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Assessment of Physicochemical Characteristics of Gundolav Lake by Using Water Quality Index

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ABSTRACT: Gundolav Lake is a part of historical, cultural, economic, and recreational life of Kishangarh. It is facing multifold pressure due to urbanization, domestic and industrial waste discharge, bathing and washing, agricultural practices and wetland encroachment. The present work is aimed to investigate water quality index of Gundolav Lake using water quality index. Different study stations at Gundolav Lake exhibited seasonal and inter-site variations in physico-chemical parameters. Nala site (Station IV) was found major source point for nutrient entry showing peculiarly high BOD (48.50 mg/l), nitrate (3.06 mg/l), phosphate (7.86 mg/l) and low DO content (3.68 mg/l) signify nutrient enriched status of the lake, favoring high productivity. The cumulative effects of anthropogenic pressure and exerted pollution load from point and non-point sources are affecting water quality of this urban water body. The water quality index value clearly reflected that Water Quality of lake was "average" and belongs to "C" category of CPCB on 100-point scale. This low value was related to human activities in the region. The implementation of WQI is necessary for public and decision makers to evaluate the water quality of the lake for sustainable management.

KEYWORDS: Water Quality, Gundolav Lake, Water Quality Index, Urbanization.

I. INTRODUCTION

Water along with land is the most important natural resource gifted to man by nature. The proper combination of these two primary resources in space and time sets the upper limit of the population and carrying capacity of the area **(Sharma *et al*., 1999).** Population also influences the quality and availability of water resources for human use. Knowing the importance of water for sustenance of life particularly in the areas of water scarcity, like Rajasthan, community management and personification of indigenous water systems evolved as a part of social life. But the situation has become much different. Lack of community perception, irrational use, widespread negligence for conservation among various stakeholders, systematic encroachment of water bodies made them merely a dump yard for domestic and industrial waste. One such wetland is Gundolav Lake, which was once used for drinking water as well as for recreational activities under tutelage of princely state of Kishangarh, now became a site of wastewater disposal and facing critical treat for its sustenance. Now the need for conservation of water bodies particularly for freshwater wetlands, is being realized everywhere on the globe. In the **Ramsar Convention (2002)**, it was emphasized that wetlands should be the starting point for integrated water management strategies, since they are the source of fresh water, maintains the health of water course and water bodies, subsequently supply water to meet the human needs and area key to future water security.

Therefore, characterization of physical, chemical and biological parameters serve as a good index in providing a comprehensive picture of the conditions prevailing in a water body. Many methods have been planned and adopted for testing of water quality. As there is lack of consensus among different experts and end users regarding perceptions and interpretation of various parameters of water quality. Therefore, it is necessary to translate water quality data in widely acceptable and unambiguous term. One of the most effective approaches for studying water quality is using of suitable indices which provide single value to the water quality in order to reach comprehensive, dynamic and consistent picture of pollution load of water body (**Prati 1971**, **Brown *et al.* 1970**). In general water quality indices incorporate data from numerous water quality parameters into mathematical equation that rates the healthiness of water body with a single number. That number is placed on a relative scale to validate the water quality in category ranging from very bad to excellent for simplicity and consumers unambiguousness. A number of indices have been developed to summarize water quality data for communication to the general public in an effective way. In this paper a widely used WQI developed by the National Sanitation Foundation (NSF) in 1970 (**Brown *et al*., 1970**) was used. Essentially, the NSFWQI converts the

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concentration data for nine analytes into one of five water quality classes, ranging from very bad to excellent. Therefore, present study is carried out to achieve water quality status of Gundolav Lake by using NSFWQI.

