EVALUATION OF PHYSICO - CHEMICAL PARAMETERS AND MICROBIOLOGICAL POPULATIONS OF CAUVERY RIVER WATER IN THE PALLIPALAYAM REGION OF TAMILNADU, INDIA

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Abstract

The present investigation was carried out to evaluate physico-chemical parameters and total heterotrophic bacterial and fungal populations from Cauvery River water in the Pallipalyam region during the period from January 2009 to December 2009 . Physico-chemical parameters were analyzed using APHA standard procedure and microbiological count done by standard pour plate technique. The Physico-chemical parameters like temperature, hydroxyl ionic concentration (pH), electrical conductivity recorded were in a range of 24.7 - 29 C ^{o}, 7.5 - 9.2, and 406 - 982 µS/cm respectively. Besides, turbidity, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total hardness and Total alkalinity of river water samples recorded were in the ranges of 7 – 11 NTU, 5 - 12mg/L, 291-701mg/L , 3 - 5mg/L, 228-364mg/L, and 139 - 245mg/L respectively. Nitrite, Phosphate, Chemical Oxygen Demand (COD) and Chloride of the river water exhibits within the ranges of 0.012 - 0.102 mg/L, 0.019 -.023 mg/L, 41.08 - 77.24 mg/L, and 53.56 - 143.16 mg/L respectively. A calcium and magnesium levels of the water samples during the study period were analyzed and the results recorded were in the ranges of 57.31 - 101.4 mg/L and 27.22 - 57.35 mg/L respectively. The amount of Sodium, Potassium and Ammonical nitrogen of the water samples estimated were in the ranges of 35.44 - 88.57 mg/L and 3 - 8 mg/L, 5.83 and 3.26 mg/L respectively. Bicarbonates and carbonates levels analyzed during the study period recorded were in the ranges of 164.7-303.78 mg/L and 2.4 - 9.6 mg/L respectively. The total bacterial and fungal populations were recorded during the study period. The maximum and minimum values of population density were ranged between 4.3 - 0.5 X 10^{3} CFU/ml, and 3.2 - 0.1 X 10^{3} CFU/ml respectively. The values of Physico-chemical parameters recorded were indicated that, the river was polluted in terms of increased accumulation of xenobiotics compounds by anthropogenic activities .The immediate attention from the concerned authorities is required to protect river from further pollution.

Index Terms**:** *River Cauvery, Physico-Chemical parameter, Microbial Population, Statistical analysis*

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1. INTRODUCTION

Water is an essential constituent of all forms of life. Not surprisingly, the unique properties of water make us wonder if it was specially created for living organisms since no other liquid can absolutely replace it. The shift in lifestyles of human communities from the traditional to the modern and urban involved the destruction of valuable non-renewable natural resources and the disintegration of the environment. Hence, billions of gallons of wastes resulting from industrial activities, housing settlements, and agricultural process are discharged into river and fresh water bodies, leading to the transformation of rivers to sewers (Srinivasan *et al.* 1980, Navneet Kumar and Sinha 2010, Mary Helen *et al.* 2011, Ramkumar, *et al.* 2010). These problems are aggravated by the persistence of non-degradable inorganic and organic pollutants and hazardous heavy metals (Abida begum *et al.* 2009). This is because our environmental laws play hide-and-seek with environmental quality even at the cost of massive ecological damage. The Cauvery river is one of the major rivers of India and is also considered sacred. The Cauvery basin extends over an area of 81,155km^{2}, which is nearly 24.7% of the total geographical area of the country. Four major tributaries, namely, the Bhavani, Noyal, Amarvathi and Thirumanimuthar rivers confluence with the Cauvery river (Hema *et al.*, 2010). The primary uses of the river's waters are for agricultural activities, household consumption, drinking, electricity etc, but nowadays the water quality of the river water is deteriorated overwhelmingly because of industrial activities, and pollution from sewage wastes, washing, bathing and miscellaneous activities (Abita begum and Harikrishna 2008; Venkatesraju *et al.* 2010). Up till now, many investigators have carried out studies on the Cauvery river but only a few are available on the Pallipalayam region of the river despite the fact that this part of the river is heavily polluted with industrial wastes, mainly from dyeing units. The

beneficial microflora of the river have been greatly reduced by xenobiotic compounds which might lead to the survival of only those organisms resistant to these compounds (Venkateshraju *et al*.2010). Evaluations of polluted water for their physicochemical and biological parameters are essential for future pollution abatement programmes (Saradhamani *et al.* 2002 and Mohammad Subhan *et al.* 2012). For this study, the sampling point (Pallipalayam region) was selected on the basis of its importance; and an attempt has been made to check the water quality by physicochemical and microbiological analyses over a period of a 12 months (January, 2009 – December, 2009). The statistical Pearson correlation matrix and Tukey HSD ANOVA analysis are highly useful tool for correlating different parameters. Correlation analysis measures the closeness of the relationship between the chosen independent and dependent variables.

