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CORRELATION OF VARIOUS PHYSICO-CHEMICAL PARAMETERS AND WATER QUALITY INDEX (WQI) OF CHANDOLA LAKE, AHMEDBAD, GUJARAT, INDIA

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ABSTRACT:

A systematic study has been carried out to assess the Water Quality Index of Chandola Lake, Ahmedabad, Gujarat, India. Water samples from ten sampling sites were collected and analyzed for physico-chemical parameters (electrical conductivity, total dissolved solids, pH, dissolved oxygen, alkalinity, total hardness, calcium, magnesium, chloride, nitrate and biological oxygen demand). The study area experiences a seasonal climate and broadly divided into three seasons as monsoon (June to September), winter (October to January) and summer (March to May). The samples were collected and analyzed for one year from September 2013 to August 2014. Each parameter was compared with the standard desirable limit of that parameter in lake water as prescribed by different agencies. The analytical data of various physico-chemical parameters indicates that some parameters like total dissolved solids, pH, alkalinity, total hardness and calcium was beyond the permissible limit according to WHO and BIS standards for drinking purpose in the year. The WQI value indicates that water samples of summer and monsoon season were unsuitable for drinking.

KEY WORD: *Chandola lake; Water Quality Index; Physico-Chemical Parameter; Correlation.*

INTRODUCTION:

Lake pollution is one of the serious environmental problems in recent years with the social – economic development and pollutant discharge increase from industry, agriculture and domesticity (Puri *et al.* 2011). Lakes are one of the important water resources used for irrigation, drinking, fisheries and flood control purposes. (Kotadiya *et al*. 2013). Water is one of the most important factors for every living organism on the earth (Thakor *et al*. 2011). Water is generally used for drinking, fisheries and other domestic purposes in this area. The lakes also provides a habitat for invertebrates, fishes and aquatic birds (Hosmani, 2013).

Water pollution also occurs when rain water runoff from urban and industrial area and from agricultural land and mining operations makes its way back to receiving waters (river, lake or ocean) and into the ground (Joshi, 2009; Qureshimatva, 2015). The use of industrial waste and domestic pollutants are the main source of water pollution in Chandola Lake.

Water Quality Index is defined as a rating representing the composite influence of different water quality parameters as the overall quality of water. The WQI was calculated from the suitability of pond water for human consumption (Florence, 2012; Yogendra, 2008). The weights for various water quality parameters were assumed to be inversely proportional to the recommended standards which have been presented in the respective chapter for the corresponding parameter (Sinhal *et al*., 2014).

Chandola Lake is the biggest lake of Ahmedabad city covering 6, 18,100 m^2 area at the eastern part. Major part of the Chandola Lake is covered by Dhobis, where the washing and clearing of cloths are carried out, whereas the remaining part of the lake is covered by slum area and small scale industries. The water in Chandola Lake is supplied through kharikat canal. The lake also receives influx of polluted water from the surrounding slum area. The colored water containing chemical was also released by the dhobis, small scale industries also released their waste directly into the lake (Verma *et. al*., 2012).

Location: located near Dani Limda Road, Ahmedabad, Gujarat.

Latitude: 22059’03.33” N

Longitude: 72035’24.19” E

Area covered: 6, 18,100 m^2

Maintained by: Ahmedabad Municipal Corporation (AMC).

Figure 1: Satellite image of Chandola Lake, Ahmedabad shows sampling points, (Source: Google map).

Therefore, scientific study needs to review strategies for conservation and better utilization of lakes. It is with this background, the present work was undertaken between September 2013 to August 2014.

MATERIALS AND METHOD:

Collection of samples:

The water samples were collected in the polyethylene bottles. Initially, the prewashed bottles were rinsed with sample water. The closed bottle was dipped in the lake at the depth of 0.5 m, and then a bottle was opened inside and was closed again to bring it out at the surface. The samples collected in three replicates from ten different points were mixed together to prepare an integrated sample (Figure 1). The study area experiences a seasonal climate and broadly divided into three seasons as monsoon (June to September), winter (October to January) and summer (March to May).

