Spatial Distribution of Non-Point Source Pollution of Vembanad Lake, Kerala, South India

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Abstract

The Vembanad lake is bordered by Alleppey, Kottayam and Ernakulam districts of Kerala covering an area of about 200 sq.km. and extending 80 kms in a NW-SE direction, from Munambam in the North to Alleppey in the South. The purpose of this study is to analyse the pollution levels and plot a spatial distribution of pollution parameters on the Vembanad lake. Spatial and Temporal variation across 35 representative sites and in post- monsoon and pre-monsoon seasons was plotted. The various parameters analysed were acidity, hardness, chloride, sulphate, COD and iron. The spatial distribution of the parameters was plotted with the aid of Geographic Information System (GIS). The analysis results were used for identifying relatively more polluted areas and hence would be helpful in adopting measures to ameliorate water quality and control outflow of wastes into the lake.

Keywords – Vembanad, Pollution, Kerala, GIS.

1. Introduction

Kerala has a continuous chain of lagoons or backwaters along its coastal region. The Vembanad wetland system and its associated drainage basins lie in the humid tropical region between 09˚00’ -10˚40’N and 76˚00’-77˚30’E. It is unique in terms of physiography, geology, climate, hydrology, land use, flora and fauna. The rivers are generally short, steep, fast flowing and monsoon fed. The Vembanad wetland system includes the Vembanad backwater and the deltaic lower reaches of the rivers draining into it. The Vembanad lake is bordered by Alleppey, Kottayam and Ernakulam districts of Kerala covering an area of about 200 sq km and extending 80 km in a NW-SE direction, from Munambam in the north to Alleppey in the south. Vembanad lake is selected for the study because large area of this water body is being polluted.

The width of the lake varies from 500 m to 4 km and the depth from <1m to 12m.Manimala, Meenachil, Pamba and Achenkovil flow into the lake south of Thanneermukkom and Muvattupuzha river flows into the Cochin backwaters north of Thanneermukkom barrage.

Figure 1. Location of Vembanad lake

The lake has got a freshwater dominant southern zone and a salt water dominant northern zone, both separated by a bund at Thanneermukkom, where the lake has its minimum width. The bund was constructed in 1975 to prevent salt water intrusion and to promote double cropping of paddy in about 55,000ha of low lying fields in the area (Padasekharams).

The major commercial and economic activities in the lake include agriculture, fisheries, lime shell mining, backwater tourism, etc. It is reported that there are over 1000 house boats (kettuvallams) crisscross the lake carrying the tourists into the lake.

Considering the fragile ecosystem of the wetland, deterioration of water quality and consequent damage to aquatic organisms and the shrinkage of Vembanad lake, this wetland system was included in the National Lake Conservation Programme (NLCP).

Diffuse water pollution is mainly related to the way we use and manage land and soil. It can affect rivers, lakes, coastal waters and ground waters. Ground waters are vulnerable and can be affected by, pollutants that leach from the land surface and from areas of contaminated land. Surface waters are affected by rainfall that washes over and off the land (run-off). Rivers can also be influenced by springs and seepages from groundwater that contribute to their flow. If the groundwater connection with surface waters is high, pollution can pass from one to affect the other. Run-off has increased as agriculture has intensified and as we have built more roads and houses. This often happens where we have degraded the natural permeability of the landscape and reduced its capacity to retain water.

Unlike point source pollution, we cannot easily control diffuse pollution by issuing licenses or permits. Regulatory approaches have to be more subtle and in many cases need to be well connected to the land use planning system.

