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Assessment of water quality by evaluating the pollution potential of Hazratbal basin of Dal lake, Kashmir, India

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ABSTRACT

Dal Lake, situated in the heart of Srinagar city in India is under tremendous anthropogenic pressure. This study was conducted to determine physico-chemical water quality parameters for the Hazaratbal basin of the Dal lake. Water quality was surveyed from May 2013 to August 2013 at three different sites which were located on the Hazaratbal basin. Mathematical techniques were employed to assess the water quality parameters in simplest format. A total of seven water quality parameters namely pH, Electrical Conductivity (EC),Salinity, Dissolved Oxygen (DO), Turbidity, Air temperature and Water temperature were measured at the sampling sites. While for laboratory analysis, there were fifteen parameters namely Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Dissolved Salts (TDS), Free Carbon-dioxide, Acidity, Nitrite, Phosphate, Sulphate, Colour, Total Hardness, Alkalinity, Chloride, Calcium, Sodium and Magnesium ion concentration. Monthly changes in various physical and chemical parameters were analyzed.

Introduction

Water is an elixir of life. It is an important component of human survival. The demand for clean and potable water has increased tremendously due to rapid development and growing population. The requirement of water in all lives, from micro-organisms to man, is a serious problem today because all water resources have been reached to a point of crisis due to unplanned urbanization and industrialization (Singh et al.,2002) . The demand is not only for human beings but also for aquatic life that use water as their habitats and this aquatic life eventually become a source of protein for humans.

Thus, it is imperative that every effort should be made to protect and conserve existing water resources for present and future needs.

Lakes are subjected to various natural processes taking place in the environment, such as hydrological cycle. Storm water runoff and discharge of sewage into the lakes are two common ways that various nutrients enter the aquatic ecosystems resulting into the death of those systems. One of the most famous and beautiful lakes of world, Dal lake, is a Himalayan urban lake surrounded by mountains on its three sides. Dal lake is situated at an altitude of 1,886m above sea level between 34°6' -34°10' N latitude and 74°8' -74°9' E longitude, in the heart of the Kashmir valley on the north east of the state summer capital Srinagar at the foot of the Zabarwan mountains. The total water surface area of the lake is 11.45 Km^2 of which 4.1 Km^2 is floating under gardens. 1.151 Km^2 and 2.25 km^2 are land marsh respectively, where as a total volume estimated is 9.05×10 m^3 and the ratio between mean and maximum depth (m) ranges between .20 and .25 indicating the gentle slope of the lake bed (Jeelani and Shah.,2006). It is believed that the Dal is fed up by a number of underground springs, but the main source is the Telbal Nallah that enters into the lake on the north side of it. The lake is multi-basined comprising of four basins viz., Hazratbal, Bod Dal, Gagribal and Nigeen. By area the Hazratbal basin is the largest, named after the world famous Hazratbal shrine that is located on its bank. A lot of research has been carried out on the limnology of Dal lake yet the biggest basin-Hazratbal basin has not so for been exclusively studied. Consequently, the present endeavour has been made for which three sites of the Hazratbal basin have been selected which differ tremendously in nature and extent of pollution. Dal lake is undergoing fast eutrophication due to pollution caused by agricultural practices in the catchment area which has subsequently enriched the lake water with enormous inputs of fertilizers, nutrient content , organic matter from both autochthonous and allochthonous modes etc.

Experimental

Sampling site

Hazratbal basin is the largest basin of the world famous Dal Lake (Fig.1).

This study was conducted on this basin by choosing three sites which differ on the extent of pollution. The three sites selected from the basin were- site 1 near Telbal Nallah, site 2 Dhobi Ghat area and site 3 near Sonilank.