II. STUDY AREA

Totally rain-fed Gundolav Lake is a manmade lake amidst low hills erected on almost plain surface of eastern semiarid agro-climatic zone, located in the North of Kishangarh (Rajasthan) at $26^0 28'$ N and $74^0 52'$ E, at 500 m above MSL. The area experience moderate climate with all four seasons having total rainfall fluctuating between 110.10 mm to 1193.00 mm in past 10 years. Here soil is sandy loam to sand clay in texture and low fertile as low in nitrogen and moderate in phosphorous and potassium. Gundolav Lake is one of the many perennial shallow water bodies around Kishangarh, of which Hamir Pond, Santolav Pond, Ransamand Pond are important. The total catchment area of the lake is 13.44 sq. km. and theterrain is semi hilly and rocky. On the northern end of Gundolav, is situatedthe beautiful and auspicious 'Ram Tekri'. There is 'Khoob-Kutir' on the south east end of the lake. Yagya-sthali and Manak Tekri, Phool Mahal are other places near the lake. 'Awanna' beautifies the eastern side of the lake from where water used to come out. In the middle of the lake is situated 'Mokham Vilas' which gives a marvellous view **[Source: Kishangarh Tavarikh]**. Till the independence Gundolav Lake hold an important place as a source of drinking water supply to the city and was a destination for various recreational activities.

Plate 1: Gundolav Lake

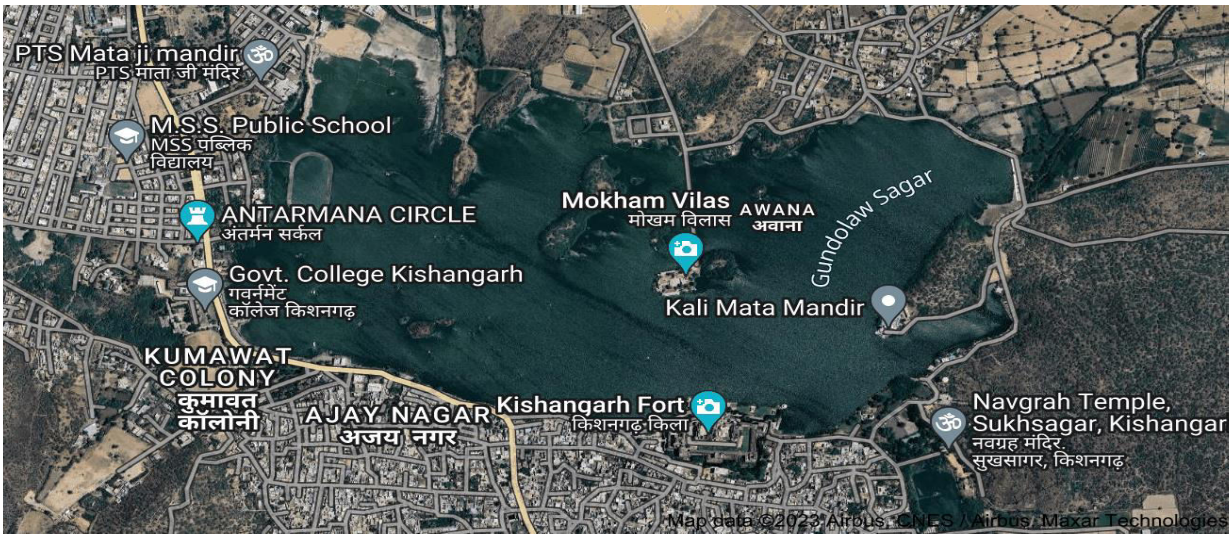

Plate 2: Satellite image of Gundolav Lake

About 1,254 bigha land in the basin of the Gundolav Lake is used for farming, when lake dried up. Due to multifold pressure of urbanization and industrialization, urban wastewater discharge, cloth washing activities, agricultural practices

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and construction of hotels andhousing colonies, the major part of the lake is greatly affected. Also, local people cultivate Singhara (*Trapa bispinosa*) **(Plate 1)**. In addition, during rainy season the water of Hamir Pond mixes with it and causes massive flush of nutrients.

