Surveillance of the Water Quality Ascertainment of Vellayani Lake

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***Abstract*- Water, the magical substance from which all life springs forth, is essential to the very existence of every life form on earth. The role of water in the living organism has not changed since life's first creation in salt water billions of years ago. Pure water is elixir of life. Vellayani Lake is the second largest fresh water lake in Kerala. It is parallel to coast. The lake is facing degradation due to anthropogenic activities such as diverting human waste, soil erosion due to distribution of vegetables and agricultural wastes pose a great threat to the usefulness of the water. This study ascertained the quality of water in Vellayani lake by using Swamee and Tyagi Water Quality Index method and Weighted Arithmetic Water Quality Index method. From the study, it is found that the water is polluted and treatment is required.**

Keywords- Water, Water quality index, Swamee and Tyagi method, Weighted Arithmetic method.

I. INTRODUCTION

Water as we know it very-very important and vital for our survival on this blue planet. An adequate supply of water alone would not guarantee our well-being as the quality of water would be a serious measure. Nowadays lakes, streams, rivers, oceans, and other water bodies are seriously polluting due to the addition of large amounts of materials to the water such as sewage, agricultural wastes, industrial wastes, domestic wastes etc.

Water quality is a term used to describe the chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose. Although scientific measurements are used to define water quality, it's not a simple thing to say that "this water is good," or "this water is bad." After all, water that is perfectly good to wash a car with may not be good enough to serve as drinking water. When the average person asks about water quality, they probably want to know if the water is good enough to use at home, to play in, to serve in a restaurant, etc., or if the quality of our natural waters is suitable for aquatic plants and animals.

II. MATERIALS AND METHODS

i. *Study Area*

Vellayani lake, the largest freshwater lake in Thiruvananthapuram, Kerala, is located between latitude 8°24'90" - 8°26'30" North and longitude 76°59'08" - 76°59'47" East [5]. The major sources of water in the lake are seasonal rains (southwest monsoon) and underground sprouts. It is linear in form, and nearly 4 km in areal extent. The area of the lake which was 750 Hectares in 1926, had been reduced to 397.5 Hectares by 2017. The area of wetlands around the lake has also changed as a result of development of agricultural land and construction. At present, the lake basin no longer discharges water via surface water courses. The canal at the north end of the lake, formerly its natural outlet, is at present discharging irrigation reflux into the lake. The climate of the Vellayani lake area is classified as hot tropical. The lake catchment includes several small towns, grassland, woodland and agricultural land used for row crops, paddies fig. 1.

Eight sampling stations were chosen along the Vellayani Lake: fig. 2. Station 1, Vandithadam is subjected to boating activities, oil pollution and dumping of solid waste; Station 2, Agricultural college is the station subjected to pollution due to synthetic fertilizer management, and the use of pesticides; Station 3, Kakkamoola right is disturbed due to anthropogenic activities such as disposal of wastes, recreational activities, dredging; Station 4, Venganoor is subjected to human disturbance due to the presence of local people; Station 5, Kakkamoola left is disturbed due to disposal of personal care products and household chemicals; Station 6, Koliyoor is subjected to heavy infestation with water hyacinth, pollution and siltation; Station 7, Vavvamoola right is disturbed due to plastic materials and waste in contact with water; Station 8, Vavvamoola left is disturbed due to illegal discharges of waste.

ii. Sampling and method of analysis

Water samples were collected directly in polyethylene bottles for a period of four months during January 2018 to April 2018 for analysis . The standard methods for examination of water was strictly followed [1]. The samples were analysed for selected nineteen parameters. Water temperature was measured using a high quality standard mercury- filled Celcius thermometer (±0.1

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ºC accuracy). pH were measured in the laboratory using a pH meter. Electrical conductivity of water was measured using conductivity meter. Parameters such as free Carbon dioxide, Total hardness, Total Dissolved Solids, Nitrate, Sulphate, Colour, Turbidity, Acidity, Alkalinity, Calcium, Magnesium, Chloride, Iron, Fluoride, E-coli and Coliform were estimated by standard laboratory procedures [7].