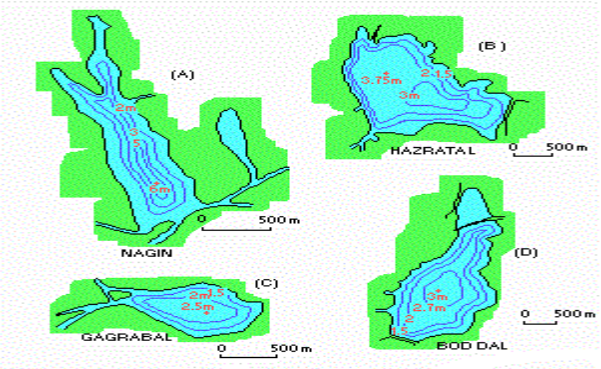

Fig.1 Bathymetric Map of Dal Lake Basins

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Sample collection and pre-treatment

The sampling network was designed to cover a wide range of determinates of key sites, which reasonably represent the water quality of the lake system. Sampling for water quality parameters were carried out at the three sites on monthly basis from May 2013 to August 2013. The samples were collected from 8:00 A.M to 10:30 A.M during the four month period. Water samples were collected using open water grab sampler (1.5 L capacity) equipped with a simple pull-ring that allowed for sampling at various depths. In order to determine the water quality, water samples were kept in 5 L polythene cans wrapped with carbon. All water samples were stored in insulated cooler containing ice and delivered on the same day to laboratory and all the samples were kept at 4°C until processing and analysis (clesceri et al., 1998).

Chemicals and reagents

Triple distilled water was used throughout the work. All chemicals and reagents were analytical grade, Merck (Darmstadt, Germany). Standard solutions of two elements (i.e Ca and Mg) were prepared by dilution of 1000 ppm certified standard solutions.

Analytical procedure

Physico-chemical parameters of water, their units and method of analysis are summarized in Table 1. The air temperature, water temperature, pH, EC, salinity, DO, turbidity of each sample were measured at the sampling points following the standard procedures of U.S Environmental Protection Agency (2007), by using mercury thermometer, digital pH, EC, DO, turbidity meter respectively. In laboratory the water samples were analyzed for other physic-chemical parameters and detection of metal ions (i.e Ca and Mg). These parameters were analysed within 48 h, COD determined on the same day of the sampling by utilizing spectroquant photometer of Merck. While as for evaluating BOD, five day incubation time at 20^0 C is a must and is measured by subtracting DO on fifth day from DO on first day multiplied by appropriate dilution factor. Colour was analysed visually by comparing the water samples with colour standards made of potassiumchloroplatinate (K_2PtCl_6) and cobaltous chloride ($CoCl_2$.$6H_2O$) in triple distilled water.

TDS and sulphate (SO_4^{2-}) were determined gravimetrically. Total hardness was measured by EDTA complexometry titration and the indicator was Erichrome Black T (EBT) at pH 10 (Eatan et al., 1995). Total alkalinity determined by acid titration using methyl-orange as end point indicator and chloride content was estimated by silver nitrate ($AgNO_3$) titration using Potasssium Chromate (K_2CrO_4) solution as an indicator. Free carbon dioxide and total acidity were measured volumetrically by making use of N/44 sodium hydroxide and N/50 sodium hydroxide as standard titrant respectively and phenolphthalein as an indicator in both the cases. Phosphate (PO_4^{3-}) and nitritre (NO_2^-) were measured spectrophotometrically. Calcium and magnesium were determined by Atomic Absorption Spectrometer (AAS) of Perkin Elmer Precisely, AAnalyst 800 at USIC, Kashmir University.

Graphical treatment

All the graphical depictions were made using Excel 2007 (Microsoft Office®).

Results

The results of various water quality parameters of the Hazratbal basin of Dal lake quarterly (May 2013 to August 2013) are based on twelve water samples (3 sampling ×4 months) are summarized in Table 2, 3, 4 and 5.

Considerable fluctuations in pH were observed during the month of may across the three sites. The pH range falls well within WHO limits. The average range of TDS and EC in the lake water was found 113-147.5 ppm and 171.75-210.75 μScm^{-1} respectively. The salinity average range was 103.75-135 ppm. DO average range was 3.99-4.69 ppm across the three sites of the Hazratbal basin of Dal lake. COD and BOD were having an average range of 12.02-21.2 ppm and 1.42-2.48 ppm respectively. Free carbon dioxide and acidity average range was 1-4.25 ppm and 2.25-6 ppm respectively. Turbidity and colour has an average range of 0.01-9.3 and 12.5-20 hazen respectively. Air temperature and water temperature were having an average range of 20.5-20.75°C and 22.75-24.25°C respectively. Alkalinity average range was 69-80 ppm. Chloride concentration was found in the average range of 8.5-12.25 ppm. The phosphate and nitrite values were found in the average range of 0.72-7.27 ppm and 0.034-0.75 ppm respectively. Sulphate was in the average range of 1.92-40.32. The average concentration range of calcium and magnesium ions was 22.75-26.25 ppm and 7-8.75 ppm respectively and was well within WHO limits.