2. MATERIAL AND METHODS

2.1 Study-area description

Pallipalayam is one of the municipal towns in the Namakkal district of Tamilnadu, lying between 11 0 10' and 11 0 20' Northern latitudes and between 77 0 30' and 77 0 40' Eastern longitudes. The river bed is rocky in the plains, which support the growth of agriculture, freshwater fauna, and flora of the Pallipalayam region.

2.2 Sample collection

Water samples were collected from the Pallipalayam region for a period of one year (January, 2009 to December, 2009) for the evaluation of physico-chemical parameters and enumeration of microbial populations. Samples were collected during the first week of every month in sterile plastic containers, transported to the laboratory after addition of a preservative reagent, and stored at 4oC till analyzed. They were then tested for various physico-chemical and microbiological parameters using standard methods.

2.3 Physico-Chemical parameters

Physicochemical determinations on the water samples were carried out through standard methodologies of the American Public Health Association (APHA, 2005). Electrical Conductivity (EC), pH, Temperature (Temp) and Turbidity (TDY) were measured in situ. Spectrophotometric determinations for the study were carried out with a UV-Visible spectrophotometer (UV-Vis Double-beam Spectrophotometer, Systronics 2201). Besides, the following parameters were determined according to the methods in parantheses mentioned next to them: Dissolved Oxygen (Winkler's method), Total Dissolved Solids, Total Suspended Solids, and Total Hardness (EDTA titration method), Total Alkalinity (Acid titration method), Ammonia (Kjeldhal's titration method), Nitrite (Spectrophotometric method), Nitrate (Ultraviolet Spectrophotometric Screening Method), Phosphate (Stannous chloride Spectrophotometric method), Chemical Oxygen Demand (Closed reflux titration method), Biochemical Oxygen Demand (Bio-assay and Winkler's method), Chlorides (Argentometric Method), Sulphates (Turbidity method), Magnesium (EDTA titration method), and Sodium and Potassium (Flame Photometric Method). The results for all parameters, except pH and EC were expressed in mg/l (APHA 2005,Tirevedi and Goel 1986).

2.4 Enumeration of total heterotrophic bacterial populations

To determine total heterotrophic bacterial populations, samples were collected in sterile containers and immediately transported to the laboratory. Bacteria and fungi were enumerated and represented as colony forming units (CFU/ml) by employing a standard pour-plate method according to Cappuccino and Sherman (1999).

2.5 Statistical Analysis

Pearson correlation matrix and Tukey HSD ANOVA were calculated to assess the relationship between the physicochemical parameters and to evaluate quarterly variations in the physicochemical properties of the water samples. The data were processed using SPSS package, Version 13.

3. RESULTS AND DISCUSSION

The work was carried out during the period January, 2009 to December, 2009. The river in the Pallipalayam region was assessed for its quality through determinations of the physicochemical properties and enumeration of the microbial population of water samples from the riverbank areas. A descriptive summary of the physicochemical properties of the water samples is presented in Table.1. The temperature profile of the water lay within the range 24.7-29˚C and the mean temperature was 26.88˚C for the period. The minimum and maximum temperatures were recorded during September and May/June of the year, respectively. Hydroxyl ionic concentration at the sampling site corresponded to a pH 7.5-9.2, with the average at 8.15 during the study. The water sample was slightly alkaline throughout the duration of the study. Electrical conductivity values of the water samples were in the range 406-982 µS/cm, with the mean at 654.17µS/cm whereas higher values for this were recorded between the months of March and June. The turbidity of the water samples was observed to lie in the range 7-11NTU during the study, with the average at 8.17NTU. A higher level of turbidity was recorded in the month of September due to the higher rainfall along the banks of the Cauvery River.