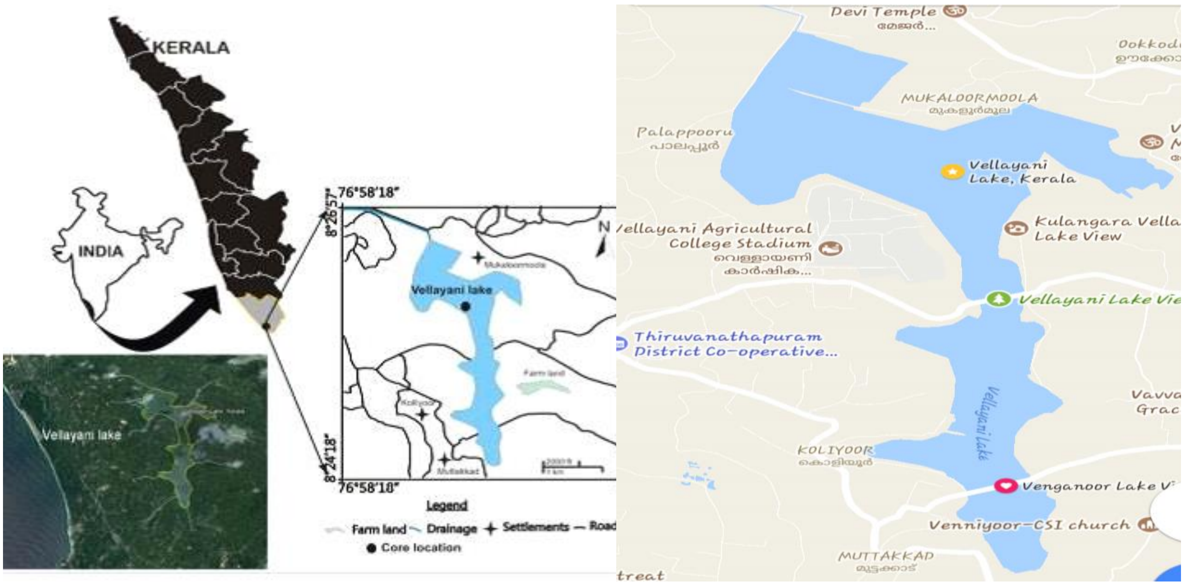

Fig 1: Location of Vellayani Lake

Fig 2: Location of eight sampling stations

(Source: Google Map)

III. WATER QUALITY INDEX (WQI)

Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. Water quality of any specific area or specific source can be assessed using physical, chemical, and biological parameters. The values of these parameters are harmful for human health if they occurred more than defined limits. Therefore, the suitability of water sources for human consumption has been described in terms of Water quality index (WQI), which is one of the most effective ways to describe the quality of water. Various WQI determination methods have been described here in.

a) SWAMEE AND TYAGI WATER QUALITY INDEX

Swamee and Tyagi (2000) suggested a mathematical form that is free from eclipsing and ambiguity [4].

$$I = (1-N+\sum_{i=1}^{N} Si^{-1/k})^{-k} \quad (1)$$

where,

k = 0.4, a positive constant

S = sub index value for i^{th} water quality variable.

The highest water quality index of water can receive is 1. Once overall WQI known, it can be compared against descriptor given in table 1

Table 1: Water Quality Index ranges of Swamee & Tyagi WQI

Descriptor Word	Numerical range
Very Bad	0 - 0.25
Bad	0.26 – 0.50
Medium	0.51 – 0.70
Good	0.71 – 0.90
Excellent	0.91– 1.00

(Source: Brown et al., 1970)

b)WEIGHTED ARITHMETIC WATER QUALITY INDEX

Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables. The method has been widely used and the calculation of WQI was made by using the following equation:

$$WQI = \frac{\sum q_n \times W_n}{\sum q_n} \quad (2)$$

where,

q_n = Quality rating of n^{th} water quality parameter.

Wn= Unit weight of n^{th} water quality parameter

The quality rating (q_n) is calculated using the expression given in equation:

$$q_n = [(Vn – Vid) / (Sn - Vid)] \times 100$$

where,

Vn = Estimated value of n^{th} water quality parameter at a given sample location.