Discussion

Chemistry of lake water

The minimum and maximum values of all physico-chemical parameters of water samples collected from the three sites are represented in Table 6. The results are compared to the World Health Organization recommended maximum permissible limits (WHO, 2004).

Water quality parameters

Air and water temperature showed a very characteristic cycle, with higher values during july and august. The pH values of collected water samples were within those defined by WHO guidelines of 6.5-8.5 (WHO, 2004). The EC was appreciable due to significant amount of dissolved salts. The annual rainfall in the basin is little so a little variation was observed during the interval. EC increases with temperature at a rate of 1.9 per cent per $^{\circ}$C (Bartram and Balance, 1996). The EC is attributed to high salinity and high mineral content in all sampling sites. It also corresponds to the highest concentration of dominant ions, which are the result of ion exchange and solubilization in the aquifer (Sachez-Perez and Tremolieres, 2003). The major cations (Ca and Mg) and major anions (Cl and SO_4) in the lake water increase EC, is consistent with other study (Zacheus and Martikainen, 1997). Alkalinity values fluctuated among all sampling sites. In the month of august all the sites showed a dip in the values of alkalinity.

The oxygen in surface water comes from air or is produced by photosynthetic organisms like algae and plants in a water body. The oxygen content is decreased with increase in water temperature. It has negative impact on organic waste processing by the aerobic micro-organisms. The monitoring of oxygen concentration in aquatic system is an important subject (Galal-Gorchev et al., 1993),as the physical, chemical and biological processes involved in oxygen fluactuation in lake are numerous. The highest value of COD was recorded at the Sonilank site and lowest at the Telbal Nallah site. COD is widely used for determining waste concentration and is applied primarily to pollutant mixtures such as domestic sewage, agricultural and industrial waste. In case of BOD the higher values were observed at Telbal Nallah area, due to local anthropogenic pollution. The phosphate concentration also varied across the three sites.

Graphic depictions for some water quality parameters of the three sites of Hazratbal Bain of Dal lake

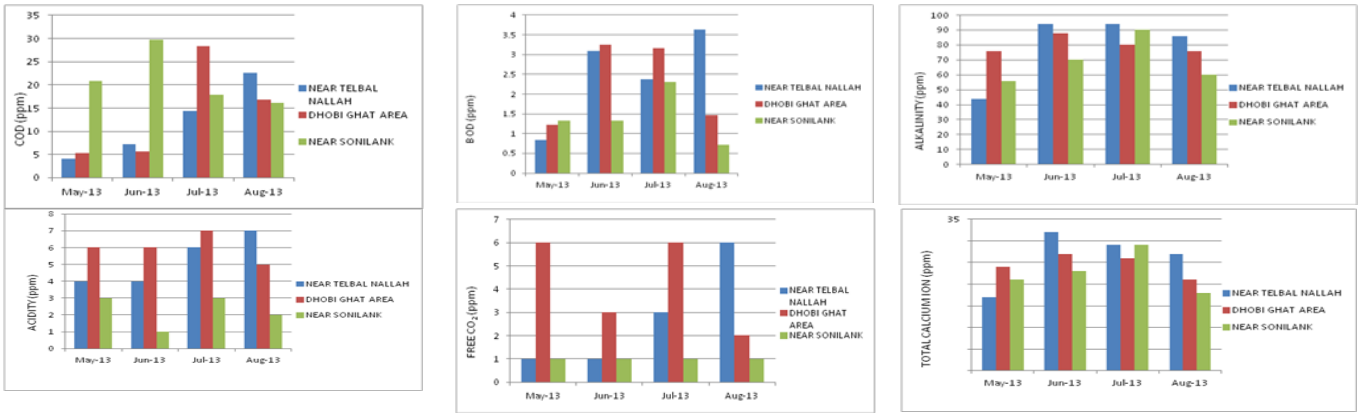

Table 1. Water quality parameters associated with their abbreviations, units and analytical methods used