Physico-chemical parameters:

To study the physico-chemical properties of the lake water content, water samples were collected from the lake surface in a clean polythin container for the period of one year, September 2013 to August 2014. Samples were collected during morning hours in between 8.00 to 10.00 a.m. using one litre container. The physical and chemical parameters were analyzed in the seasons of monsoon, winter and summer, respectively. Parameters including electrical conductivity, total dissolved solid, pH, alkalinity, total hardness, calcium, magnesium, dissolved oxygen, chloride, nitrate and biochemical oxygen demand were analyzed. Parameters such as pH, electrical conductivity and dissolved oxygen were directly evaluated in the study area, whereas other parameters were analyzed in laboratories. The parameters were compared according to the standard methods described in the literature (APHA, 1989; WHO, 1998; Botkin and Keller, 1995 and BIS, 1993).

Table No. 1. Water Quality Index (WQI) and its status according to (Chatterji and Raziuddin, 2002 and Thakor *et. al*, 2011).

Water Quality Index Level	Water Quality Status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

The weighted arithmetic index method (Brown et al, 1972; Yogendra and Puttaiah, 2008) was used for the calculation of water quality index (WQI) of the water body. Further, quality rating or sub index (q_n) was calculated by the following expression.

$$q_n = 100[V_n - V_{10}] / [S_n - V_{10}]$$

Where: q_n = Quality rating for the n^{th} water quality parameter,

V_n = Estimated value of the *nth* water quality parameters of collected sample,

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

V_{10} = Ideal value of the n^{th} water quality parameter in pure water.

(i.e. 0 for all other parameters except the parameter pH and Dissolved Oxygen (7 and 14.6 mg/L respectively.) (Let there be *n* water quality parameters and quality rating or sub index (q_n) corresponding to n^{th} parameter is a number reflecting the relative of this parameter in polluted water with respect to its standard permissible value.)

Unit weight was calculated by a value inversely proportional to the recommended standard value S_n of the corresponding parameter.

$$W_n = K / S_n$$

Where: W_n = Unit weight for n^{th} water quality parameter,

S_n = Standard permissible value of the nth water quality parameter,

K = Constant for proportionality.

The overall WQI was calculated by aggregating the quality rating with the unit weight linearly.

$$WQI = \sum q_n W_n / \sum W_n$$

Where: q_n = Quality rating for the n^{th} water quality parameter,

W_n Unit weight for n^{th} water quality parameter

RESULT AND DISCUSSION:

Physico-chemical parameters:

The physico-chemical parameters such as electrical conductivity, total dissolved solid, pH, alkalinity, total hardness, calcium, magnesium, dissolved oxygen, chloride, nitrate and biochemical oxygen of water were analyzed for the water samples collected from the Chandola Lake. These parameters were taken at the five points of the lake season wise (monsoon, winter and summer). All parameters with the mean value of the data with standard error were calculated as shown in the table **2**.

Table 2: Average with standard error values of physico-chemical parameters of water samples collected in Chandola Lake

Average with standard error values of physico-chemical parameters of water samples collected in Chandola Lake.					WHO (1998) and BIS (2003) standards for Drinking water (Annual Max.)
Sr. No.	**Parameters**	**Year 2013-14**			
		Monsoon	**Winter**	**Summer**	
1	Electrical conductivity (Ω /cm)	4.15	4	5.14	500
2	Total Dissolve Solid (mg/L)	864	974	740	259-500
3	pH	9. 4	8.4	9.5	6.5-8.5
4	Alkalinity (mg/L)	210	189	180	100
5	Total Hardness (mg/L)	356	280	320	200
6	Calcium (mg/L)	125	120	130	75
7	Magnesium (mg/L)	36	33	30	150
8	Dissolved Oxygen (mg/L)	3. 22	3.12	3.4	7.5
9	Chloride (mg/L)	122	128	148	200
10	Nitrate (mg/L)	8.78	9.22	9.31	11
11	Biochemical Oxygen Demand (mg/L)	1.9	2.3	1.8	6.9

Electrical conductivity

Electrical conductivity is a measure of water capability to transmit electric current and also it is a tool to assess the purity of water. The electrical conductivity ranged from 4 to 5.14Ω/cm. The highest electrical conductivity was reported during summer season (5.14 Ω/cm) may be the attributed to the predominance of non-leached substratum and the large size of the catchment area (Verma et al. 2012).