2. Literature Review

According to a journal published in the International Research Journal Of Environmental Sciences titled "Water Quality Assessment of a Tropical Wetland Ecosystem with Special reference to Backwater Tourism, Kerala, South India", the river water of study area was moderately polluted in respect to the analyzed parameters. pH, total hardness, chloride and fluoride were found within permissible limit but the higher values of BOD attributed that the river water was not fit for drinking purpose. The journal published by K.K Balachandran on "Ecosystem modelling of Vembanad lake", mentions that the progressive deterioration of many of the Indian estuaries caused by anthropogenic activities is of concern because these areas have never been considered as primary targets of conservation. The article published on "Sustainability and livelihood issues of Vembanad ecosystem fisher folk communities with special reference to Muhamma and Thanneermukkom villages" gives, the sustainable livelihood framework focus on the sustainable livelihoods of inland fisher folk communities whose issues are divergent and close watch on the empirical realities that are complex and interrelated have brought to light the impact of ecosystem degradation and resource depletion on the life of this community. The prevalence of faecal indicator bacteria, Escherichia coli and pathogenic bacteria, Vibriocholerae, Vibrio parahaemolyticus and Salmonella in Vembanad lake were analyzed in "Increased prevalence of indicator and pathogenic bacteria in Vembanad lake: a function of salt water regulator, along south west coast of India" by Abhirosh Chandran, A. A. M. Hatha and Sherin Varghese.

3. Objective

The main objective of the study is to determine the spatial variation of non-point source or diffuse pollution in Vembanad lake, Kerala, South India. The spatial variation is plotted using QGIS 1.8.0 with the laboratory test results of water quality parameters as inputs.

4. Methodology

Analysis of water quality was done both spatially and temporally. 35 representative sites were taken into consideration for a statistically robust analysis.

These sites were located between 9° 32' 1.03" N - 76° 22' 2.28" E and 9° 40' 27.99" N - 76° 25' 0.4" E. These sites were chosen taking into consideration the various ecological and human effect that were observed as probable pollution causes, including areas adjacent to resorts and other tourism hotspots; commercial areas such as boat jetties and residential areas such as the R- Block, etc. The samples were collected according to grid analysis, mainly from the boundary of the lake as there were many resorts and industrial outlets located. The waste water outlet from the house boats also influenced the selection of site. 5 litres of each sample was collected in air-tight containers and shifted to the laboratory within 24 hours of sampling.

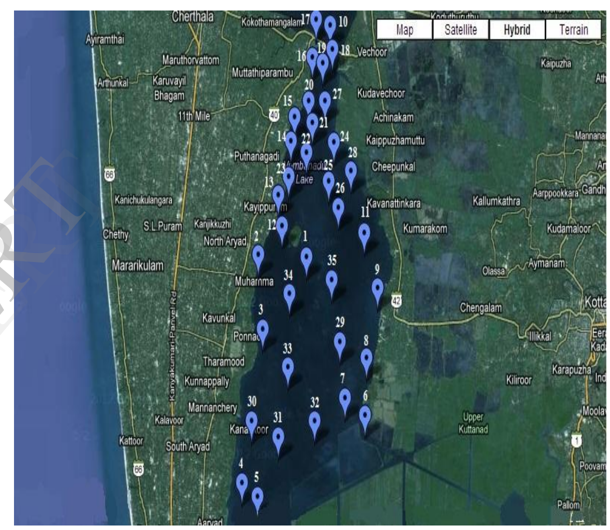

Figure 2. Sampling sites

To determine temporal variation the water samples were collected in two seasons, pre monsoon season (Jan-Feb) and post monsoon season (Oct-Nov). Water quality was checked across parameters like hardness, sulphate, chlorides, iron, acidity and COD. These parameters were chosen taking into consideration the type of activities around the lake and the probable pollution causing agents associated with it. For example, hardness was chosen as a parameter because of the high number of residential and tourism settlements around the lake which discharge untreated soap water into the lake. All the water quality tests were conducted as per Indian Standards. The spatial variation of parameters was plotted using QGIS software.