Parameters	Abbreviations	Units	Analytical methods
pH	pH	pH unit	pH meter
Air temperature	A –Temp	°C	Thermometric
Water temperature	W –Temp	°C	Thermometric
Colour	Colour	Hazen	Visually
Electrical conductivity	EC	μScm^{-1}	Electrometric
Salinity	Salinity	ppm	Electrometric
Total Dissolved Solids	TDS	ppm	Gravimetric
Total Hardness	T-Hard	ppm	Titrimetric
Turbidity	Turbidity	NTU	Turb metric
Dissolved Oxygen	DO	ppm	Prob method
Chemical Oxygen Demand	COD	ppm	Spectroquant photometric
Biochemical Oxygen Demand	BOD	ppm	Prob metod (5 days later)
Total Alkalinity	T-Alk	ppm	Titrimetric
Phosphate	PO_4	ppm	Spectrometric
Sulphate	SO_4	ppm	Gravimetric
Nitrite	NO_2	ppm	Spectrophotometric
Free carbon dioxide	Free CO_2	ppm	Titrimetric
Acidity	Acidity	ppm	Titrimetric
Total Chloride	T-Cl	ppm	Titrimetric
Calcium	Ca	ppm	AAS
Magnesium	Mg	ppm	AAS
Sodium	Na	ppm	AAS

Table 2 First sampling, May 2013

Parameters	Site-1 Near Telbal Nallah	Site-2 Dhobi Ghat Area	Site -3 Near Sonilank
pH	7.59	7.53	7.96
Air temperature (°C)	20	21	21
Water temperature (°C)	18	19	20
Colour (hazen)	10	15	15
Electrical conductivity ($\mu S\ cm^{-1}$)	107	147	124
Salinity (Ppm)	69	94	80
Total Dissolved Solids (ppm)	75	103	87
Total Hardness (ppm)	48	82	64
Turbidity (NTU)	9.3	0.01	0.01
Dissolved Oxygen (ppm)	5.12	3.61	5.41
Chemical Oxygen Demand (ppm)	4.0	5.2	20.9
Biochemical Oxygen Demand (ppm)	0.83	1.22	1.33
Total Alkalinity (ppm)	44	76	56
Phosphate (ppm)	4.1	0	0
Sulphate (ppm)	15.2	11.2	16.2
Nitrite (Ppm)	0.020	0.14	0.026
Free carbon dioxide (ppm)	1	6	1
Acidity (ppm)	4	6	3
Total Chloride (ppm)	9	10	8
Calcium (ppm)	17	24	21
Magnesium (ppm)	2	5	3
Sodium (ppm)	0.68	1.28	0.88

Table 3 Second sampling, June 2013

Parameter	Site-1 Near Telbal Nallah	Site-2 Dhobi Ghat Area	Site -3 Near Sonilank
pH	8.15	7.95	8.24
Air temperature (°C)	21	19	19
Water temperature (°C)	24	26	24
Colour (hazen)	10	25	15
Electrical conductivity (µS cm^{-1})	214	200	107
Salinity (ppm)	137	128	69
Total Dissolved Solids (ppm)	150	140	75
Total Hardness (ppm)	116	96	90
Turbidity (NTU)	2.55	2.58	0.01
Dissolved Oxygen (ppm)	4.27	3.95	4.01
Chemical Oxygen Demand (ppm)	7.2	5.6	29.8
Biochemical Oxygen Demand (ppm)	3.09	3.24	1.32
Total Alkalinity (ppm)	94	88	70
Phosphate (ppm)	8.7	0	0.7
Sulphate (ppm)	23.04	7.68	1.92
Nitrite (ppm)	0.034	0.089	0.031
Free carbon dioxide (ppm)	1	3	1
Acidity (ppm)	4	6	1
Total Chloride (ppm)	9	14	11
Calcium (ppm)	32	27	23
Magnesium (ppm)	9	7	8
Sodium (ppm)	0.71	1.11	0.86

