be due to evaporation and high temperature.

Salinity plays a major role in controlling various physical, chemical and biological processes occurring in the aquatic environment. In the present study, the salinity varied broadly between 0.02ppt in November-2015 to 12.26ppt in March-2016 (Table 2). The annual mean values of salinity revealed that among the six stations, the lowest value recorded in S-1 and highest in S-6 (Table 3). Two way anova showed significant variations for the salinity between stations and between months at 5% level ($P<0.05$) (Table 4). In Poovar (S-6) impact of saline intrusion was obvious in the distribution of salinity. A saline intrusion component may be present in some waters (Banks *et al*., 1998).

Dissolve oxygen is indispensable for the maintenance of life processes of all organisms. The DO values in this study range from 6.26mg/l in October-2015 to 4.10mg/l in March-2016 (Table. 2). Annual mean values of DO revealed that among the six stations, the lowest value recorded in S-1 and highest in S-6 (Table 3). Two way anova showed significant variations for the DO between stations and between months at 5% level ($P<0.05$) (Table 4). The higher concentration of DO during winter can be attributed to the fact that cold water contains more oxygen as compared to warm water as the DO is inversely proportional to the water temperature (Hynes, 1988).

Sodium is an important alkali metal found in all fresh waters. The main sources of Na in water resources are from rocks and clay minerals. In the case of sodium, the values are very less during all months in the high land and midland stations whereas in Poovar, the lowland station, values are very high. The values ranged from 2.43mg/l in November-2015 to 355.63mg/l in March-2016 (Table 2). Annual mean values of Na revealed that among the six stations, the lowest value recorded in S-1 and highest in S-6 (Table 3). Two way anova showed significant variations for Na between stations at 5% level ($P<0.05$) and no significant variation observed between months ($P>0.05$) (Table. 4). In the present study the distribution of sodium follows the same trend of TDS and salinity. Sodium is found in association with high concentration of chloride resulting in salinity (Roshinebegam and Selvakumar, 2014).

Nitrate is the highly oxidized form of nitrogen compounds; it is commonly present in surface and ground waters, because it is the end product of aerobic decomposition of organic nitrogenous matter. Though very low nitrate is detected in some months from the upstream when samples in the mid and lowland invariably show considerable concentrations of the nutrient. The values ranged between 0.09mg/l in March-2016 and 3.36mg/l in October-2015 (Table 2). Annual mean values of nitrate revealed that among the six stations, the lowest value recorded in S-1 and highest in S-6 (Table 3). Two way anova showed significant variations for the DO between stations and between months at 5% level ($P<0.05$) (Table 4). The high concentration may be due to the leaching from the drainage or due to the cesspool or improper sanitation. High values of nitrate during rainy season can be due to influx of nitrogen rich flood water that brings large amount of contaminated sewage water. Such heavy concentrations of nitrate associated with monsoon rain have been reported from several areas (Nair *et al.,* 1983).

The phosphorus occurs in natural waters almost solely as phosphates rather a free state. The phosphate values ranged between 0.010mg/l in March-2016 and 0.16mg/l in June and October-2015 (Table 2). Annual mean values of phosphate revealed that among the six stations, the lowest value recorded in S-1 and highest in S-6 (Table 3). Two way anova showed significant variations for the phosphate between stations and between months at 5% level ($P<0.05$) (Table. 4). Phosphate values comparatively high at Poovar are possibly due to the continuous contact of seawater. The highest concentration in rainy months is in agreement with the observations of Chakraborthy *et al.* (1959).

Pearson Correlation matrix was computed between the different physico-chemical parameters for each station. The parameters showed fluctuations according to the change in months in each station. So the correlation clearly depicted between parameters with in a station. In S-1 water temperature was found to be positively significant at 1% level with total alkalinity, TDS, salinity and Na. The dissolved oxygen showed negatively significant correlation at 1% level with water temperature, total alkalinity, TDS and salinity. Similar correlation pattern was observed in S-2, S-3, S-4, S-5 and S-6 with fluctuations in the level of significance. Nutrients such as NO_3 and PO_4 showed negatively significant correlation at both 1% and 5% level with all other parameters in S-1, S-2, S-3, S-4 and S-6 (Table 5). This clearly indicates the increase in concentration of nitrate and phosphate in heavy monsoon months; consequent to decrease in other parameters and vice versa in pre-monsoon months.

