Water Quality Assessment Using Physico-Chemical Parameters And NSF-WQI Indicator

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Abstract

Osman Sagar was created by damming the Musi River in 1920, to provide an additional source of drinking water for Hyderabad and to protect the city after the great Musi River flood of 1908.The flood problem and the shortage of drinking water problem have been solved after the Nizam consulted Sri Sir M. Visvesvaraya. The Osman Sagar and Himayat Sagar lakes are home for large number of native plant and animal species, therefore water quality and health of the lake are vital for conservation of these species. The present study aimed at evaluation of the Osman Sagar and Himayat Sagar using NSF-WQI as an indicator of water quality. WQI is a suitable tool to examine and classify spatial and temporal variations in water quality and pollution levels in a water body. Water pumping sites were selected, and sampling of Water is done by taking composite samples. Water samples will be taken and placed in dark bottle, kept in ice box to prevent any change in chemical properties of the samples prior to transportation to the lab for further analysis. Nitrates, orthophosphate, NH_4^+, NH_3, Iron, Salinity, Electron conductivity (EC) and pH were measured. Water quality assessment carry out based on values obtained from nine factors including Dissolved oxygen (DO), Fecal coliform, BOD, pH, Water temperature (^{0}c), Phosphate, Nitrate, Total suspended solid (TSS) and Turbidity According to the test results, Water quality index (WQI) in both reservoirs is ranging between 50-70. Himayat Sagar has a water quality index value of 56.66, while Osman Sagar has a value of 57.1. are indicating that the available water quality status as Moderate quality. As per our results more parameters of water need to be much treated before supplying to the consumers in the present time.

Keywords: NSF-WQI index, water quality.

1. Introduction

An important method for identifying water quality and its suitability for drinking is the Water Quality Index (WQI). Physical, chemical, and biological factors can be used to evaluate the water quality of any particular place or source. WQI has the capacity to combine the majority of the various water quality characteristics into a single value in order to express the data in a clear and comprehensible way. It combines data from several sources to create a comprehensive picture of a water system. This raises public awareness as well as the policy

makers' comprehension of the emphasized water quality challenges.
Puri et al., (2011) have studied WQI and calculated for different surface water resources especially lakes, in Nagpur city, comprising of three seasons. WQI was calculated using the formula given by National Sanitation Foundation (NSF) information system. Padmaja and Anji (2017) conducted the field research on physico-chemical quality assessment of Osman Sagar and Himayat Sagar in Hyderabad and asserted the reservoir lake quality. They indicated that anthropogenic activities have caused changes in parameters assessed. Chandra et al., (2012) in their study assessed drinking water quality of various lakes i.e., Porur lake Chennai, Hussain Sager Hyderabad and Vihar Lake Mumbai. For these lakes, water samples were collected from six different sites and composite sample were prepared. Mahesh et al., (2013) have used WQI developed by the Canadian Council of Ministers of the Environment (CCME) to Hebbal lake of Mysore to study its impact on aquatic life, livestock and to know whether it is suitable for recreation, irrigation and drinking. Rajaand Venkatesan (2010) did the Assessment of surface water Pollution and its Impact in and around Punnam Area of Karur.

There are multiple WQIs unique to a region as a result of various studies conducted by national and international organisations like the World Health Organization (WHO) and Environmental Protection Agency (EPA) involved in water quality assessment and pollution control. There isn't a single WQI that is acknowledged by everyone. Therefore, it is important to evaluate the different WQIs and create the most appropriate, generally applicable WQI.

The present work is proposed to assess the water quality of Osman Sagar and Himayat Sagar using physico-chemical and biological parameters such as dissolved oxygen (DO), Fecal coliform, pH, Turbidity, Total solids, Total phosphates, Nitrates, Temperature change, Bio-chemical oxygen demand (BOD) by NSF-WQI index. Variations of WQI of Osman Sagar and Himayat Sagar lakes in Hyderabad city for different years were also analyzed.