MATERIAL AND METHODOLOGY: The study was conducted during the period of July 2021 to June, 2022 to explore nutrient sector of ecological subsystem. The samples were analyzed immediately for parameters, which need to be determined instantly and rest of the sample was refrigeratedat $4^{0}C$ to be analyzed later. For the estimation of DO and BOD, water samples were fixed at the sites. All the analysis methods followed standard procedures mentioned in "Standard Methods for Examination of Water and Wastewater 20^{th} Edition (1998)," published by **APHA**, and "Chemical and Biological Methods for Water Pollution Studies" by **Trivedi and Goel (1986)**. Temperature, transparency, turbidity, pH, total dissolved solids (TDS), dissolved oxygen (DO), nitrate-nitrogen, biological oxygen demand (BOD) and phosphates were the main parameters analyzed for assessment of nutrient sector. To assess water quality of this water body, Brown's water quality index was used. A water quality index provides single value to the water quality. It integrates data generated from physicochemical and microbial analysis after assigning due weights to different parameter **(Table1)**. The index can be used to compare different study sites where same objectives and variables are used (**Kankal *et al.*, 2012**). The final calculation of Water Quality Index (WQI) is done by aggregation of subindices using weighted sum index method. The index is given by NSFWhere, q_i = the quality of the i^{th} parameter (a number between 0 and 100 read from the sub-index graph) W_1 = the weight of the i^{th} parameter

Table:1 Weights for parameters included in Brown's WQI

Parameters	Final weight
Faecal coliform density	0.17
Dissolved oxygen	016
pH	0.11
BOD-(5day)	0.11
Nitrates	0.1
Phosphates	0.1
Temperature	0.1
Turbidity	0.08
Total dissolved solids	0.07

Table:2 Interpretation and designated best end use of water on the basis of WQI quality scale.

WQI Quality Scale	CBCB Class	Interpretation	Use
91-100	A	Excellent water quality	Drinking water source without conventional treatment but after disinfection
71-90	B	Good water quality	Outdoor bathing (organized)

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51-70	C	Medium or average water quality	Drinking water source after conventional treatment and disinfection
26-50	D	Fair water quality	Propagation of wild life and Fishries
0-25	E	Poor water quality	Irrigation, industrial cooling, controlled waste disposal

Figure 1 Map of Gundolav Lake showing different study stations and surroundings

For proper coverage of entire study area and to investigate prevailing physicochemical conditions, five study sites (Figure 1) were selected on the basis of anthropogenic load, pollution intake and location-based parameters. The study sites were Bheru Ghat (Station I in the South with prevailing bathing and washing activities), Shiv Ghat (Station II, also in the South and have deeper water zone witha lot of human activities), Temple Corner (Station III, least disturbed site situated in the South-East dimensions), Nala Site (Station IV, in the West, point of discharge of untreated domestic sewage and practice of agricultural and grazing activities), and Awanna ki Pal (Station V, in the East, agricultural fields and few hutments are also quite near to this site).

III. RESULT AND DISCUSSION

With increased in anthropogenic meddling as a consequence of disregard to the socio- cultural values of water reservoirs, there is increase in quality deterioration of their water that can lead to acceleration of the process of eutrophication. The quality of physical, chemical and biological parameters serves as a good index in providing a complete andreliable picture of the conditions prevailing in a water body **(Mishra *et al.*, 1999).** Standard deviation and annual mean values of various physico-chemical parameters for different study stations are shown in table no.1.