Total dissolved solids:

Total dissolved solids denote mainly the various kinds of minerals presents in the water. Total dissolved solids indicate the salinity behavior of groundwater (Goher, 2002). The total dissolved solids ranged from 740 to 974 mg/L. The highest total dissolved solids was reported during winter (974 mg/L) due to the addition of organic sources such as leaves, silt, plankton, and industrial waste and sewage (Pandit and Solanki, 2006).

pH:

pH value is very important for plankton growth (Chisty, 2002). According to Umavathi et al (2007) pH is ranged 5 to 8.5 is best for plankton growth. During present study water pH values were found was 8.4 to 9.5. It is indicating alkalinity nature throughout the study period. The high values may be due to attributed sewage discharged by surrounding industries and slum area.

Alkalinity:

The alkalinity of surface water is primarily a function of carbonate, hydroxide content and also includes the contributions from borates, phosphates, silicates and other bases. Alkalinity is a measure of the capacity of water to neutralize a strong acid (Wetzel, 1983). The alkalinity in the water samples ranged from 180 to 210 mg/L. The high alkalinity recorded during monsoon season was 210 mg/L due to high nutrients in water through the runoff water from the surrounding area (Verma *et al.*, 2012).

Total Hardness:

Principally the water hardness is changed by ions such as calcium, magnesium, carbonate, bicarbonate, chloride and sulphate in water (Kotadiya et al, 2013). The total Hardness from the water samples at Chandola Lake ranged between 356 to 280 mg/L. The highest amount of total hardness in the water samples was recorded during monsoon was 356 mg/L due to the presence of high content of calcium and magnesium in addition to sulfate and nitrate in the sewage waste added during monsoon (Uduma, 2014).

Calcium:

Calcium is most abundant ions in fresh water and is important in shell construction, bone building and plant precipitation of lime (Narayan *et al*, 2008). The analysis of calcium revealed a ranged between 130 to 120 mg/L. The highest amount of calcium recorded in water samples the during summer season was 130 mg/L by the dilution of water at high temperature and also due to high vegetation of phytoplankton.

Magnesium:

Magnesium is often associated with calcium in all kinds of waters, but its concentration remains generally lower than the calcium. Magnesium is essential for chlorophyll growth and acts as a limiting factor for the growth of phytoplankton (Smitha *et al,* 2007). The amount of magnesium recorded in the water samples ranged between 30 to 36 mg/L. The highest amount of magnesium in the water samples was recorded during monsoon season 36 mg/L.

Dissolved oxygen:

The higher value of dissolved oxygen indicates good aquatic life. The amount of dissolved oxygen in water samples ranged between 3.12 to 3.4 mg/L. The highest amount of dissolved oxygen was recorded during the summer season was 3.4 mg/L due to the high vegetation of phytoplankton (Solanki, 2007).

Chloride:

The chloride in drinking water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt and saline intrusion (Solanki, 2006). A chloride concentration in water samples was noticed between 148 to 122 mg/L. The highest chloride reported in summer season was 122 mg/L due to the discharge of domestic sewage from the surrounding area (Pawar and Pulle, 2005).

Nitrate:

Nitrates are contributing to freshwater through the discharge of sewage and industrial wastes and runoff from agricultural fields. The highest amount of nitrate concentration was known to support the formation of blooms (Solanki, 2001). The amount of nitrate recorded in the water samples ranged from 9.31 to 8.78 mg/L. The highest amount of nitrate was recorded during the summer season was 9.31 mg/L because of high vegetation which supported the growth of plankton and forming blooms during summer (Shastry *et al*, 1970).