2. Materials and Methods

2.1 National Sanitation Foundation Water Quality Index

There are 4 types of methods to obtain the water quality index
1. Weight arithmetic water quality index
2. National sanitation foundation water quality index (NSFWQI)
3. British Colombia water quality index (BCWQI)
4. Canadian council of ministers of the environment (CCME)water quality index (WQI)

In this study NSF-WQI is used. NSF-WQI is a water quality index method developed by paying great rigor in selecting parameters, developing a common scale and assigning weights. The attempt was supported by the National Sanitation Foundation (NSF) in order to calculate WQI of various water bodies critically polluted. The proposed method for comparing the water quality of various water sources is based upon nine water quality parameters such as Temperature, pH, Turbidity, Faecal coliform, Dissolved oxygen, Biochemical oxygen demand, Total phosphates, Nitrates and Total solids. The water quality data are recorded and transferred to a weighting curve chart, where a numerical value of Qi is obtained.

The mathematical expression for NSF WQI is given by,
WQI = summation n_i=1(Q_i*w_i)
where, Q_i = Sub-index for i^{th} water quality parameter, w_i =weight associated with water quality parameter, n = Number of water quality parameters.

Table 1: (a) Water quality weights; (b) Water quality rating according to NSF WQI

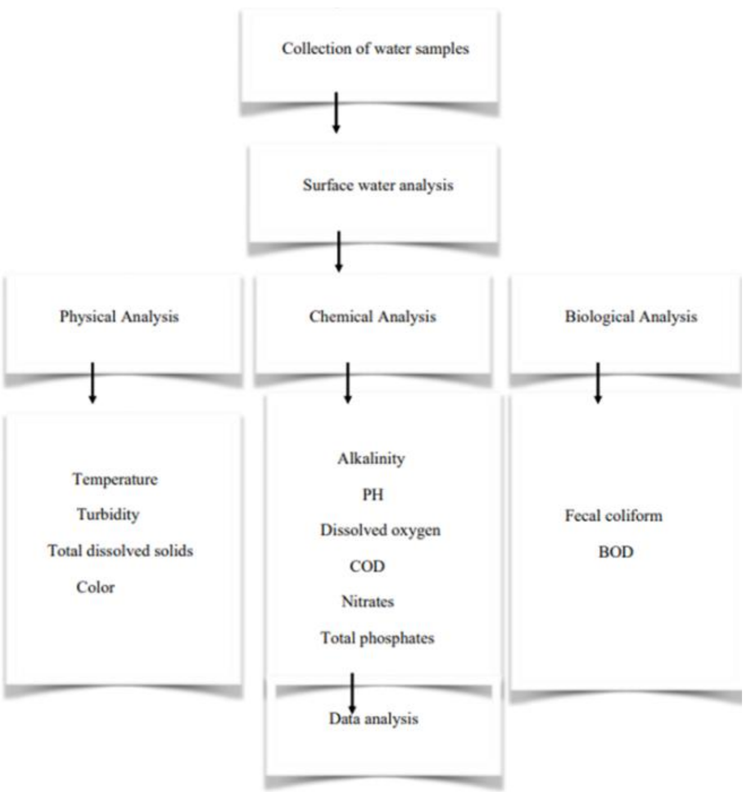
S NO	ANALYTE	WQI WEIGHTS
1	DISSOVED OXYGEN	0.17
2	FECAL CALIFORM DENSITY	0.15
3	PH	0.12
4	BOD	0.10
5	NITRATES	0.10
6	TOTAL PHOSPHATES	0.10
7	TEMPARATURE CHANGE	0.10
8	TURBITY	0.08
9	TOTAL SOLIDS	0.08

(a)

RANGE	QUALITY
90-100	EXCELLENT
70-90	GOOD
50-70	MEDIUM
25-50	BAD
0-25	VERY BAD

(b)

The study is based on determining WQI of the above specified lakes using NSF-WQI. The procedure for finding the inputs required for calculating WQI is detailed in step-by-step manner in the following flow chart.



2.2 Selection of site and sampling

Typically, sample locations are chosen based on three factors: Inlet (the location where the main feeder opens up toward the lagoon), Center (the location where the lagoon's broad stream value is given), and Outlet (the position anywhere the run over occurs).