The dissolved oxygen content of the river water was about 5.12mg/L throughout the study and a lower level of DO was recorded during the month of May (3.38mg/L). In the month of September the DO level rose on account of higher rainfall along the river catchment areas. The solid content of the water

samples was measured separately for dissolved solids and suspended solids. The results showed TDS and TSS levels as being within the range 291-701mg/L and 3-5mg/L, respectively, during the study period. Values for total hardness of the water were within the range 228-364mg/L, with the average at 281mg/L, during the study. The maximum hardness level was recorded in the month of April.

Total alkalinity of the water was within the range 139-245mg/L, with the mean at 166.08 mg/L; the minimum and maximum levels were recorded during the months of December and April, respectively, of the study year. Phenolphthalein alkalinity values were recorded during the months May-August within the range 4-16 mg/L; the remaining periods of the study did not reveal any phenolphthalein alkalinity in the water samples. Ammonical nitrogen in the present study reached a maximum (5.83 g/L) and minimum (3.26 g/L) level in June and September, respectively. The nitrite content of the river water had values within the range 0.012-0.102 mg/L, with the mean level at 0.047 mg/L, during the study. The stagnant nature of the water during the month of May could have increased the nitrite content while the rainy period could have decreased it to 0.012 mg/L, as observed in the month of September. The nitrate content of the water sample was analyzed within the range 1.24-3.01 mg/L, with the average level at 1.92 mg/L, during the study. The phosphate levels of the water were within the range 0.019-.023 mg/L, with the mean level at 0.0154 mg/L, during the study. The maximum phosphate level during the study was recorded in the month of December.

Chemical oxygen demand values of the water were measured within the range 41.08-77.24 mg/L, with the average at 58.52 mg/L, during the study. The minimum and maximum levels were recorded during the months of June and November, respectively. Biological oxygen demand measurements at the sampling site showed values within the range 10.77-31.77 mg/L, with an average of 24.63 mg/L. The maximum BOD was recorded in the month of May and the minimum in September of the year of study. Chloride content in the present study was within the range 53.56-143.16 mg/L, with the mean at 102.45 mg/L. The minimum and maximum levels were recorded in the month of February and May, respectively. Sulphate content of the water attained the minimum (10.34 mg/L) and maximum (59.67 mg/L) levels during the months of November and May, respectively. The calcium and magnesium levels of the water were also assessed and the results for these were within the ranges 57.31-101.4 mg/L and 27.22-57.35 mg/L, respectively. Sodium and potassium levels of the water attained the minimum and maximum of 35.44 mg/L and 88.57 mg/L, respectively (for sodium), and 3 mg/L and 8 mg/L, respectively (for potassium). The average values for sodium and potassium were 58.62 mg/L and 4.83 mg/L, respectively. The levels of bicarbonates and carbonates during the study were found to lie within the ranges 164.7-303.78 mg/L and 2.4-9.6 mg/L, respectively. A correlation matrix for the present study showed significant positive and negative relationships between the parameters, as seen in Table.2. The study results were segregated into four quarter-periods for the enumeration of significant seasonal variations in each parameter. The results showed significant variations in EC, TDS, TH, Cl and Ca during the period of the study. The complete ANOVA results are presented in Table.3. A consolidated report of all the physicochemical parameters studied showed values for these to be significantly higher than their standard limits on account of pollution of the river water by industrials activities (WHO 1990, Raja et al. 2008, Abita begum et al. 2009, Hema et al. 2010, Shiddamallaya and Pratima, 2008). Indian rivers are under a severe threat of pollution by industrial effluents and municipal sewage wastes, and from anthropogenic activities of a dense population, leading to a major alteration in the physicochemical qualities of water (Varun prasath and Nicholas daniel 2010). According to a news report of May 01, 2008, in The Hindu, dyeing units, power looms, and various miscellaneous industries have increased their discharge of effluents into neighboring water bodies which finally find their way into the Cauvery river basin and its tributaries. Mohamed Abubaker Sithik et al. (2009) reported pollution of water in places of pilgrimage such as Agnitheertham and Kothandaramar Temple; the south-eastern coast of India is contaminated by faecal coliforms. The growth of phytoplankton as an index of pollution of water by industrial activities was reported by Shekhar et al. (2008); a comparison of phytoplankton species diversity and physico-chemical parameters between two perennial polluted water bodies was reported by and Rajagopal et al. (2010). Tables 4 & 5 show a decrease in total heterotrophic populations on account of pollution by industrial toxic effluents. A consequence of this is a drastic reduction in the population of beneficial microflora of river water involved in natural waste degradation. The predominant bacterial and fungal species identified based on Bergey's Systematic Manual of Bacteriology (David R Boone et al.,2001),) were Pseudomonas sp, Bacillus sp, Cornybacterium sp Acinetobacter sp, Aspergillus sp and Penicillum sp (data not shown). These species are able to degrade the toxic endocrine disrupting chemical (EDC), bisphenol-A, due to their acquired resistance mechanisms (Vijayalakshmi and Ramadas 2010). The population of fungal and bacterial flora are less in the summer season because of the climatic conditions. Likewise, the fewer microbes that survived the winter season increased in number during the monsoon. Saradhamani et al. (2002) reported that beneficial Phyto- and Zoo-plankton populations in river water are greatly reduced by the load of organic wastes from the paper mills and other industries. Abita begum and Harikrishna (2008) reported that rotifer species are disappearing from rivers due to pollution, and only species capable of tolerating the increased organic loads. Venkatesraju et al. (2010) reported that high concentrations of coliforms in river water due to municipal sewage disposal render the water unfit for human consumption