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Table 3: Annual mean values and standard deviation of physico-chemical characteristics of water at different study stations of Gundolav Lake

Temperature (in ^{0}C)		Station 1	Station 2	Station 3	Station 4	Station 5	Overall
	Average	23.00	22.92	22.58	23.65	23.13	23.06
	Standard Deviation	5.58	5.55	5.46	5.82	5.71	5.61
Transparency (in cm)							
	Average	64.44	62.30	85.60	30.20	64.43	60.96
	Standard Deviation	10.30	9.65	9.43	11.56	9.65	9.78
Turbidity (in NTU)							
	Average	7.55	8.57	7.16	41.05	8.01	14.47
	Standard Deviation	3.58	4.84	3.63	12.33	4.65	5.39
pH (in unit)							
	Average	7.7	9.60	8.44	8.50	8.49	8.49
	Standard Deviation	0.50	0.51	0.52	0.67	0.51	0.51
Total Dissolved Solid (in mg/l)							
	Average	356.25	353.83	335.50	1334.25	352.92	546.55
	Standard Deviation	143.70	144.12	136.33	463.09	150.51	188.81
Dissolved Oxygen (in mg/l)							
	Average	6.27	6.12	6.68	3.68	6.29	5.81
	St. Deviation	1.64	1.59	1.74	2.16	1.65	1.70
Biological Oxygen Demand (in mg/l)							
	Average	18.86	19.23	17.48	48.50	18.56	24.71
	Standard Deviation	13.71	13.53	12.81	49.55	13.45	20.09
Nitrate-Nitrogen (in mg/l)							
	Average	1.13	1.07	0.61	3.06	1.21	1.74
	Standard Deviation	0.57	0.55	0.51	2.45	0.58	0.89
Phosphate (Total) (in mg/l)							
	Average	2.24	2.27	1.76	7.86	2.31	4.23
	Standard Deviation	1.43	1.38	1.22	4.97	1.34	1.72

Temperature: Temperature has a considerable impact on water chemistry, and when the temperature and chemical composition of a lake's water exceed particular thresholds, a variety of events can occur. During the investigation, the mean of temperature varied from 22.5°C to 23.6°C (at station-4) with corresponding WQI value 2.21 to 2.32. **Temperature** was found negatively correlated with DO **(Das, 2000)**, transparency **(Reid and Wood, 1976)**, and pH; and positively correlated with turbidity **(Pradhan *et al.*, 2003)**, conductivity, nitrates, sodium, potassium, and BOD.

pH: pH is a measurement of the amount of H+ ions in water. It can be any number from 0 to 14. pH values fluctuate mostly as a result of component input into water bodies. The majority of biological processes and biochemical reactions are regulated by pH. The pH of the Gundolav Lake water wasfound to be slightly higher in the current study, ranging from 7.7 to 9.6 with corresponding WQI value of 9.74 to 3.31. **Das and Pandey (1978)** opined that high alkalinity indicates pollution. The pH of a typical eutrophic lake, according to **Spence (1964)**, ranges from 7.4 to 9.8. The current findings supportSpence's (1964) statement that the Gundolav Lake is eutrophic based on its pH range.

Total dissolved solids: The term solid refers to the matter that remains as residue upon evaporation. Total solids include both dissolved solids and suspended solids. A large number of salts are found dissolved in water. Ahigh concentration of dissolved solids raises the density of water, affects freshwater organisms' osmoregulation, reduces the solubility of gases (such as O_2), diminishes the usefulness of water for drinking, and leads to eutrophication of the aquatic ecosystem. During the investigation, the average TDS was varied from 335.50 mg/L (at station-3) mark as less polluted site to 1334.25 mg/L (at station-4), was marked as more polluted with corresponding WQI value of 3.82 to 1.40. TDS (**Maruthanayagam *et al.*, 2003, Kamath *et al.*, 2006**) showed their maxima in summer. All these parameters were found lower in post monsoon season while they exhibited gradual increasing trend in winter and summer. Throughout the investigation period comparatively low value of **TDS** was recorded at station III. This is due to negligible disturbance at this station. Whereas, at station IV, higher values indicate maximum disturbance due to human activities. Water body

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exhibited high values of TDS at the point of discharge of sewage. Also, the amount of total solids was found highest during the summer and lowest in winter **(Ugale and Hiware, 2005)**.