Three different techniques of sampling are typically used to get water samples. Catch or Grab sampling are made up of either a single discrete sample or several discrete samples that were taken over the course of no more than 15 minutes. Composite sampling is the composition of a variety of grab samples taken at various intervals from the same sample location. Included sampling is a variety of grab samples gathered simultaneously at several locations. In this study, composite samples are used to sample the water and determine its physicochemical characteristics.

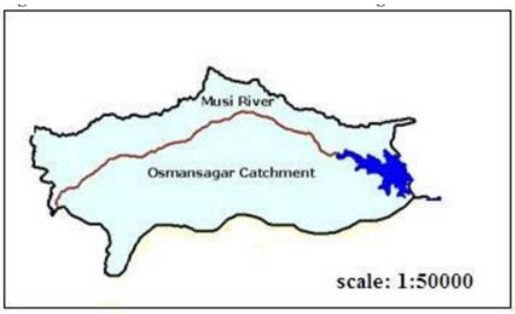
2.3 Study Area and Data Source

The current study area includes the catchment areas of the Himayat Sagar and Osman Sagar reservoirs. The reservoirs Himayat Sagar (1340 km2) and Osman Sagar (736 km2) were built on the Esa and Musi rivers, respectively. The two reservoirs provide drinking water to Hyderabad City, which is located between latitudes 17^0 10' and 17^0 50' north and latitudes 78^0 10' and 78^0 50' east. Except for a few hillocks and valleys, the catchments of the Himayat Sagar and Osman Sagar reservoirs exhibit flat to slightly undulating landscape.

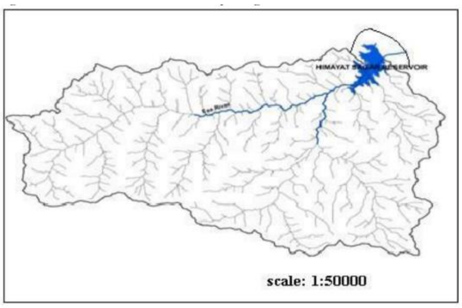
Data collection

Water is sampled by taking a composite sample at the required place in order to determine its physicochemical characteristics. Two locations' worth of lake water samples were taken in pre-cleaned bottles, labelled, and then moved to the ice box. The samples were promptly examined in the lab after being transported there. According to the American Public Health Association's standard protocol, fecal coliform counts, total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), sulphate (SO_2^-), nitrate (NO_3^-), and electrical conductivity (EC) were all tested (APHA 1995).

Figure 1 Catchment area of (a) Osman Sagar and (b) Himayat Sagar



(a)



(b)

2.4 Input parameters

2.4.1 Dissolved oxygen

The volume of oxygen that has been dissolved in water is known as dissolved oxygen (DO). The iodometric method, which is a titration-based method and depends on the oxidising property of DO, and the membrane electrode process, which operates based on the rate of molecular oxygen diffusion over a membrane, are the two ways that are frequently used to measure DO concentration.

2.4.2 Fecal coliform

The total and fecal coliform bacteria test is a primary indicator of drinking water's "potability," or suitability for consumption. It detects the presence of disease-causing organisms by measuring the concentration of total coliform bacteria.

2.4.3 Turbidity

Turbidity is a measure of cloudiness in water. The more turbid the water, the murkier it is. Turbidity can be caused by soil erosion, waste discharge, urban runoff, bottom feeders like carp that stir up sediments, household pets playing in the water, and algal growth.

2.4.4 pH

pH is defined as the negative logarithm of H + ion concentration. For living organisms' pH level between 6.5 to 8.2 is optimal, even a slight change in the pH may be fatal.

2.4.5 Total phosphate

Phosphorus is usually present in natural water as phosphates (orthophosphates, polyphosphates, and organically bound phosphates. Excess phosphorus causes extensive algal growth called "blooms," which are a classic symptom of cultural eutrophication and lead to decreased oxygen levels in creek water.

2.4.6 Temperature change

Temperature affects many physical, biological, and chemical characteristics of a creek: amount of oxygen that can be dissolved in water, rate of photosynthesis of plants, metabolic rates of animals, and the sensitivity of organisms to toxic wastes, parasites, and diseases. Measurement of temperature change can help detect sources of thermal pollution and suggest the size of habitat for organisms that are more sensitive to temperature variation.