But at S-5 nitrate showed moderately positive correlation with water temperature. This clearly indicates the high rate of decomposition in Premonsoon months resulted in the increase in concentration of nitrate. Dissolve oxygen has a moderately significant positive correlation with NO_3 and PO_4, which might be due station specific increase in DO during monsoon month consequent to the increase in nutrient concentration, where as the annual mean of DO decreases from highland to lowland (S-1 to S-6) with corresponding increase in nutrient concentration, reaches its maximum at Poovar (S-6), which is located above the estuary. Much evidence has linked low DO levels to the enrichment of estuaries with nutrients (Morris *et al*., 1978).

CONCLUSIONS

This study it is revealed that deterioration of quality of water is very high at downstream stretches of the river. This is due to high anthropogenic disturbances associated with the region. Wild use of chemical fertilizers and pesticides, devious dumping of domestic wastes are also the major causes of deterioration of water especially in Neyyattinkara and Poovar sampling stations. The quality of water is depleting rapidly with the change in human life style i.e., construction activities, utilization of agricultural land and forest land for other developmental purposes and poor waste management. It is evident that water quality problems prevalent in the region are due to improper disposal of refuse, contamination of water by sewage and surface runoff. Apart from the lowering of water quality, the estuarine contact may also adversely impact the fresh water system at Poovar. Therefore a programme must be devised to educate the general public on the proper disposal of refuse, treatment of sewage for a broader perspective for maintaining fresh water.

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REFERENCES

Abdul Aziz, P.K. and Nair, N.B. 1978. The nature of pollution in the retting zones of the backwaters of Kerala. *Aquatic Biology* 3: 41-62.

Aboo, K.M. and Mandal, K.C. 1967. Preliminary observation on upper lake of Bhopal. *J.Env. Health*, 9-12.

APHA. 2012. Standard Methods for examination of water and wastewater (22nd ed.), 1175 pp. American Public Health Association, Washington DC.

Banks, D., Reimann, C. and Skarphagen, H. 1998. The comparative hydrochemistry of two granitic island aquifers: The Isles of Scilly, UK and the Hvaler Islands, Norway. *The Science of the Environment. Elsevier Science B.V.* 209: pp. 169-183.

Bureau of Indian Standards, Indian Standards (IS: 10500). 2004. Drinking Water Specification: New Delhi.

Chakraborthy, R.D., Ray, P. and Singh, S.B. 1959. A quantitative study of the plankton and the physico-chemical conditions of the River Yamuna at Allahabad in 1954-55. *Indian J Fish.* 6: pp. 186-203.

Carpenter, S.R., Caraco, N.F., Correll., D.L., Howarth, R.W., Sharpley, A.N. and Smith, V.H. 1998. Non-point pollution of surface waters with phosphorus and nitrogen. *Ecological Applications* 8: 559-568.

EPA. 1976. In: Quality criteria for water, Environmental protection agency, Washington, D.C.

Hynes, H.B.N. 1988. Biogeography and origins of the North American Stoneflies (Plecoptera). *Mem.Ent.Soc.Can* 144: 31-37.

Morris, A.W., Mantoura, R.F.C., Bale, A.J. and Howland, R.J.M. 1978. Very low salinity regions of estuaries: Important sites for chemical and biological reactions. *Nature* 274: 678-680.

Murugan, A. and Ayyankkannu, K. 1991a. Ecology of Uppanar Backwater, Cuddalore, 1. Physico-chemical parameters. *Mahasagar* 24 (1): 31-38.

Naiman, R.J. 1992. New Perspectives for Watershed Management. In: R. J. Naiman (ed.), Watershed Management: Balancing Sustainability and Environmental Change. *Springer-Verlag*, New York, pp. 3-11.

Nair, N.B., Abdul Azis, P.K., Dharmaraj, K., Arunachalam, M., Krishna Kumar, K. and Balasubramanian, N.K. 1983. Ecology of Indian estuaries, Part I: Physico-chemical features of water and sediment nutrients of Ashtamudi estuary. *Ind. J. Mar. Sci* 12: 143-150.

Srivastava, C.P. 1992. Pollutants and nutrients status in raw sewage. *Indian Journal Environment Protection* 18: 109-111.

Roshinebegam, K. and Selvakumar, S. 2014. Seasonal Changes in Physico-Chemical Parameters of Mullai Periyar River, Tamil Nadu, India. *Chem. Sci. Rev. Lett* 3(9): 66-73.