Table 1. GPS co-ordinates of 35 sampling sites

SI No.	LATITUDE	LONGITUDE
1	9° 36’ 15.56” N	76° 23’ 23.56” E
2	9° 36’ 19.13” N	76° 22’ 3.89” E
3	9° 34’ 59.63” N	76° 22’ 11.40” E
4	9° 32’ 15.50” N	76° 21’ 36.93” E
5	9° 32’ 1.03” N	76° 22’ 2.28” E
6	9° 33’ 28.18” N	76° 25’ 1.84” E
7	9° 33’ 46.58” N	76° 24’ 27.91” E
8	9° 34’ 29.04” N	76° 25’ 4.69” E
9	9° 35’ 43.71” N	76° 25’ 22.33” E
10	9° 40’ 22.29” N	76° 24’ 4.03” E
11	9° 36’ 41.69” N	76° 25’ 0.4” E
12	9° 36’ 49.12” N	76° 22’ 43.53” E
13	9° 37’ 21.80” N	76° 22’ 37.42” E
14	9° 38’ 19.33” N	76° 22’ 57.73” E
15	9° 38’ 45.02” N	76° 23’ 4.54” E
16	9° 39’ 47.91” N	76° 23’ 33.64” E
17	9° 40’ 27.99” N	76° 23’ 40.63” E
18	9° 39’ 56.2” N	76° 24’ 6.95” E
19	9° 39’ 41.98” N	76° 23’ 51.80” E
20	9° 39’ 2.16” N	76° 23’ 27.75” E
21	9° 38’ 39.29” N	76° 23’ 33.89” E
22	9° 38’ 6.99” N	76° 23’ 23.38” E
23	9° 37’ 41.86” N	76° 22’ 53.72” E
24	9° 38’ 18.57” N	76° 24’ 9.72” E
25	9° 37’ 36.53” N	76° 24’ 0.46” E
26	9° 37’ 9.11” N	76° 24’ 16.53” E
27	9° 39’ 1.83” N	76° 23’ 54.59” E
28	9° 37’ 46.89” N	76° 24’ 37.54” E
29	9° 34’ 45.92” N	76° 24’ 19.62” E
30	9° 33’ 22.43” N	76° 21’ 51.92” E
31	9° 33’ 5.38” N	76° 22’ 37.03” E
32	9° 33’ 21.83” N	76° 23’ 36.98” E
33	9° 34’ 19.11” E	76° 22’ 53.09” E
34	9° 35’ 37.11” N	76° 22’ 54.95” E
35	9° 35’ 51.73” N	76° 24’ 6.02” E

5. Results and discussion

The water quality parameters were checked for the 35 representative samples in both the wet season and dry season. The spatial and temporal variation of non point source pollution in Vembanad lake was hence plotted. The spatial distribution was plotted using QGIS software. The test results are as follows:

Table 2. Water quality test results

SAMPLE	COD (mg/l)		HARDNESS (mg/l)		CHLORIDE (mg/l)		IRON (Conc.of iron (µg) in 50 mL)		SULPHATE (mg/l)		TOTAL ACIDITY (mg/l)	
NO:	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY
1	29.0	51.0	28	640	8.44	496.3	0.20	0.30	5.50	160	6	8
2	24.8	43.7	26	1020	3.47	684.9	0.10	0.25	5.00	210	10	8
3	24.8	43.7	22	840	2.48	774.2	0.10	0.15	5.25	220	8	8
4	24.8	43.7	28	540	1.00	466.5	0.15	0.20	3.93	200	6	8
5	16.5	36.4	20	620	0.50	496.3	0.15	0.20	3.75	180	8	10
6	29.0	36.4	40	420	14.40	357.3	0.10	0.15	3.50	160	8	8
7	29.0	43.7	40	620	17.40	516.2	0.10	0.20	4.88	220	8	8
8	8.3	51.0	38	560	14.89	416.9	0.20	0.30	2.78	150	6	8
9	29.0	43.7	34	520	13.40	446.7	0.15	0.25	4.25	230	6	8
10	16.5	72.8	28	1020	7.44	1042	0.15	0.30	4.75	240	6	10
11	12.4	36.4	40	540	15.88	387.1	0.20	0.30	4.83	220	8	8
12	20.7	21.8	24	1040	4.96	1022	0.20	0.35	4.75	210	6	6
13	17.6	21.8	32	980	4.47	1687	0.30	0.45	2.75	140	8	6
14	20.7	29.1	28	1080	5.95	1433	0.15	0.25	2.63	160	6	8
15	24.8	29.1	40	940	7.44	1334	0.10	0.20	4.00	180	10	6
16	8.3	36.4	30	960	9.92	1200	0.15	0.30	4.70	220	6	10
17	12.4	36.4	36	1100	16.38	1551	0.15	0.25	5.00	240	8	8
18	27.8	123.8	26	1020	7.94	1476	0.10	0.20	5.00	250	8	10
19	41.4	36.4	30	940	8.93	955.9	0.15	0.30	4.50	200	6	10
20	12.4	43.7	28	1120	5.96	1156	0.10	0.20	3.75	170	8	8
21	16.5	51.0	26	940	5.96	928.6	0.10	0.25	4.50	190	6	8
22	16.0	29.1	22	1000	5.45	750.5	0.10	0.15	4.00	170	6	8
23	8.3	87.4	28	880	4.96	1456	0.15	0.25	3.25	160	8	8
24	8.3	123.8	32	880	4.47	988.5	0.20	0.30	4.63	230	6	8
25	8.3	131.0	30	720	5.46	876.3	0.20	0.35	3.75	180	8	6
26	10.6	65.2	32	630	6.45	550.7	0.20	0.40	3.75	170	6	8
27	11.4	48.3	30	940	5.46	755.3	0.10	0.15	4.43	210	6	8
28	9.2	112.8	36	790	6.45	1275	0.15	0.25	4.00	200	10	6
29	10.8	65.2	36	580	14.39	540.5	0.20	0.35	4.50	220	6	10
30	28.6	43.9	26	720	1.98	528.4	0.15	0.20	4.00	190	8	10
31	20.9	38.9	22	640	5.46	448.4	0.15	0.25	4.25	210	6	10
32	26.5	42.1	30	580	15.38	664.2	0.20	0.35	4.43	230	6	14
33	18.3	43.7	20	770	2.98	880.5	0.15	0.30	5.00	240	6	6
34	20.8	44.2	24	940	3.97	749.6	0.10	0.30	5.15	250	10	8
35	26.9	52.5	28	750	7.44	478.1	0.15	0.20	4.85	220	8	8