2.4.7 Biochemical oxygen demand (BOD)

The amount of oxygen consumed by microorganisms (such as aerobic bacteria) in the oxidation of organic materials is measured by the BOD. Other aquatic species are deprived of the oxygen they require to survive when oxygen is used during the breakdown process. A variety of more sensitive organisms may be replaced with organisms that are more tolerant of lower dissolved oxygen levels.

2.4.8 Total dissolved solids
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Total solids in water are made up of dissolved solids along with suspended and settleable solids. Calcium, chlorides, nitrate, phosphorus, iron, sulphur, and other ions are among the dissolved solids in stream water that would flow through a filter with holes as small as 2 microns (0.002 cm). Plankton, algae, fine organic waste, silt and clay particles, and other particulate materials are examples of suspended solids. These are particles that a 2-micron filter will not be able to capture. The water balance in the cells of aquatic organisms is influenced by the concentration of total dissolved solids.

2.5 Steps involved in Water Quality Assessment

1.Water Quality Parameters to be incorporated as per standard procedures of APHA (American Public Health Association).
2.Development of Rating Curves (source of Q value in NSFWQI) to find our subindex values.
3.Finding out WQI value by using NSF WQI mathematical expression.

3. Results and Discussions

3.1 Physico Chemical Analysis of Water:

The results of physico-chemical analysis are shown in the below table:

Table 3: Physico- chemical parameter values of Osman Sagar

S.No	Parameter	Units	Method	Results Obtained	IS10500:2012 (2ndRevision)	Permissible limit in the absence of other so
1	P^H	-	APHA 23rd 4500H^+B	7.83	6.5-8.5	

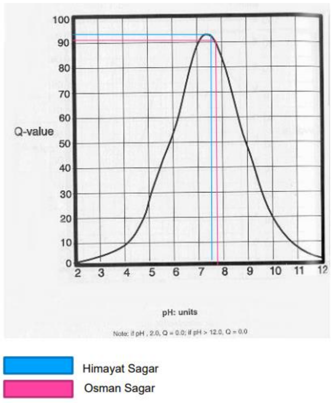
2	Total suspended solids	Mg/L	APHA 23rd 2540 D	7	Absent	<5
3	Temperature	^0c	-	26	<40	NM
4	Total dissolved solids (TDS)	Mg/L	APHA 23rd 2540C	285	<500	<2000
5	Total solids (TS)	Mg/L	APHA 23rd 2120 B	292	5	15
6	BOD	Mg/L	APHA 23rd 5210 B	36	<3	<3
7	Total phosphates	Mg/L	APHA 23rd 4500 P C	1.2	NM	NM
8	Nitrates	Mg/L	APHA 23rd 4500 NO_3B	5.9	45	No relaxation
9	Turbidity	NTU	APHA 23rd 2130 B	15	1	5
10	Facel coliform	CFU/L	APHA 23rd 9221 F	17	Absent	Absent
11	Dissolved oxygen	Mg/L	APHA 23rd 4500 O C	6.9	6.5	6.5

Table 4: Physico- chemical parameter values of Himayat Sagar

S.No	Parameter	Units	Method	Results Obtained	IS10500:2012 (2ndRevision)	Permissible limit in the absence of other so
1	P^H	-	APHA 23rd $4500H^+B$	7.64	6.5-8.5	No relaxation
2	Total suspended solids	Mg/L	APHA 23rd 2540 D	12	Absent	<5
3	Temperature	^0c	-	27	<40	NM
4	Total dissolved solids (TDS)	Mg/L	APHA 23rd 2540C	288	<500	<2000
5	Total solids (TS)	Mg/L	APHA 23rd 2120 B	300	5	15
6	BOD	Mg/L	APHA 23rd 5210 B	108	<3	<3
7	Total phosphates	Mg/L	APHA 23rd 4500 P C	1.1	NM	NM
8	Nitrates	Mg/L	APHA 23rd 4500 NO_3B	4.6	45	No relaxation
9	Turbidity	NTU	APHA 23rd 2130 B	25	1	5
10	Facel coliform	CFU/L	APHA 23rd 9221 F	22	Absent	Absent
11	Dissolved oxygen	Mg/L	APHA 23rd 4500 O C	6.8	6.5	6.5