Table 4 Third sampling, July 2013

Parameter	Site-1 Near Telbal Nallah	Site-2 Dhobi Ghat Area	Site -3 Near Sonilank
pH	7.97	7.99	8.06
Air temperature (°C)	20	19	20
Water temperature (°C)	26	26	26
Colour (hazen)	15	25	20
Electrical conductivity (µS cm^{-1})	286	300	271
Salinity (ppm)	183	192	174
Total Dissolved Solids (ppm)	200	210	190
Total Hardness (ppm)	112	100	104
Turbidity (NTU)	2.43	5.72	0.51
Dissolved Oxygen (ppm)	4.48	3.90	4.77
Chemical Oxygen Demand (ppm)	14.3	28.3	17.9
Biochemical Oxygen Demand (ppm)	2.38	3.16	2.31
Total Alkalinity (ppm)	94	80	90
Phosphate (ppm)	6.4	0	0.7
Sulphate (ppm)	15.36	23.04	15.36
Nitrite (ppm)	0.051	0.030	0.065
Free carbon dioxide (ppm)	3	6	1
Acidity (ppm)	6	7	3
Total Chloride (ppm)	9	15	11
Calcium (ppm)	29	26	29
Magnesium (ppm)	10	9	8
Sodium (ppm)	0.84	1.42	1.11

Table 5 Fourth sampling, August 2013

Parameter	Site-1 Near Telbal Nallah	Site-2 Dhobi Ghat Area	Site -3 Near Sonilank
pH	7.95	8.00	8.04
Air temperature (°C)	21	23	23
Water temperature (°C)	23	26	25
Colour (hazen)	15	15	10
Electrical conductivity (µS cm^{-1})	236	157	143
Salinity (ppm)	151	101	92
Total Dissolved Solids (ppm)	165	110	100
Total Hardness (ppm)	126	104	82
Turbidity (NTU)	6.02	0.43	0.01
Dissolved Oxygen (ppm)	4.90	4.50	4.57
Chemical Oxygen Demand (ppm)	22.6	16.8	16.2
Biochemical Oxygen Demand (ppm)	3.63	1.46	0.71
Total Alkalinity (ppm)	86	76	60

Phosphate (ppm)	9.9	2.9	2.9
Sulphate (ppm)	40.32	34.56	32.64
Nitrite (ppm)	0.032	0.040	0.022
Free carbon dioxide (ppm)	6	2	1
Acidity (ppm)	7	5	2
Total Chloride (ppm)	7	10	9
Calcium (ppm)	27	21	18
Magnesium (ppm)	14	13	9
Sodium (ppm)	0.80	1.46	1.18

Table 6. Range and average of water quality parameters at different sites of Hazratbal Basin of Dal Lake during May 2013- August 2013

Parameters	WHO limits	Site-1 Near Telbal Nallah	Site-2 Dhobi Ghat Area	Site -3 Near Sonilank
pH	6.5-8.5	Range 7.59-8.15 Average 7.91	Range 7.53-8.0 Average 7.87	Range 7.96-8.24 Average 8.07
Air temperature (^oC)		Range 20-21 Average 20.5	Range 19-23 Average 20.5	Range 19-23 Average 20.75
Water temperature (^oC)		Range 18-26 Average 22.75	Range 19-26 Average 24.25	Range 20-26 Average 23.75
Colour (hazens)		Range 10-15 Average 12.5	Range 15-25 Average 20	Range 10-20 Average 15
Electrical conductivity ($\mu S\ cm^{-1}$)	1500	Range 107-286 Average 210.75	Range 147-300 Average 201	Range 107-228 Average 171.75
Salinity (ppm)		Range 69-183 Average 135	Range 94-192 Average 128.75	Range 69-174 Average 103.75
Total Dissolved Solids (ppm)	1000	Range 75-200 Average 147.5	Range 103-210 Average 140.75	Range 75-190 Average 113
Total Hardness (ppm)		Range 48-126 Average 100.5	Range 82-104 Average 95.5	Range 64-104 Average 85
Turbidity (NTU)		Range 2.43-9.3 Average 5.07	Range 0.01-5.72 Average 2.18	Range 0.01-0.51 Average 0.13
Dissolved Oxygen (ppm)		Range 4.27-5.12 Average 4.69	Range 3.61-4.50 Average 3.99	Range 4.01 Average 4.69
Chemical Oxygen Demand (ppm)	10	Range 4-22.6 Average 12.02	Range 5.2-28.3 Average 13.97	Range 16.2-29.8 Average 21.20
Biochemical Oxygen Demand (ppm)	6	Range 0.83-3.63 Average 2.48	Range 1.22-3.24 Average 2.27	Range 0.71-2.31 Average 1.42
Total Alkalinity (ppm)	200	Range 44-94 Average 79.5	Range 76-88 Average 80	Range 56-90 Average 69
Phosphate (ppm)		Range 4.1-9.9 Average 7.27	Range 0-2.9 Average 0.72	Range 0-2.9 Average 1.07
Sulphate (ppm)	250	Range 15.2-40.32 Average 23.48	Range 7.68-34.56 Average 19.12	Range 1.92-32.64 Average 16.45
Nitrite (ppm)	3	Range 0.02-0.051 Average 0.034	Range 0.03-0.14 Average 0.075	Range 0.022-0.06 Average 0.036
Free carbon dioxide (ppm)		Range 1-6 Average 2.75	Range 2-6 Average 4.25	Range 1 Average 1
Acidity (ppm)		Range 4-7 Average 5.25	Range 5-7 Average 6	Range 1-3 Average 2.25
Total Chloride (ppm)	250	Range 7-9 Average 8.5	Range 10-15 Average 12.25	Range 8-11 Average 9.75
Calcium (ppm)	100	Range 17-32 Average 26.25	Range 21-27 Average 24.5	Range 18-29 Average 22.75
Magnesium (ppm)	50	Range 2-14 Average 8.75	Range 5-13 Average 8.5	Range 3-9 Average7
Sodium		Range 0.68-0.84 Average 0.75	Range 1.11-1.46 Average 1.31	Range 0.86-1.18 Average 1.00