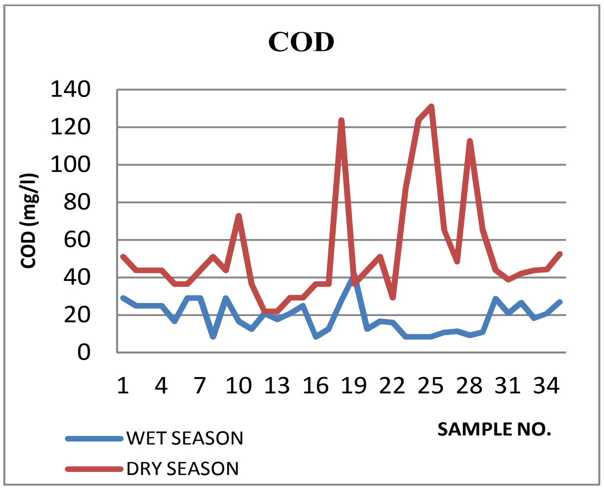

Figure 3. COD test results

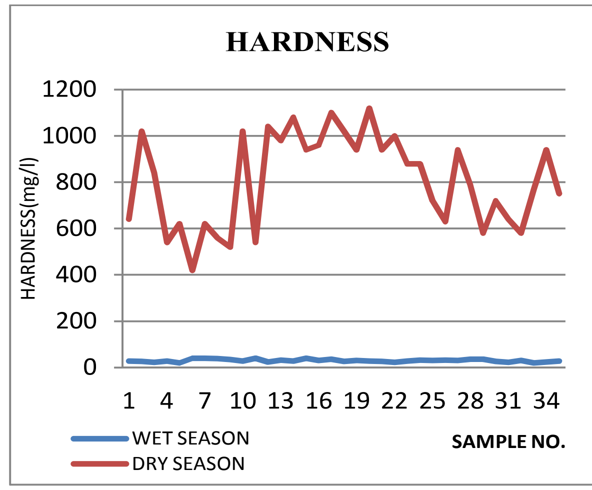

Figure 6. Hardness test results

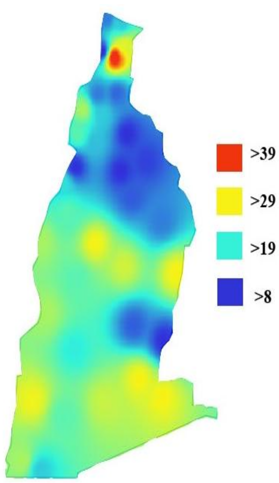

Figure 4. COD (Wet)

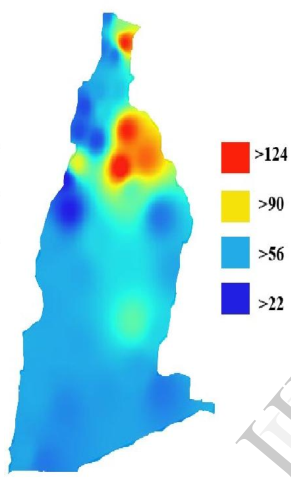

Figure 5. COD (Dry)

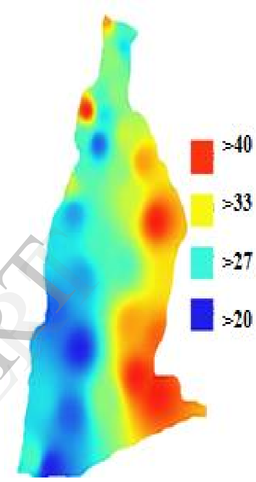

Figure 7. Hardness (Wet)

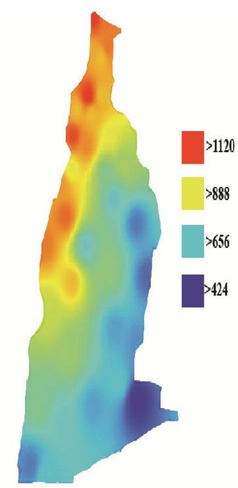

Figure 8. Hardness (Dry)

COD: The COD test is used extensively in the analysis of industrial wastes. It is particularly valuable in surveys designed to determine and control losses to sewer systems. Results may be obtained within a relatively short time and measures taken to correct errors on the day they occur. In conjunction with the BOD test, the COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances .The test is widely used in the operation of treatment facilities because of speed with which results can be obtained.

As per Indian standards the COD value of the effluent discharged into the inland waters should not exceed a permissible value of 250mg/l. From figure 3 the COD levels at 35 stations are within the desirable limits in both seasons. But for the dry season the COD values are comparatively higher.

Hardness: Hardness of water is an important consideration in determining the suitability of water for domestic and industrial uses. Environmental engineers use it as a basis for recommending the need for softening processes. The relative amounts of calcium and magnesium hardness and of carbonate and non carbonate hardness present in water are factors in determining the most economical type of softening process to use, and become important considerations in design. Determination of hardness serves as a basis for routine control of softening processes.

As per Indian Standards, the desirable limit of hardness for drinking purpose is 300 mg/L. From figure 6, the hardness levels at all 35 stations are within the desirable limits for the wet season. But for the dry season the hardness values are much higher than the desirable limits.