Dissolved oxygen: All aquatic species rely on dissolved oxygen in water, and it is thought to be the factor that represents the physicaland biological processes occurring in a water body. It is necessary for the development and maintenance of life. It has a significant impact on the nature of an entire aquatic environment. The oxygen that a water body obtains comesmostly from two sources: the atmosphere and the photosynthetic activity of chlorophyll-bearing plants. The concentration of dissolved oxygen is also affected by surface agitation caused by temperature, the rate of respirationof living organisms, and the rate of decomposition of dead organic matter. Low temperature in winter contributed rise in DO. Maximum value of 6.68 mg/l was recorded at station III in December with corresponding WQI value of 15.01 was marked as least polluted. During summer as a result of high temperature and more oxygen utilization DO was recorded less (minimum 3.68 mg/l at station IV in June with corresponding WQI value of 6.12 marked as most polluted site). **Rani *et al.* (2004)** reported lower values of dissolved oxygen in summer months due to higher rate of decomposition of organicmatter and limited flow of water in low oxygen holding environment due to high temperature. There is an inverse relation between DO and oxygen utilization in terms ofBOD and COD. This relation was clearly reported by **Das (2000)** also.

Biochemical Oxygen demand: The aerobic decomposition of organic matter by microbes primarily depends upon the availability of dissolved oxygen. The rate of removal or consumption of oxygen by microorganisms, for this degradation is called the BOD or biological oxygen demand of the water body. **BOD gives** a complete picture of the nature and extent of pollution and about the water quality **(Kumar and Sharma, 2002).** Oxygen utilization, in the terms of BOD was found maximum in summer season. BOD was found maximum in June at station IV (BOD 48.50 mg/l with corresponding WQI value of 0.22). These high values were sufficient to mark station IV as most polluted site while station III having lowest BOD (0.68 mg/l in December with corresponding WQI value of 9.64) was marked as least polluted. High values of BOD due to accumulation of domestic sewage were also reported by **Mohan *et al.* (2007)** at Naya Talab, Jodhpur ranging between 88 - 535 mg/l. **Sharma and Gupta (2004)** also found the municipal waste water responsible for maximum organic pollution, resulting in an increased BOD. Same situation prevails at station IV. Regarding BOD values, following ranking order was evident to show pollution load at different stations during the study period. Station IV > Station II > Station I > Station V > Station III.

Nitrogen-Nitrate: Nitrate is the highest oxidized form of nitrogen, and in water its most important source is biological oxidation of nitrogenous organic matter. It is an integral component of all essential organic molecules, without whom the existence of life cannot be expected. During investigation average nitrate values, from 0.61 to 3.06 mg/l with corresponding WQI value of 9.03 to 7.62 were recorded, indicate higher biological productivity. According to **Sylvester (1961)** the domestic sewage is mainly responsible for greater concentration of nitrates in fresh waters. **Paulose and Maheshwari (2007)** opined that high nitrate content can be correlated with high rate of organic decomposition while **Chouhan and Sharma (2007)** found agricultural runoff as a main contributor to the nitrate nitrogen in reservoir.

Phosphate: In aquatic systems, phosphorus can be found as free ions, absorbed into sediments and soils, or mineralized in soil, rocks, and sediments. Total average phosphate was also found higher, ranging from 1.76 to 7.86 mg/l with corresponding WQI value of 3.15 to 0.61. This confirms the polluted status of Gundolav and more deposition of organic matter in it. **Ranga (1995)** also reported high phosphorus-phosphate concentration during monsoon in the water of Anasagar Lake, Ajmer. He emphasized that the difference in phosphate-phosphorusconcentration at different stations was due to the addition of detergents and faecal matter of human and avian origin.