Vid = Ideal value for n^{th} parameter in pure water. (Vid for pH = 7 and 0 for all other parameters)

Sn = Standard permissible value of n^{th} water quality parameter

The unit weight (Wn) is calculated using the expression given in equation:

$$W_n = k / S_n$$

where,

S_n = Standard permissible value of n^{th} water quality parameter.

k = Constant of proportionality and it is calculated by using the expression $k = [1 /\sum(1/ Sn = 1, 2\ldots n)]$

Table 2: Water Quality Index ranges of Weighted Arithmetic WQI

Sl. No	WQI	Status	Possible usages
1	0 – 25	Excellent	Drinking, Irrigation and Industrial
2	25– 50	Good	Domestic, Irrigation and Industrial
3	51 -75	Fair	Irrigation and Industrial
4	76 – 100	Poor	Irrigation
5	101 -150	Very Poor	Restricted use for Irrigation
6	Above 150	Unfit for Drinking	Proper treatment required before use

IV. RESULT AND DISCUSSION

A detailed study is attempted from the results obtained after the laboratory analysis of water collected from the Vellayani Lake. These results are also compared with drinking water standards as per IS 10500-2012 [3].

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Table 3: Various water quality parameters of the lake water during January 2018

Sl No	Station point	Unit	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
1	Colour	Hazen/Pt.Co.Unit	29	29	29	29	37	34	34	38
2	Turbidity	NTU	5.98	4.92	5.33	6.05	10.7	7.38	8.25	9.96
3	pH		6.20	6.7	6.72	6.53	6.94	7.38	7.26	7.56
4	Electrical Conductivity	µs/cm	122.7	126.4	122.4	123.7	123.4	126.6	125.3	127.7
5	Temperature	ºC	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3
6	Acidity	mg/L	9	11	7	7	5.5	5.5	4.7	4.7
7	Alkalinity	mg/L	35	37	37	29	29	34	34	35
8	Sulphate(as SO_4)	mg/L	3.4	3.4	4.8	3.9	5.3	5.9	5.9	6.1
9	Total Dissolved Solids(TDS)	mg/L	60.7	63.4	61.7	62.1	62.1	60.9	60.8	62.1
10	Total Hardness as ($CaCO_3$)	mg/L	29	29	25	25	25	32	31	27
11	Calcium(Ca)	mg/L	7	7	7	7	7	7.3	7	7
12	Magnesium(Mg	mg/L	2.32	2.37	1.39	1.33	1.37	1.49	2.56	3.15
13	Chloride as (Cl)	mg/L	29	32	33	33	32	34	32	34
14	Fluoride as(F)	mg/L	0.22	0.24	0.24	0.23	0.26	0.26	0.25	0.26
15	Iron as(Fe)	mg/L	0.361	0.301	0.362	0.314	0.417	0.45	0.353	0.413
16	Nitrate as(NO_3)	mg/L	0.58	0.609	0.583	0.59	0.63	0.45	0.431	0..47
17	Residual Chlorine(RC)	mg/L	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
18	Coliform	MPN/100mL	150	1050	250	25	1100	470	510	980
19	E.coli	MPN/100mL	150	1050	150	8	48	450	490	980

Table 4: Various water quality parameters of the lake water during February 2018

	Station point	Units	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
1	Colour	Hazen/Pt.Co.Units	30	30	30	30	35	40	35	40
2	Turbidity	NTU	6.39	6.9	6.97	6.15	7.56	11.76	8.69	10.48
3	pH		6.83	6.87	6.81	6.94	7.23	6.96	7.91	7.89
4	Electrical Conductivity	µs/cm	123.1	128.3	124.9	124.8	127.8	124.7	126.4	128.9
5	Temperature	ºC	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
6	Acidity	mg/L	10	12	8	8	6	6	5	5
7	Alkalinity	mg/L	36	38	38	30	35	30	35	36
8	Sulphate(as SO_4)	mg/L	3.6	3.6	5	4.2	6.1	5.6	6.1	6.3
9	Total Dissolved Solids(TDS)	mg/L	61.4	64.2	62.4	62.5	61.7	62.2	61.8	63.4
10	Total Hardness as ($CaCO_3$)	mg/L	30	30	26	26	33	26	32	28
11	Calcium(Ca)	mg/L	8	8	8	8	7.4	8	8.2	8.9
12	Magnesium(Mg)	mg/L	2.43	2.43	1.458	1.458	1.567	1.458	2.89	3.45
13	Chloride as (Cl)	mg/L	30	34	34	34	36	34	33	35
14	Fluoride as(F)	mg/L	0.24	0.255	0.25	0.25	0.28	0.25	0.27	0.28
15	Iron as(Fe)	mg/L	0.377	0.316	0.387	0.322	0.498	0.421	0372	0.491
16	Nitrate as(NO_3)	mg/L	0.591	0.615	0.594	0.608	0.467	0.644	0.456	0.498
17	Residual Chlorine(RC)	mg/L	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
18	Coliform	MPN/100mL	150	1100	150	28	580	1100	530	1100
19	E.coli	MPN/100mL	150	1100	150	11	560	53	365	1100