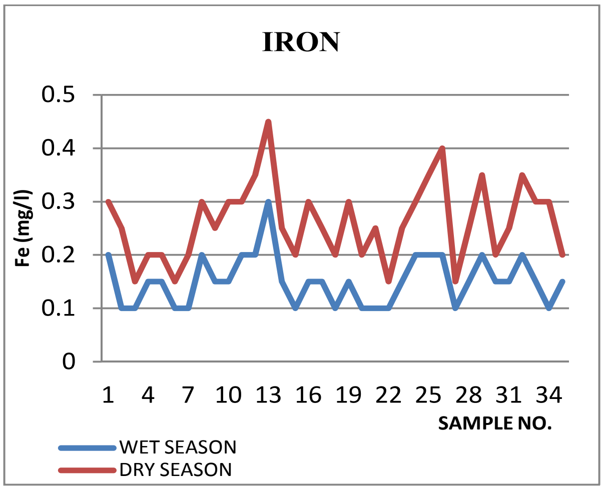

Figure 9. Iron test results

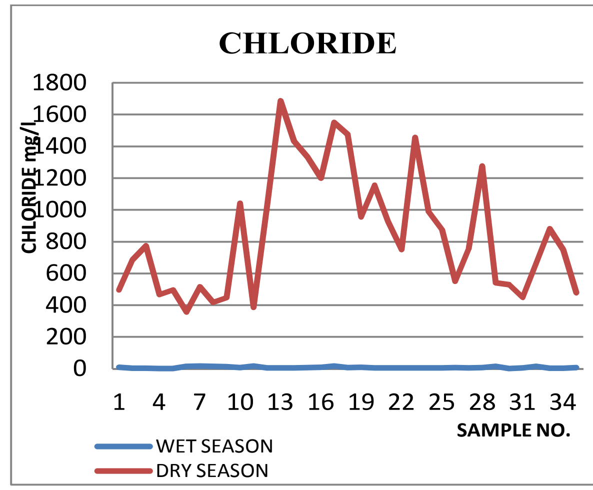

Figure 12. Chloride test results

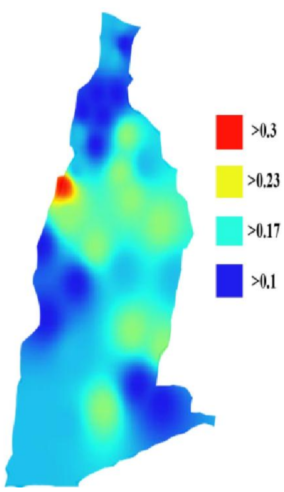

Figure 10. Iron (Wet)

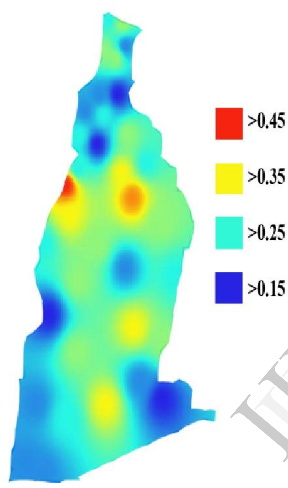

Figure 11. Iron (Dry)

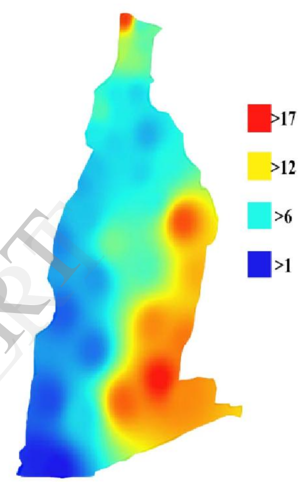

Figure 13. Chloride (Wet)

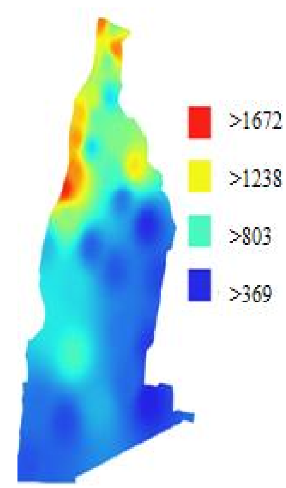

Figure 14. Chloride (Dry)

Iron: In explorations for new water supplies, particularly from underground sources iron and manganese determinations are an important consideration. Supplies may be rejected on this basis alone. When supplies containing amounts in excess of 0.3mg/L iron or 0.05mg/L manganese are developed , the engineer must decide whether treatment is justified and if so, the best method of treatment. The iron determination is helpful in assessing the extent of corrosion and aiding in the solution of these problems.