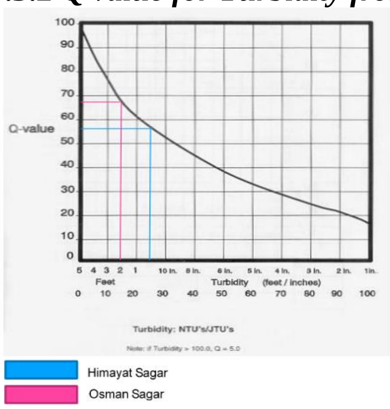
3.3 Finding out the Sub Index Value (Q) from rating curves

3.3.1 Q value for pH from rating curve



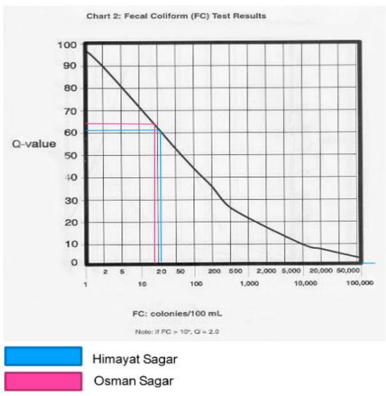
From the P^H Rating curve, the subindex value of Q for
Himayat Sagar is 92. i.e., Q_i =92
Osman Sagar is 89. i.e., Q_i = 89

3.3.2 Q value for Turbidity from Rating curve:



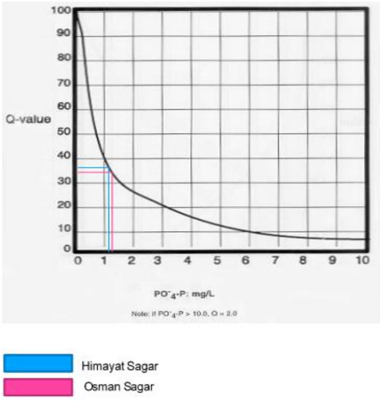
From the Turbidity Rating curve, the subindex value of Q for
Himayat Sagar is 57. i.e., Qi =57
Osman Sagar is 67. i.e., Qi =67

3.3.3 Q value for Faecal coliform from Rating curve:



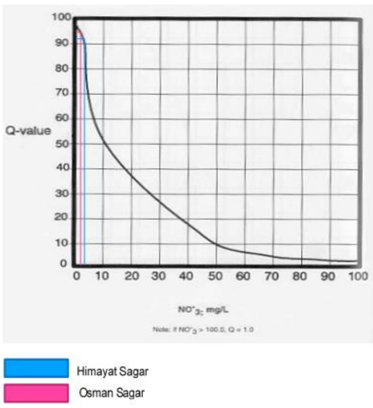
From the Rating curve the subindex value of Faecal coliform Q for
Himayat Sagar is 62. i.e., Qi =62
Osman Sagar is 65. i.e., Qi =65

3.3.4 Q value for Total Phosphates from Rating curve:



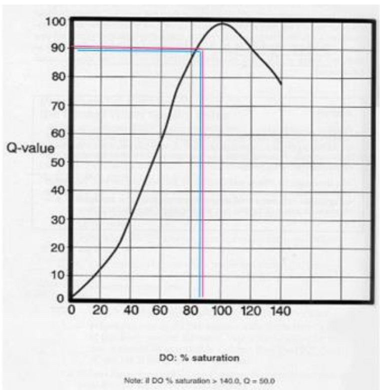
From the Rating curve the subindex value of Q for Total Phosphates in
Himayat Sagar is 38. i.e., Qi =38
Osman Sagar is 36. i.e., Qi =36