CONCLUSIONS

The present study attempts to analyze the physico-chemical and microbiological parameters of water from a part of the Cauvery river (Pallipalayam region). The levels for these parameters are higher than their acceptable limits; the decreased levels of beneficial microbial populations in the river water samples are an indication that the river is encumbered with large quantities of xenobiotic compounds. A continuous monitoring of the quality of water and steps to prevent further pollution of the river are to be taken to stop further deterioration in the water quality.

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Table - 1. Descriptive summary of the physicochemical properties of sampling point (Pallipalalyam)

Parameters	N	Range	Mini	Max	Sum	Mean	Std. Dev	Variance
Temp (˚C)	12	04.30	24.70	29.00	322.60	26.88	1.779	3.167
pH	12	01.70	7.50	9.20	97.80	8.15	0.511	0.261
EC (µS/cm)	12	576.00	406.00	982.00	7850.00	654.17	173.724	30180.152
DO (mg/L)	12	01.74	3.38	5.12	47.72	3.98	0.477	0.228
Tdy (NTU)	12	04.00	7.00	11.00	98.00	8.17	1.193	1.424
TDS (mg/L)	12	410.00	291.00	701.00	5608.00	467.33	122.961	15119.515
TSS (mg/L)	12	02.00	3.00	5.00	45.00	3.75	0.754	0.568
TH (mg/L)	12	136.00	228.00	364.00	3372.00	281.00	42.166	1778.000
TA (mg/L)	12	114.00	135.00	249.00	1993.00	166.08	30.315	918.992
PA (mg/L)	4	12.00	4.00	16.00	29.00	7.25	5.852	34.250
AN (mg/L)	12	2.57	3.26	5.83	50.68	4.22	0.862	0.743
NO_2 (mg/L)	12	0.09	0.01	0.10	0.57	0.05	0.029	0.001
NO_3 (mg/L)	12	1.77	1.24	3.01	22.98	1.92	0.526	0.277
PO_4 (mg/L)	12	0.21	0.02	.23	1.85	0.15	0.059	0.004
COD (mg/L)	12	36.16	41.08	77.24	702.28	58.52	10.413	108.432
BOD (mg/L)	12	21.00	10.77	31.77	295.57	24.63	5.894	34.734
Cl (mg/L)	12	89.60	53.56	143.16	1229.35	102.45	28.197	795.051
SO_4 (mg/L)	12	49.33	10.34	59.67	312.45	26.04	15.148	229.471
Ca (mg/L)	12	44.09	57.31	101.40	993.95	82.83	15.411	237.504
Mg (mg/L)	12	30.13	27.22	57.35	432.55	36.05	8.604	74.040
Na (mg/L)	12	53.13	35.44	88.57	703.46	58.62	18.783	352.791
K (mg/L)	12	5.00	3.00	8.00	58.00	4.83	1.267	1.606
HCO_3 (mg/L)	12	139.08	164.70	303.78	2431.46	202.62	36.984	1367.828
CO_3 (mg/L)	4	7.20	2.40	9.60	17.40	4.35	3.511	12.330