Table 5: Various water quality parameters of the lake water during March 2018

Sl No	Station point	Units	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
1	Colour	Hazen/Pt.Counits	30	40	30	30	40	35	35	40
2	Turbidity	NTU	6.2	6.53	5.61	5.08	10.5	7.56	8.69	7.98
3	pH		6.93	6.29	6.89	6.93	6.97	7.1	6.92	6.9
4	Electrical Conductivity	µs/cm	120.3	131.4	125.8	125.8	125.4	126.7	125.9	129.4
5	Temperature	ºC	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
6	Acidity	mg/L	4	4	6	6	6	6	7	7
7	Alkalinity	mg/L	30	30	30	30	30	33	34	36
8	Sulphate(as SO_4)	mg/L	7	6.4	3.2	4.4	3.2	4.3	3.2	3.9
9	Total Dissolved Solids(TDS)	mg/L	60.2	65.6	63	62.8	62.8	62.3	62.8	64.7
10	Total Hardness as ($CaCO_3$)	mg/L	34	34	24	30	44	38	37	41
11	Calcium(Ca)	mg/L	9.6	9.6	8	8	8.8	7.7	8.9	9.8
12	Magnesium(Mg)	mg/L	2.43	2.43	0.97	2.43	5.346	1.89	2.42	3.78
13	Chloride as (Cl)	mg/L	36	36	32	34	36	35	33	34
14	Fluoride as(F)	mg/L	0.26	0.27	0.26	0.26	0.265	0.26	0.28	0.29
15	Iron as(Fe)	mg/L	0.36	0.478	0.35	0.27	0.396	0.567	0.46	0.518

16	Nitrate as(NO_3)	mg/L	0.48	0.494	0.48	0.46	0.47	0.567	0.46	0.518
17	Residual Chlorine(RC)	mg/L	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
18	Coliform	MPN/100mL	460	1100	290	11	1100	550	477	1100
19	E.coli	MPN/100mL	460	1100	42	3	1100	540	245	1100

Table 6: Various water quality parameters of the lake water during April 2018

Sl no	Station point	Units	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
1	Colour	Hazen/Pt.Co.Units	32	33	42	35	32	32	40	42
2	Turbidity	NTU	6.4	6.64	5.85	5.09	10.98	8.95	9.54	5.34
3	pH		7.14	6.58	6.98	7.94	7.54	6.86	7.29	7.93
4	Electrical Conductivity	µs/cm	122.6	141.9	128.5	124.6	128.4	124.6	127.5	131.2
5	Temperature	°C	25.8	25.98	25.7	25.9	25.9	25.9	25.9	25.9
6	Acidity	mg/L	5	8	7	6	6	5	7	10
7	Alkalinity	mg/L	32	35	36	38	39	34	36	38
8	Sulphate(as SO_4)	mg/L	7	6.9	6.8	7.4	6.5	4.8	5.68	6.54
9	Total Dissolved Solids(TDS)	mg/L	62.5	65.8	63.5	62.8	62.8	61.8	62.4	62.1
10	Total Hardness as ($CaCO_3$)	mg/L	32	32	25	28	34	28	27	32
11	Calcium(Ca)	mg/L	9	9	9	98	8	7.9	7.9	8.9
12	Magnesium(Mg)	mg/L	2.54	2.68	1.984	2.64	2.54	2.54	2.51	1.95
13	Chloride as (Cl)	mg/L	32	34	35	34	38	35	38	37
14	Fluoride as(F)	mg/L	0.26	0.294	0.272	0.294	0.264	0.28	0.271	0.247
15	Iron as(Fe)	mg/L	0.34	0.367	0.358	0.384	0.349	0.42	0.429	0.381
16	Nitrate as(NO_3)	mg/L	0.6	0.652	0.67	0.674	0.639	0.55	0.475	0.48
17	Residual Chlorine(RC)	mg/L	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
18	Coliform	MPN/100mL	160	1100	160	30	1100	600	570	1100
19	E.coli	MPN/100mL	160	1100	160	10	56	600	465	1100

Swamee and Tyagi WQI method was used for calculating WQI. Eight parameters are used for calculating WQI by this method. The significant parameters considered are pH, Temperature, Total Dissolved Solids, Nitrate, Fluride, Coliform, Turbidity and Iron.