The Permeability Index (PI)

The PI is also a useful tool which indicates whether water samples are suitable for irrigation. The classification of water is done as Class I (>75%), Class II (25-75%) and Class III (<25%) to find out suitability of water for irrigation purpose. Irrigated water influenced by Na, Ca, Mg and HCO_3 ion contents affects the permeability of the soil after a long term use. Class I and II are categorized as good water quality for irrigation and Class III as unsuitable for irrigation having a maximum permeability of 25%. The PI was calculated employing the following equation, where all the ions are expressed in meq/L.

$$PI = \frac{Na^+ + \sqrt{HCO_3} \times 100}{Ca^{2+} + Mg^{2+} + Na^+}$$

The PI for sites Dhobi Ghat and Sonilank were 30.09 and 30.24 respectively. The water quality at all the two sites fall under Class II, and hence regarded as good for irrigation purposes and for the site near Telbal Nallah the PI was found to be 27.02 and falls under Class II, hence suitable for agricultural purposes.

Kelly's Ratio (KR)

KR was calculated employing the following equation:

$$KR = \frac{Na^+}{Ca^{2+} + Mg^{2+}}$$

Kelly's ratio less than one is generally considered suitable for irrigation.Telbal site, Dhobi Ghat site and Sonilak site have KR equal to 0.021, 0.04 and 0.033 respectively and hence fit for irrigation.

Sodium Adsorption Ratio (SAR)

The SAR parameter evaluates the sodium hazard in relation to calcium and magnesium concentrations. This parameter is commonly used as an index to evaluate water suitability for irrigation purposes. The SAR was calculated by the following equation:

$$SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$$

If SAR value is < 10, the water is safe for irrigation with no structural deterioration. On the other hand, the SAR value is > 6-9, the irrigation water will cause permeability problems on shrinking and swelling types of clayey soils. Continued use of water having high SAR leads to breakdown in the physical structure of the soil particles. 0.18, 0.32 and 0.25 were the respective SAR values for Telbal site, Dhobi Ghat and Sonilank site.

Magnesium Hazard (MH)Magnesium concentration of water plays an important role in determining the quality of water for irrigation purposes and hence, agricultural use. Magnesium hazard was determined by employing the following equation:

$$MH = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \times 100$$

Generally, magnesium hazard more than 50 is considered harmful and unsuitable for irrigation use. The respective MH for Telbal site, Dhobi Ghat site and Sonilank site were 25.0, 25.95 and 23.52.