Table - 2. Correlation matrix of the physicochemical properties of Pallipalayam water sample

	Temp	pH	EC	DO	Tdy	TDS	TSS	TH	TA	PA	AN	NO2	NO3	TP	COD	BOD
Te mp	1	.681(a)	.439	-.472	-.059	.444	.058	.327	.341	.518	.789(b)	.815(b)	.198	.560	-.560	.454
pH	.681(a)	1	.268	-.444	.194	.267	-.177	.217	-.136	.996(b)	.694(a)	.573	-.073	.161	-.586(a)	.404
EC	.439	.268	1	-.292	-.193	1.00(b)	.045	.981(b)	.792(b)	.226	.729(b)	.723(b)	.489	.364	-.562	.231
DO	-.472	-.444	-.292	1	.245	-.295	.452	-.161	.146	.163	-.384	-.410	-.202	-.705(a)	.394	-.993(b)
Tdy	-.059	.194	-.193	.245	1	-.191	.455	-.213	-.184	-.641	-.070	.027	.295	-.294	-.029	-.258
TDS	.444	.267	1.00(b)	-.295	-.191	1	.052	.980(b)	.795(b)	.222	.732(b)	.726(b)	.492	.374	-.565	.235
TSS	.058	-.177	.045	.452	.455	.052	1	.017	.451	.543	.056	.053	.132	-.015	-.025	-.431
TH	.327	.217	.981(b)	-.161	-.213	.980(b)	.017	1	.787(b)	.297	.668(a)	.640(a)	.415	.254	-.518	.092
TA	341	-.136	.792(b)	.146	-	.795(b	.451	.787	1	.004	.487	.564	.440	.257	-.254	-.169

					.184	)		(b)								
PA	.518	.996(b)	.226	.163	-.641	.222	.543	.297	.004	1	.741	-.412	-.733	-.268	-.619	-.213
AN	.789(b)	.694(a)	.729(b)	-.384	-.070	.732(b)	.056	.668(a)	.487	.741	1	.820(b)	.260	.492	-.875(b)	.333
NO_2	.815(b)	.573	.723(b)	-.410	.027	.726(b)	.053	.640(a)	.564	-.412	.820(b)	1	.423	.502	-.585(a)	.382
NO_3	.198	-.073	.489	-.202	.295	.492	.132	.415	.440	-.733	.260	.423	1	.194	-.274	.183
TP	.560	.161	.364	-.705(a)	-.294	.374	-.015	.254	.257	-.268	.492	.502	.194	1	-.540	.692(a)
COD	-.560	-.586(a)	-.562	.394	-.029	-.565	-.025	-.518	-.254	-.619	-.875(b)	-.585(a)	-.274	-.540	1	-.328
BOD	.454	.404	.231	-.993(b)	-.258	.235	-.431	.092	-.169	-.213	.333	.382	.183	.692(a)	-.328	1
Cl	.836(b)	.627(a)	.266	-.200	.376	.272	.304	.166	.244	-.121	.714(b)	.763(b)	.250	.386	-.596(a)	.185
SO_4	.598(a)	.711(b)	.709(b)	-.416	.091	.707(a)	-.038	.644(a)	.345	.224	.827(b)	.775(b)	.455	.205	-.717(b)	.379
Ca	.310	.440	.890(b)	-.246	-.125	.884(b)	-.220	.909(b)	.517	.657	.680(a)	.599(a)	.312	.079	-.530	.172
Mg	.096	-.449	.409	.157	-.242	.417	.528	.411	.759(b)	-.502	.115	.220	.312	.429	-.084	-.159
Na	.812(b)	.820(b)	.274	-.318	.358	.276	.069	.175	.066	.367	.739(b)	.716(b)	.261	.204	-.612(a)	.298
K	.531	.112	.494	.143	.260	.499	.523	.459	.720(b)	-.370	.401	.569	.303	.208	-.109	-.170
HCO_3	.341	-.136	.792(b)	.146	-.184	.795(b)	.451	.787(b)	1.00(b)	.004	.487	.564	.440	.257	-.254	-.169
CO_3	.518	.996(b)	.226	.163	-.641	.222	.543	.297	.004	1.00(b)	.741	-.412	-.733	-.268	-.619	-.213