Table 7: WQI using Swamee & Tyagi method

STATION	WQI of January 2018	WQI of February 2018	WQI of March 2018	WQI of April 2018
P_1	0.46	0.44	0.47	0.45
P_2	0.48	0.47	0.48	0.49
P_3	0.48	0.45	0.47	0.48
P_4	0.45	0.44	0.46	0.44
P_5	0.46	0.46	0.47	0.46
P_6	0.45	0.45	0.48	0.46
P_7	0.47	0.45	0.46	0.46
P_8	0.46	0.45	0.47	0.48

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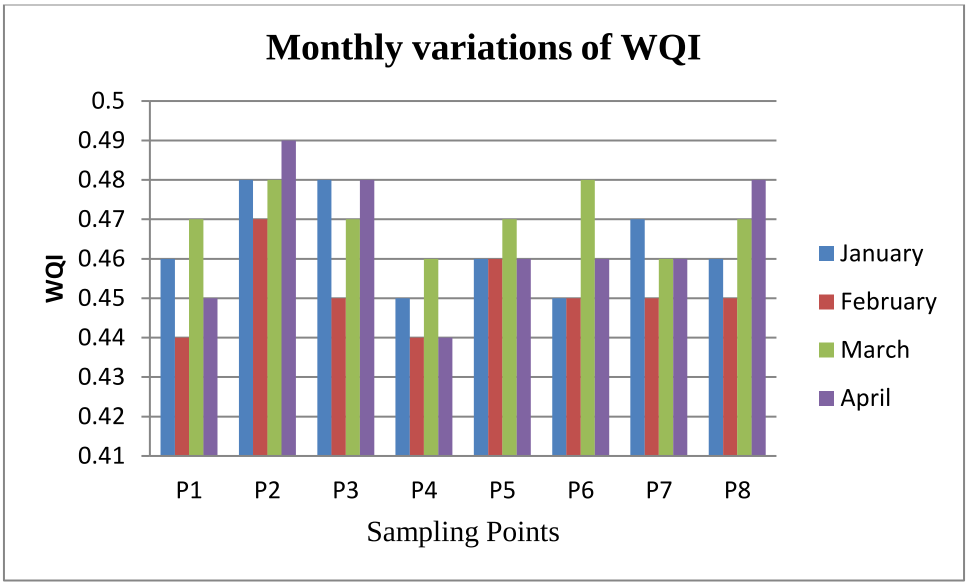

Fig 3: Monthly variation of WQI according to Swamee & Tyagi WQI

Weighed Arithmetic WQI method is used for calculating WQI with the significant parameters. In this method, eight parameter is used for calculating WQI. The parameters used are Total Dissolved Solids, Iron, pH, Nitrate, Total Hardness, Chloride, Sulphate and Alkalinity.

Table 4: WQI using Weighted Arithmetic method

STATION	WQI of January 2018	WQI of February 2018	WQI of March 2018	WQI of April 2018
P_1	91.39	92.32	93.99	91.67
P_2	93.34	93.96	92.96	94.59
P_3	91.89	93.25	92.82	92.56
P_4	92.56	91.12	91.08	92.21
P_5	93.01	91.78	92.89	92.04
P_6	92.69	93.64	91.93	92.31
P_7	92.86	92.64	91.56	93.48
P_8	92.05	91.74	92.58	93.21