3.3.5 Q value for Nitrates value from Rating curve:



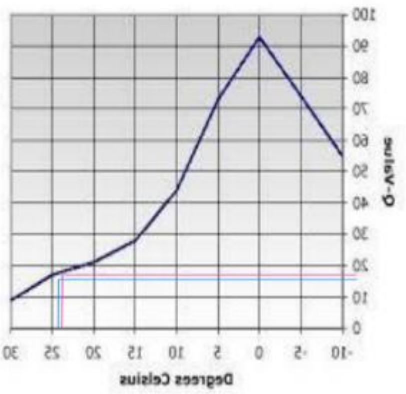
From the Rating curve the subindex value of Q for Total Nitrates in
Himayat Sagar is 67. i.e., Qi =67
Osman Sagar is 61. i.e., Qi =61

3.3.6 Q value for Dissolved Oxygen value from Rating curve:



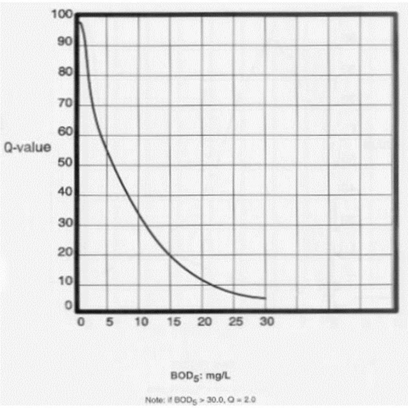
From the Rating curve the subindex value of Q for Dissolved Oxygen in
Himayat Sagar is 88. i.e., Qi =88
Osman Sagar is 89. i.e., Qi =89

3.3.7. Q value for Temperature value from Rating curve:



By adopting several calculations while calculating Q value for Temperature The obtained values are From the Rating curve the subindex value of Q for Temperature in Himayat Sagar is 13. i.e., Qi =13 Osman Sagar is 14. i.e., Qi =14

3.3.8 Q value for BOD from Rating curve:



From the Rating curve the subindex value of Q for BOD in Himayat Sagar is 2. i.e., Q_i =2
Osman Sagar is 2. i.e., Q_i =2
These Q values are taken as 2 Because of the obtained value is greater than the graph values.

3.4 Calculating WQI Value

NSF WQI = $\sum WiQi\ p\ i$=1
where W_i is the weight (in terms of relevance) ascribed to the water quality parameter, i is the subindex (Q-value) for the i^{th} water quality parameter, and p is the total number of water quality parameters.

Table 5: Water Quality index of Osman Sagar

Parameters	Weight factor	Standard values as per IS10500:2012	Values obtained	Q values	$W_i * Q_i$
P^H	0.12	6.5-8.5	7.83	89	11.04

Temperature (^{0}c)	0.10	<40	26	14	1.3
Turbidity (NTU)	0.08	1	15	67	4.56
Total dissolved solids(mg/L)	0.17	5	285	60	4.8
Dissolved oxygen(mg/L)	0.17	<6.5	6.9	89	14.96
BOD(mg/L)	0.10	<3	36	2	0.2
Total phosphates	0.10	0.005-5	1.2	36	3.8
Total nitrates	0.10	<45	5.9	61	6.7
Fecal coliform	0.15	Absent	17	65	9.3
					∑=56.6

Table 6: Water Quality Index of Himayat Sagar

Parameters	**Weight factor**	**Standard values as per IS10500:2012**	**Values obtained**	**Q values**	**$W_i * Q_i$**
P^H	0.12	6.5-8.5	7.64	92	11.04
Temperature (^{0}c)	0.10	<40	27	13	1.3
Turbidity (NTU)	0.08	1	25	57	4.56
Total dissolved solids(mg/L)	0.17	5	288	60	4.8
Dissolved oxygen(mg/L)	0.17	<6.5	6.8	88	14.96
BOD(mg/L)	0.10	<3	108	2	0.2
Total phosphates	0.10	0.005-5	1.1	38	3.8
Total nitrates	0.10	<45	4.6	67	6.7
Fecal coliform	0.15	Absent	22	62	9.3
					∑=57.1

As Per NSF-WQI calculations the obtained Water quality index (WQI) in both reservoirs is ranging between 50-70. Himayat Sagar has a water quality index value of 56.66, while Osman Sagar has a value of 57.1. are indicating that the available water quality status as Moderate quality. As per our results more parameters of water need to be much treated before supplying to the consumers in the present time