Biochemical Oxygen Demand:

The biochemical oxygen demand may be defined as the oxygen required for the microorganism to perform the biological decomposition of dissolved solids or organic matter in the waste water under aerobic conditions (Verma *et al*, 2010). The biochemical oxygen demand reported from water samples was ranged between 2.3 to 1.8 mg/L. The high demand of oxygen in the water was recorded during the winter season was 2.3 mg/L due to the addition of organic waste in lake by industries which also be responsible for the increase in BOD (Pandit and Solanki, 2004).

Water Quality Index (WQI):

WQI of Chandola Lake was established from various physico-chemical parameters in three seasons (monsoon, winter and summer) during September 2013 to August 2014. The values of various physico-chemical parameters for calculation of water quality index are presented in **table 2** were used to get WQI. Season wise WQI calculations are presented in the tables **3, 4 and 5**. The WQI obtained for the water body in different seasons of the study period i.e., monsoon, winter and summer are 120.8704, 93.0917 and 121.9263 respectively.

Table 3: Calculation of WQI of water samples in monsoon season of Chandola Lake.

Calculation of Water Quality Index of water samples in monsoon season of Chandola Lake							
Sr. No	**Parameter**	**Observed Value (V_n)**	**Standard Valus (S_n)**	**Ideal Value (V_{10})**	**Unit Weight (W_n)**	**Quality Rating (Q_n)**	**W_nQ_n**
1	Electrical conductivity (Ω /cm)	4.15	300	0	0.371	1.3833	0.5137
2	Total Dissolve Solid (mg/L)	864	500	0	0.0037	172.8	0.63936
3	pH	9.4	7.5	7	0.219	480	105.12
4	Alkalinity (mg/L)	210	120	0	0.0155	175	2.7125
5	Total Hardness (mg/L)	356	300	0	0.0062	118.666	0.7357
6	Calcium (mg/L)	125	75	0	0.025	166.6666667	4.1666
7	Magnesium (mg/L)	36	30	0	0.061	120	7.32
8	Dissolved Oxygen (mg/L)	3.22	5	14.6	0.3723	118.5416	44.1330
9	Chloride (mg/L)	122	250	0	0.0074	48.8	0.3611
10	Nitrate (mg/L)	8.78	45	0	0.0412	19.511	0.8038
11	Biochemical Qxygen Demand (mg/L)	1.9	5	0	0.3723	38	14.1474
					ΣW_n= 1.4946	**ΣQ_n = 1459.36944**	**ΣW_nQ_n = 180.6529**
WQI= 120.8704							

Table 4: Calculation of WQI of water samples in winter season of Chandola Lake.

Calculation of Water Quality Index of water samples in winter season of Chandola Lake							
Sr. No	**Parameter**	**Observed Value (V_n)**	**Standard Valus (S_n)**	**Ideal Value (V_{10})**	**Unit Weight (W_n)**	**Quality Rating (Q_n)**	**W_nQ_n**
1	Electrical conductivity (Ω /cm)	4	300	0	0.371	1.333	0.4946
2	Total Dissolve Solid (mg/L)	974	500	0	0.0037	194.8	0.72076
3	pH	8.4	7.5	7	0.219	280	61.32

4	Alkalinity (mg/L)	189	120	0	0.0155	157.5	2.44125
5	Total Hardness (mg/L)	280	300	0	0.0062	93.333	0.5786
6	Calcium (mg/L)	120	75	0	0.025	160	4
7	Magnesium (mg/L)	33	30	0	0.061	110	6.71
8	Dissolved Oxygen (mg/L)	3.12	5	14.6	0.3723	119.5833	44.5208
9	Chloride (mg/L)	128	250	0	0.0074	51.2	0.37888
10	Nitrate (mg/L)	9.22	45	0	0.0412	20.48888	0.8441
11	Biochemical Qxygen Demand (mg/L)	2.3	5	0	0.3723	46	17.1258
					ΣW_n= 1.4946	**ΣQ_n = 1234.2388**	**ΣW_nQ_n = 139.13504**
WQI= 93.0917							

Table 5: Calculation of WQI in summer season of Chandola Lake.