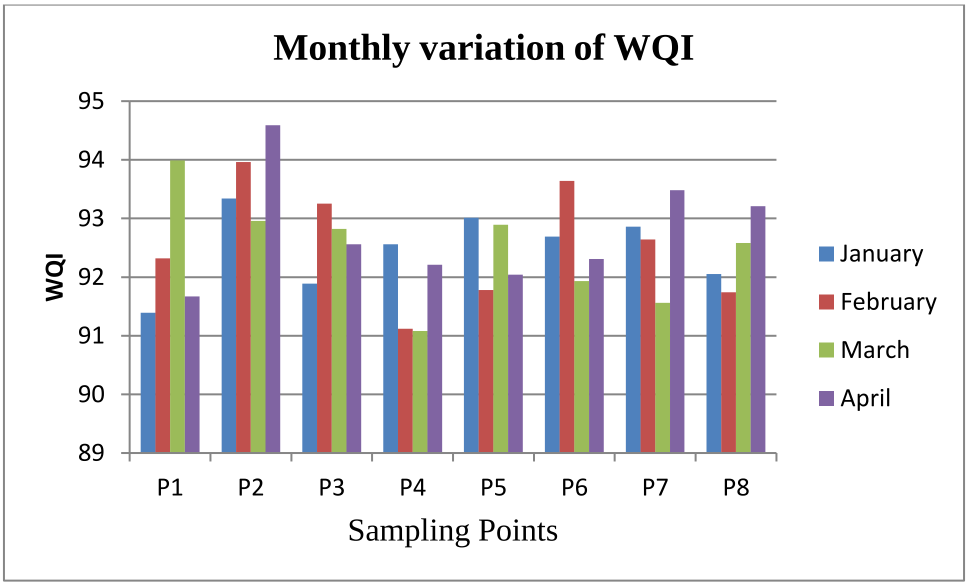

Fig 4: Monthly variation of WQI according to Weighted Arithmetic method

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The monthly variations of various water quality parameters of the lake water during January 2018 to April 2018 are shown in Table 3, Table 4, Table 5 and Table 6. Colour varies from 29 Hazen unit to 38 Hazen unit in January 2018, 30 Hazen unit to 40 Hazen unit in February 2018, 30 Hazen unit to 40 Hazen unit in March 2018 and 32 Hazen unit to 42 Hazen unit in April 2018 which shows that intensity of colour exceeds the permissible limits which is 5 Hazen unit, due to the excessive growth of algae. The turbidity varies from 4.92 NTU to 9.96 NTU, 6.15 NTU to 11.76 NTU, 5.08 NTU to 10.51 NTU and 5.09 NTU to 10.98 NTU in January 2018, February 2018, March 2018 and April 2018 respectively which indicates turbidity were above the desirable limit (1 NTU) for all the above said months due to the presence of dissolved salts in it. The pH varies from 6.2 to 8.45 in January 2018, 6.83 to 7.91 in February 2018, 6.93 to 8.23 in March 2018 and 6.58 to 7.94 in April 2018 indicating that the water samples were almost neutral range of 6.5 to 8.5. pH is one of the most important single factor which influences aquatic life since most of the aquatic organisms are adapted to an average pH and do not withstand abrupt changes. The electrical conductivity varies from 122.4μs/cm to 127.7 μs/cm in January 2018, 123.1μs/cm to 128.9μs/cm in February 2018,120.3 μs/cm to 131.4μs/cm in March 2018 and 122.6μs/cm to 141.9μs/cm in April 2018. This seasonal variation in the values of conductivity is mostly due to increased concentration of salts because of evaporation, dilution resulted from precipitation brings down its values. Temperature for January 2018, February 2018 , March 2018 and April 2018 are 24°C, 25.5°C, 25.9°C and 25.8°C respectively which indicates that it is equal to the atmospheric temperature. The acidity varies from 4.7mg/L to 11mg/L in January 2018, 5mg/L to 12mg/L in February 2018, 4mg/L to 7mg/L in March 2018 and 5mg/L to 10mg/L in April 2018 indicating that the acidity is more higher in the month February 2018 as a result of seasonal rainfall. The low value of acidity in other months may be due to higher water temperature. The alkalinity is a measure of buffering capacity of water and is important for aquatic life in a fresh water system because it equilibrate the pH range that occur as a result of photosynthetic activity of plants in water. In the present study, the alkalinity varies from 29mg/L to 37mg/L, 30 mg/L to 38mg/L, 30mg/L to 36mg/L and 32mg/L to 39 mg/L in January 2018, February 2018 March 2018 and April 2018 respectively indicating that alkalinity of the lake water is within the desirable limit of 200mg/L. Total dissolved solids varies from 60.7mg/L to 62.1mg/L in January 2018, 61.4mg/L to 64.2mg/L in February 2018, 62.8mg/L to 65.6mg/L in March 2018 and 61.8mg/L to 65.8mg/L in April 2018 which shows that total dissolved solids concentration increases from January 2018 to April 2018 but the variations are within the permissible limit (500mg/L) for all the months. The Sulphate varies from 3.4 mg/L to 6.1mg/L in January 2018, 3.6mg/L to 6.1mg/L in February 2018, 3.2 mg/L to 6.4mg/L in March 2018 and 4.8mg/L to 7.4mg/L in April 2018. During the study period, the concentration of Sulphate does not showed marked difference, although low values were observed. The total hardness of the lake varies from maximum of 44mg/L to minimum of 25mg/L which shows that the water samples is within the permissible limit of 200mg/L. High values of hardness may be probably due to regular addition of sewage and detergents to the lake from nearby residential areas. The Calcium varies from 7mg/L to 7.3mg/L in January 2018, 7.4mg/L to 8.9mg/L in February 2018, 7.7mg/L to 9.6mg/L in March 2018 and 7.9mg/L to 9.8mg/L in April 2018 indicating that the water samples is within the desirable limit of 75mg/L. The maximum amount of Calcium was observed in pre-monsoon months and it may be due to shrinkage of water volume in those months. The Iron varies from 0.301mg/L to 0.417mg/L in January 2018, 0.316mg/L to 0.498mg/L in February 2018, 0.271mg/L to 0.567mg/L in March 2018 and 0.348mg/L to 0.429mg/L in April 2018 indicating that the water samples were slightly exceeds the permissible limit 0.3mg/L because of the chemicals and fertilizers discharged from the agricultural college nearby the lake. The fluoride varied from 0.22mg/L to 0.26mg/L in January 2018, 0.24mg/L to 0.28mg/L in February 2018, 0.26mg/L to 0.29mg/L in March 2018 and 0.26mg/L to 0.294mg/L in April 2018 shows that the fluoride concentration in the lake water is within the permissible limit 1mg/L.