Table-3. ANOVA results for the Pallipalayam water sample

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

Param.	Cl	SO_4	Ca	Mg	Na	K	HCO_3	CO_3
Temp	.836(b)	.598(a)	.310	.096	.812(b)	.531	.341	.518
pH	.627(a)	.711(b)	.440	-.449	.820(b)	.112	-.136	.996(b)
EC	.266	.709(b)	.890(b)	.409	.274	.494	.792(b)	.226
DO	-.200	-.416	-.246	.157	-.318	.143	.146	.163
Tdy	.376	.091	-.125	-.242	.358	.260	-.184	-.641
TDS	.272	.707(a)	.884(b)	.417	.276	.499	.795(b)	.222
TSS	.304	-.038	-.220	.528	.069	.523	.451	.543
TH	.166	.644(a)	.909(b)	.411	.175	.459	.787(b)	.297
TA	.244	.345	.517	.759(b)	.066	.720(b)	1.00(b)	.004
PA	-.121	.224	.657	-.502	.367	-.370	.004	1.00(b)
AN	.714(b)	.827(b)	.680(a)	.115	.739(b)	.401	.487	.741
NO_2	.763(b)	.775(b)	.599(a)	.220	.716(b)	.569	.564	-.412
NO_3	.250	.455	.312	.312	.261	.303	.440	-.733
TP	.386	.205	.079	.429	.204	.208	.257	-.268
COD	-.596(a)	-.717(b)	-.530	-.084	-.612(a)	-.109	-.254	-.619
BOD	.185	.379	.172	-.159	.298	-.170	-.169	-.213
Cl	1	.566	.178	-.001	.908(b)	.537	.244	-.121
SO_4	.566	1	.744(b)	-.078	.743(b)	.170	.345	.224

Ca	.178	.744(b)	1	-.006	.326	.290	.517	.657
Mg	-.001	-.078	-.006	1	-.299	.455	.759(b)	-.502
Na	.908(b)	.743(b)	.326	-.299	1	.325	.066	.367
K	.537	.170	.290	.455	.325	1	.720(b)	-.370
HCO_3	.244	.345	.517	.759(b)	.066	.720(b)	1	.004
CO_3	-.121	.224	.657	-.502	.367	-.370	.004	1

Table - 4 Enumerations of Bacterial populations in Pallipalyam water sample duringJanuary 2009 to December 2009

	Sum of Squares	df	Mean Square	F	Sig.
Temp	20.330	3	6.777	3.737	.060
pH	1.237	3	0.412	2.019	.190
EC	269521.667	3	89840.556	11.507	**.003**
DO	.317	3	0.106	0.387	.766
Tdy	7.000	3	2.333	2.154	.172
TDS	134446.000	3	44815.333	11.250	**.003**
TSS	2.917	3	0.972	2.333	.150
TH	16136.667	3	5378.889	12.577	**.002**
TA	4978.250	3	1659.417	2.587	.126
PA	30.250	1	30.250	0.834	.457
AN	5.460	3	1.820	5.364	.026
NO_2	.006	3	0.002	3.992	.052
NO_3	.495	3	0.165	0.518	.681
TP	.017	3	0.006	2.107	.178
COD	523.998	3	174.666	2.089	.180
BOD	55.190	3	18.397	0.450	.724
Cl	7213.349	3	2404.450	12.554	**.002**
SO_4	1668.914	3	556.305	5.204	.028
Ca	2272.622	3	757.541	17.828	**.001**
Mg	274.519	3	91.506	1.356	.324
Na	2586.744	3	862.248	5.331	.026
K	9.667	3	3.222	3.222	.083
HCO_3	7409.627	3	2469.876	2.587	.126
CO_3	10.890	1	10.890	0.834	.457

Table 5 Enumerations of Fungal populations in Pallipalyam water sample January 2009 to December 2009

Fungi – Dilution (CFU/ml)	January	February	March	April	May	June	July	August	September	October	November	December
10^2	3.0	3.2	0.1	0.1	0.1	3.1	3.2	3.3	3.2	3.2	3.2	3.2
Bacteria– Dilution (CFU/ml)	January	February	March	April	May	June	July	August	September	October	November	December
10^2	4.0	3.5	0.5	0.5	0.5	3.2	3.2	3.3	3.5	3.5	4.0	4.3