Water Quality Index Computation:-

Weighed 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 by various scientists and the calculation of WQI was made by using the following equation:

$$WQI = \sum QiWi / \sum Wi$$

The quality rating scale (Qi) for each parameter is calculated by using this expression

$$Qi = 100[(Vi-Vo/Si-Vo)]$$

Where,

Vi is estimated concentration of ith parameter in the analyzed water

Vo is the ideal value of this parameter in pure water

Vo = 0 (except pH = 7.0)

Si is the recommended standard value of ith parameter

The unit weight (Wi) for each water quality parameter is calculated is calculated by using the following formula:

Wi = K/Si

Where,

K = proportionality constant and can also be calculated by using the following equation:

$$K = 1 / \sum(\frac{1}{Si})$$

The rating of water quality according to this WQI is given in table.

Table 7. Water Quality Rating as per Weight Arithmetic Water Quality Index Method

WQI Value	Rating of Water Quality	Grading
0-25	Excellent water quality	A
26-50	Good water quality	B
51-75	Poor water quality	C
76-100	Very poor water quality	D

By employing important physico-chemical parameters like COD, EC, TDS, BOD, nitrite, total alkalinity, sulfate, chloride, Ca and Mg ions for which the recommended standard values were available in arithmetic water quality index equation and doing the required simulations for the for the three sites of the Hazratbal Basin of the Dal Lake i.e. site 1, Near Telbal Nallah; site 2, Dhobi Ghat Area; site 3, Near Sonilank.

The grade of the water quality of the Hazratbal basin of Dal Lake over the four month period for the three sites was found "B" which means the water quality is good.

Over all water quality of the basin

The phosphate concentrations were high near Telbal Nallah site because of contamination caused by agricultural wastes which come along with the Telbal Nallah and join the Hazratbal basin of the Dal lake at the said site. Nitrites did not vary much across the three sites. If in excess i.e >1 ppm, nitrites can produce a serious condition in fish called 'brown blood disease'. Nitrites can also react directly with hemoglobin in human blood to produce methemoglobin. Methemoglobin destroys the ability of the red blood cell to transport oxygen. Chlorides are well below permissible limits of WHO. Chlorides get into surface water from agricultural runoffs and effluent waste water from waste water treatment plants. Water temperature also changes during the four month period. Water temperature regulates the metabolism of aquatic ecosystem. High water temperature stresses aquatic ecosystem by reducing the ability of water to hold essential dissolved gases like oxygen and thereby fish kills occur in water bodies because of depletion of oxygen. Total hardness of lake water at the three sites falls more or less within 61 to 120 Ppm and hence the water can be regarded as moderately hard. Free carbon dioxide remains constant at 1Ppm near Sonilank site and also the acidity did not show many fluctuations at this site.

Dissolved metals in lake

The concentrations of calcium and magnesium ions are well within the permissible limits (WHO, 2004). In a watery solution calcium is mainly present as $Ca^{2+}_{(aq.)}$ but it may also occur as calcium hydroxide, $Ca(OH)_{2(aq.)}$. Calcium is an important determinant of water hardness, and it also functions as a pH stabilizer, because of its buffering qualities. Calcium also gives water a better taste. Water hardness influences aquatic organisms concerning metal toxicity. In softer water, membrane permeability in gills is increased. Calcium also competes with other ions for binding spots in the gills. Consequently, hard water better protects fish from direct metal uptake.

Magnesium is mainly present as $Mg^{2+}_{(aq.)}$ in watery solutions. It also occurs as magnesium sulphate, $MgSO_4$. $MgSO_4$ adds a bitter flavor to water. Environmental problems indirectly caused by magnesium in water are caused by applying softeners.

Conclusion

In this study, different water quality parameters of the surface water of Hazratbal Basin of Dal Lake were evaluated. The information drawn from the data reveals that it is possible to formulate viable strategies which could reduce the pollution potential of the lake water. The main cause of degradation of the lake is the discharge of agricultural wastes and municipal sewage water. Fishing and boating activities among the major source responsible for lake water deterioration. This study helps in identification of pollution sources and understanding variations in water quality for effective lake water management. Interventions like reduction in anthropogenic discharge, rehabilitations of households in the vicinity of Lake Basin, reforestation and stoppage of encroachments should be made possible, otherwise high level pollution will greatly influence the population.

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