3.5 Comparing variations of water quality index for different years

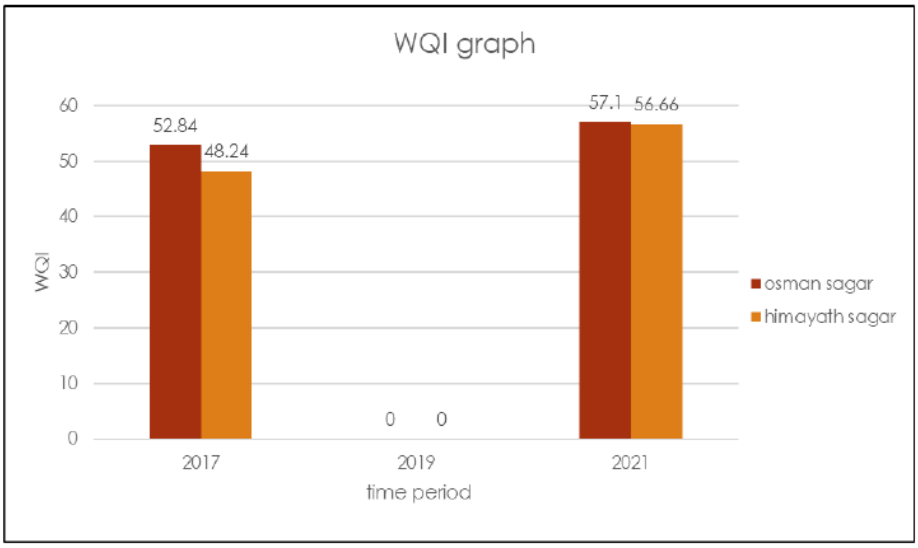


Figure 2: WQI graph for different years

The Water Quality Index value in Osman Sagar and Himayat Sagar lakes for the year 2021 have increased from 52.84 to 57.1 and 48.24 to 56.66 respectively in comparison with the year 2017. Due to the absence of required water quality parameters in the year 2019 the WQI is not determined.

4. Conclusions

1. According to the current study, the water quality in both reservoirs is of medium quality.
2. Himayat Sagar has a water quality index value of 56.66, while Osman Sagar has a value of 57.1, So Proper treatment should be taken before directly supplying to the consumers.
3. The Water Quality Index value in Osman Sagar and Himayat Sagar lakes are quite improved when compared with 2017 results

References

Baird, R. B., Eaton, A. D., & Clesceri, L. S. (2012). Standard methods for the examination of water and wastewater (Vol. 10). E. W. Rice (Ed.). Washington, DC: American public health association.

Chandra, S., Singh, A., & Tomar, P. K. (2012). Assessment of Water Quality Values in Porur Lake Chennai, Hussain Sagar Hyderabad and Vihar Lake Mumbai, India. *Chemical Science Transactions*, *1*(3), 508-515.

Clesceri, L. S. (1998). Standard methods for examination of water and wastewater. American Public Health Association, 9.

IS 10500:2012 Standards (2ndRevision) to compare the obtained results with standards specified by the code.

K[1], M. K. M., Mahesh, M. K., & R[1], S. B. CCME Water Quality Index and Assessment of Physico-Chemical Parameters of Chikkakere, Periyapatna, Mysore District, Karnataka State, India.

Padmaja, K., Cherukuri, J., & Reddy, M. A. (2017). Assessment of Water Quality of Himayathsagar Lake in Hyderabad–A Case study. *Journal of Environmental Science, Toxicology and Food Technology*, *11*(1), 18-22.

Puri, P. J., Yenkie, M. K. N., Sangal, S. P., Gandhare, N. V., Sarote, G. B., & Dhanorkar, D. B. (2011). Surface water (lakes) quality assessment in Nagpur city (India) based on water quality index (WQI). *Rasayan Journal of Chemistry*, *4*(1), 43-48.

Ramteke, D. S., & Moghe, C. A. (1988). Manual on water and wastewater analysis. *National environmental engineering research institute (NEERI), Nagpur*