The Magnesium varies from 1.33mg/L to 3.15mg/L in January 2018, 1.458mg/L to 3.45mg/L in February 2018, 0.972mg/L to 5.346mg/L in March 2018 and 1.95mg/L to 2.68mg/L in April 2018 indicating that the magnesium concentration is higher in the month March 2018 and also concentration of Magnesium in the lake water is within the permissible limit 30mg/L. The decreased amount of Magnesium may occur when there is an abundance of diatoms. The Chloride varies from 29mg/L to 34mg/L in January 2018, 30 mg/L to 36mg/L in February 2018, 32mg/L to 36mg/L in March 2018 and 32mg/L to 38mg/L in April 2018 shows that concentration of Cloride increases from January 2018 to April 2018. The permissible limit of Chloride in water is 250mg/L. Nitrate varies from 0.431mg/L to 0.63mg/L in January 2018, 0.456mg/L to 0.644 mg/L in February 2018, 0.467mg/L to 0.567 mg/L in March 2018 and 0.48 mg/L to 0.674 mg/ Lin April 2018 which exceeds the permissible limit 45mg/L, that shows presence of organic matter. E.coli varies from 8 to 1050 in January 2018, 11 to 1100 in February 2018, 3 to 1100 in March 2018 and 10 to 1100 in April 2018 indicating that Vellayani Lake was infected heavily in all months. This is because of native peoples attach their domestic animals in the banks of the lake and thereby causing fecal contamination from domestic animals. Coliforms varies from 25 to 1100 in January 2018, 28 to 1100 in February 2018, 11 to 1100 in March 2018 and 30 to 1100 in April 2018 indicating that Vellayani lake was polluted heavily in all months because of fecal contamination from animals and humans.

From the results obtained from the above said methods for the months January 2018 to April 2018, it is clear that the most polluted location is P_2 (Agricultural College) and the least polluted is P_4 (Venganoor). P_2 is heavily polluted and it is be due to the waste disposal from nearby Agricultural College.

V. CONCLUSION

According to Swamee and Tyagi WQI method, the water quality index was found to be varying from 0.44 to 0.49. Based on the values the water is "bad" and treatment is required. As per Weighted Arithmetic method, water quality index is between 91.08 and 94.59 so the water is of "poor" quality. Hence water from these station points should be avoided for drinking purpose and can used for other purposes like irrigation.

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