Calculation of Water Quality Index in summer season of Chandola Lake							
Sr. No	**Parameter**	**Observed Value (V_n)**	**Standard Valus (S_n)**	**Ideal Value (V_{10})**	**Unit Weight (W_n)**	**Quality Rating (Q_n)**	**W_nQ_n**
1	Electrical conductivity (Ω /cm)	5.14	300	0	0.371	1.7133	0.635646667
2	Total Dissolve Solid (mg/L)	740	500	0	0.0037	148	0.5476
3	pH	9.5	7.5	7	0.219	500	109.5
4	Alkalinity (mg/L)	180	120	0	0.0155	150	2.325
5	Total Hardness (mg/L)	320	300	0	0.0062	106.666	0.6613
6	Calcium (mg/L)	130	75	0	0.025	173.333	4.3333
7	Magnesium (mg/L)	30	30	0	0.061	100	6.1
8	Dissolved Oxygen (mg/L)	3.4	5	14.6	0.3723	116.6666	43.435
9	Chloride (mg/L)	148	250	0	0.0074	59.2	0.4380
10	Nitrate (mg/L)	9.31	45	0	0.0412	20.68888	0.85238
11	Biochemical Qxygen Demand (mg/L)	1.8	5	0	0.3723	36	13.4028
					ΣW_n= 1.4946	**ΣQ_n = 1412.2688**	**ΣW_nQ_n =182.2311**
WQI= 121.92633							

Also, **table** 1 explains water quality classification based on WQI criteria, which in turn, indicates that Water Quality Index (WQI) of all season samples are within the category of unsuitable for drinking (> 100) during summer season and monsoon season whereas poor water quality during winter (76-100). Hence, it can be seen that the water quality of lake system was highly deteriorating from winter season to the summer season and monsoon season due to the industrial activity and domestic sewage directly released into the lake. WQI results indicate that water at Chandola Lake is highly polluted during the whole year and this water cannot utilise for public consumption and irrigation.

Correlation coefficient:

The correlation between two variables is expressed by Pearson coefficient 'r'. There is a direct correlation between two parameters if a change in one of them affects the other in a linear way. The correlation coefficients (r) among various quality parameters were calculated and the values are given in **table 6**. Pearson correlation coefficient 'r' indicated a good positive relation between nitrate and dissolved oxygen (r= 0.996), magnesium and alkalinity (r= 974), chloride and electric conductivity (r= 942) whereas good negative relation between Calcium and total dissolved solids (r= -0.999), pH and biological oxygen demand (r= -0.994), nitrate and alkalinity (r= -0.991).

CONCLUSION:

The present study shows detailed physico-chemical characteristics and quality of water in Chandola lake, Ahmedabad, Gujarat, India. The monsoon, winter and summer seasons shows different seasonal fluctuations in various physico-chemical parameters. The water parameters indicate that the water of the lake is rich high level of organic pollutants which are coming from nearby sources. Total dissolved solids, pH, alkalinity, total hardness and calcium was beyond the permissible limit according to WHO and BIS standards for drinking purpose. The correlation coefficient indicates positive and negative significant correlation of physico-chemical parameters with each other. To improve quality of water there should be continuous monitoring of pollution level and stop the direct release of pollutants from the industries and domestic sewage. The authority of AMC and other civic body must take action against this.

This present situation may drastically affect the aquatic as well as terrestrial organism's growth in the water repository and significant pollutants dumped by industries and domestic sections pose an additional threat to the water quality in the near future. To sustain the ecology and aquatic life in the Chandola lake, certain measures and planning must be undertaken by the civic body to combat the pollution rate in the lake.

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