As per Indian Standards, the permissible concentration of Fe in potable water is 0.3 mg/L and as per effluent standards the concentration of Iron to discharge into inland surface water is 3 mg/l. From figure 9, the concentration of iron obtained from the 35 stations is low. But in dry season, the desirable limit for drinking purpose is found to be exceeded.

Chlorides: In many areas the level of chlorides in natural water is an important consideration in the selection of supplies for human, industrial and agricultural use. Where brackish water must be used for domestic purposes, the amount of chlorides present is an important factor in determining the type of desalting apparatus to be used. The chloride determination is used to control pumping of groundwater from locations where intrusion of seawater is a problem. Chlorides interfere in the determination of chemical oxygen demand. A correction must be made or else a complexing agent such as $HgSO_4$ can be added.

As per Indian Standards, the desirable limit of chloride is 250 mg/L. From figure 12, the Chloride levels at all 35 stations are well within the desirable limit for the wet season. But the values for the dry season are very high.

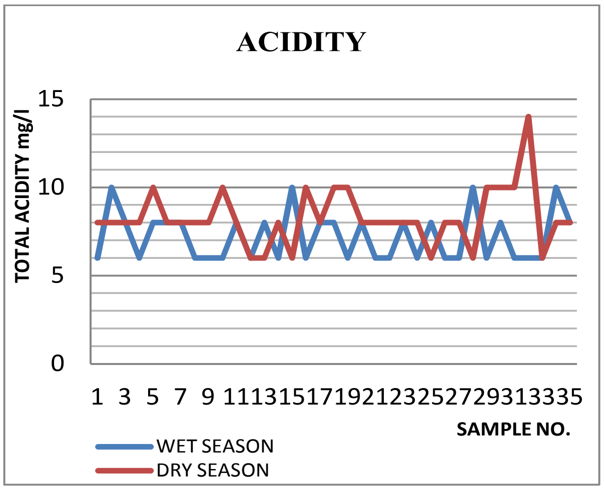

Figure 15. Acidity test results

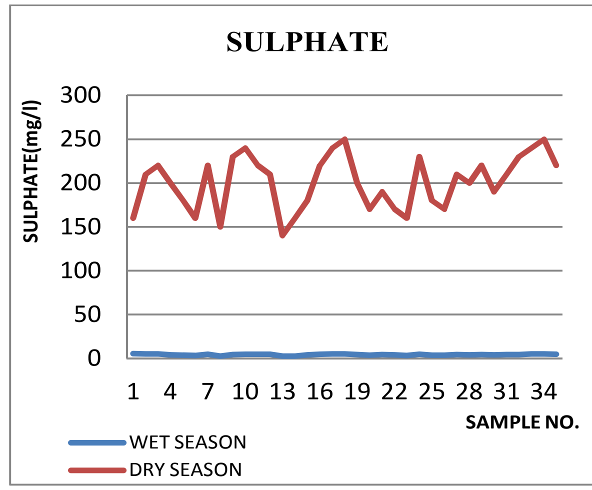

Figure 18. Sulphate test results

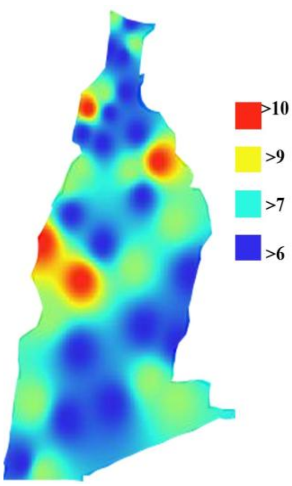

Figure 16. Acidity (Wet)