Transparency and Turbidity: Natural water in biotic habitats is infested with lot of particulate matter, both in living and nonliving forms which makes the water turbid. Penetration of light is often limited by the suspended materials restricting the photosynthetic zone wherever aquatic habitats have appreciable depth. Turbidity especially when caused by clay and silt particles is often important as limiting factor, conversely when turbidity is a result of living organisms, measurements of transparency become indices of productivity. Transparency was maximum in winter season (85.60 cm in December at station III with corresponding TSI value of 62.34 mark as least polluted site) while minimum in rainy season (30.20 cm in August at station IV with corresponding TSI value of 77.34 was marked as more polluted). It was found negatively correlated with turbidity **(Trivedi *et al.* 1987)** and nitrate, and positively correlated with pH and DO. As per **Khan and Khan (1985)** slight to moderate alkaline supports good planktonic growth. Turbidity was maximum in winter season (41.05 NTU in December at station IV with corresponding WQI value of 3.48 mark as most polluted site, while minimum in rainy season (7.16 NTU cm in August at station III with corresponding WQI value of 6.43 was marked as least polluted.

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IV. CONCLUSION

In essence the physico-chemical composition of the lake reveals that it is tending, fast towards 'eutrophism' particularly at station IV. The quality of water is deteriorating day by day due to inflow of domestic sewage, municipal waste, agricultural runoff and effluents of organic waste of animal and human origin into the lake. Deterioration of water quality and eutrophication are assuming alarming state in Gundolav, due to casual attitude of people concerned with development of urban population. Therefore, there is an urgent need of regular monitoring of water quality to govern the status and diverting the citysewage away from the lake to preserve the flora and fauna of this ecosystem. If waste inputis not checked then it will severely impair water dynamics and will cause eutrophication of the entire system. Overall, coordinated efforts of various stakeholders and proper community involvement are the primary needs to restore the ecological subsystem of the lake and to make it useful for further social and economic exploration. In nutshell, the results depict that the water quality of Gundolav rated “Average or medium” and belongs to “C” category of CPCB during the all the month of study and all the stations. Based on these findings, the stations located at the entrance of the pollutants showed lower WQI throughout the study period because of discharge of untreated sewage, rich in organic waste, both from point sources (viz. Nalla site), and non-point sources. The water quality index value of this lake was found much lowered during rainy season. The According to the results of this study, NSF water quality index is a good index for evaluation of the quality of lake water in which it can be used to determine the water quality at designated stations used for a variety of uses.

RECOMMENDATIONS: In order to assist recuperation of the lake and to explore it in sustainable manner; immediate priority should be given to identification and abatement of lacuna in existing information and tools failing to conserve the lake and catchment area. It is necessary to identify the grounds of pollution-source expansion and to check them, to strengthen administrative coordination and explore possibilities of Public Private Partnership (PPP). It is also necessary to prepare action plan on lake restoration providing sufficient space to beautification in order to develop economic subsystem. A forestation in catchment area, prohibition of construction and garbage disposal near lake should be enforced. Sewer network and sewage treatment plant should be materialized to limit nutrient entry in the lake system. Besides source control, some palliative actions should be commenced with prime importance in order to cope up the problem of eutrophication in the lake system. Continuous water quality monitoring, dredging and de-silting, regulated agriculturalpractices, promotion of restricted growth of ‘nutrient removing plants’ like duck-weeds and *Eichhornia* and their periodical harvesting, bio-remediation and bio-manipulation, rejuvenation of traditional drainage system should be employed. Community basedindigenous knowledge system for water harvesting should be materialized to aware and insures involvement of community in efforts for conservation of this natural wealth. But all these efforts will not be motorized until development of proper liaison among different stakeholders. Gundolav lake have high potential for being developed as a city level recreational center and its location and surroundings give an invincible opportunity to develop it as a prominent tourist spot. The lake periphery should be declared as a ‘protected area’ to protect the lake system from unwanted human meddling. It would be better if government recommend the lake for its declaration as a ‘World Heritage Site’, keeping more than 500-year-old cultural heritage in mind.

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