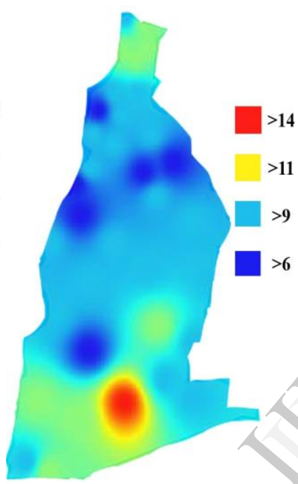

Figure 17. Acidity (Dry)

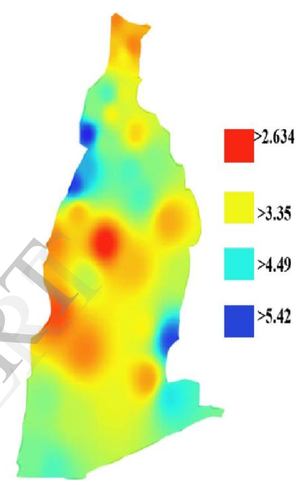

Figure 19. Sulphate (Wet)

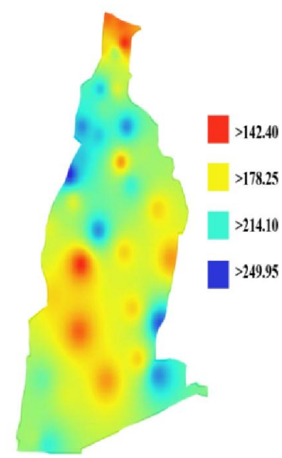

Figure 20. Sulphate (Dry)

Acidity: Carbon dioxide determination is particularly important in the field of public water supplies. In the development of new supplies, it is an important factor that must be considered in the treatment method and the facilities needed. Many underground supplies require treatment to overcome corrosive characteristics resulting from carbon dioxide. The amount present is an important factor in determining whether removal by aeration or simple neutralization with lime or sodium hydroxide will be chosen as the treatment method. Most industrial wastes containing mineral acidity must be neutralized before they may be discharged to rivers or sewers or subjected to treatment of any kind.

From figure 15, there is only a slight increase in the value of acidity from wet season to dry season. Generally the acidity ranges between 5-10 in both seasons. But in dry season it could be seen that the acidity has abnormally increased in a few of the sampling sites.

Sulphate: The sulphate content of natural waters is an important consideration in determining their suitability for public and industrial water supplies. The amount of sulphate in waste water is a factor of concern in determining the magnitude of problems that can arise from reduction of sulphates to hydrogen sulphide. In anaerobic digestion of sludges and industrial wastes, the sulphide is reduced to hydrogen sulphide, which is evolved with methane and carbon dioxide. Knowledge of sulphate of sludge or waste fed to digestion units provides a means of estimating the hydrogen sulphide content of gas produced. From this information, the designing engineer can determine whether scrubbing facilities will be needed to remove hydrogen sulphide and the size of the units required.

According to Indian Standards, the permissible limit of sulphate in drinking water is 200 mg/L. From Figure 18, the concentration of sulphate for the wet season is well within the desirable limits. But the concentration in the dry season is abruptly higher.

6. Conclusion

Analysis of water was done from 35 undefined points to assess diffuse pollution characteristics. From the analysis of the results, it can be concluded that the parameters- Iron, acidity and COD in the wet season and dry season have not undergone significant change. But the values of hardness, chloride and sulphate have undergone dramatic change.

In general, the concentration of parameters was higher in dry season. An important factor affecting the variation of results in the two seasons was the Thanneermukkom Bund. In the wet season, the bund was open to let flow through to the other side and in the dry season, the bund was closed which reduced the flow of water. Moreover, the level of water in the dry season was very low compared to the wet season

Also, the dry season was the tourism season which saw increased number of houseboats on the lake and increased outflow of wastes from these boats and resorts into the lake.

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