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Strengthening The Crucial Pillar Of 'Information' In Integrated Lake Basin Management: Data On Water Quality Of Nathsagar Reservoir, India

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Abstract:
Background: *In the onset of global Climate Change impacts, and potential multifactorial threats of pollution, inland waterbodies like lakes and reservoirs demand a serious attention for conservation. Considering the importance of surface freshwaters to environment and society, it is imperative to address the issue of management of these waterbodies so as to continue the services rendered by them. The present investigation is a short but sincere effort in this direction. For the purpose of ILBM application, this work heavily relies on the Report of International Lake Environment Committee Foundation, Japan.*
Material & Methods: *Physico-chemical analysis of water sample was conducted as per IS 3025, APHA, and ICP-OES. The water quality data was scrutinised and interpreted so as to determine the suitability of water from Nathsagar Reservoir for various purposes. Literature on Integrated Lake Basin Management was reviewed in order to gain insight about the six pillars of ILBM process, with special emphasis on the pillar of 'Information.'*
Results: *As the outcome of the qualitative analyses of water sample, it was inferred that the water from Nathsagar Reservoir is suitable for drinking, bathing, fisheries, irrigation and industry. Though, the sampling site showed organic load, the pollution was site-specific and could not be considered to apply for the entire reservoir. Data on water quality is vital for deciphering the status of the waterbody, and formulating strategies and policies for conservation.*
Conclusion: *The present work envisaged application of ILBM framework for assessing the hydrological status of Nathsagar Reservoir, while focusing on the aspect of scientific 'Information' on water quality, facilitating the attainment of mentioned Sustainable Development Goals. More broad-spectrum studies on temporal and spatial zones are suggested in case of this reservoir.*
Keywords: *ILBM, India, Information, Nathsagar Reservoir, Water Quality.*

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I. Introduction

Climate change is recognised as a major threat to the survival of species and integrity of ecosystems worldwide (Hulme, 2005). The predicted ecological and hydrological changes associated with climate change will potentially affect the performance of the infrastructure (e.g., surface water management systems) and thereby will affect the different uses of water in many areas (Erwin, 2009). Thus, water quality data on physico-chemical characteristics is crucial for determining the ecological health of the aquatic system and suggesting the its utility for various purposes like drinking, bathing, agriculture and industrial. Healthy aquatic ecosystem depends on overall water quality and biological variability (Ramulu and Banergy, 2013). Therefore, periodic water quality monitoring helps in knowing the limnochemical and limnobiological components of the ecosystem, indicating the level of pollution of the waterbody (Tiwari, 1992; Kaushik and Saksena, 1995). Accurate and timely information on the quality of water is necessary to shape a sound public policy and to implement the water quality improvement programmes efficiently (Sunita Enviro, undated).

Comprising more than 90% of the readily available liquid freshwater on the surface of our planet. Lakes and reservoirs are the key components of global water resource systems (Nakamura, 2011). It is no denying fact that the numerous lakes and reservoirs, all over the country without exception, are in varying degrees of environmental degradation. The principal causes of degradation are unabated encroachments, eutrophication, and rapid silting. There has been quantum jump in population during the last century without corresponding expansion in civic infrastructure, resulting in lakes and reservoirs, especially the urban lakes, becoming sinks for contaminants (ILEC, 2005). In fast-growing, urbanising, and developing countries like India where controlling water pollution of water bodies is a major challenge, there is a need for robust management of the water quality of all the rivers to detect changes in the physico-chemical parameters of water for remedial measures and create awareness among the common man (Shukla and Sharma, 2023).

Integrated Lake Basin Management (ILBM) is an approach for achieving sustainable management of lakes and reservoirs through gradual, continuous and holistic improvement of basin governance, including sustained efforts for integration of institutional responsibilities, policy directions, stakeholder participation, scientific and traditional knowledge, technological possibilities, and funding prospects and constraints. It has been conceptualized on the basis of the premise that achievement in managing lakes, reservoirs and their basins is facing a serious global challenge. ILBM also takes the position that the problems facing individual lakes/ reservoirs cannot be properly addressed unless the fundamental issue of sustainable resource development, use and conservation facing the lakes/ reservoirs is addressed globally, and with strong, long-term political commitment. The ILBM Process also is designed for lake/ reservoir basin stakeholders collectively to fill the gaps between what has already been achieved, and what remains to be achieved realistically in continuing governance improvements over time. (RCSE and ILEC, 2014)

In contrast to lotic water systems, lakes do not necessarily respond to perturbations or pollution in a linear fashion. This is due in large part to their stagnancy of impounded water mass held over long time, which allows time delays in response to external disturbances. The result can be a non-linear response (hysteresis) to increasing pollutant loads. (RCSE and ILEC, 2014)

In the event of aforesaid scenario concerning inland freshwater bodies of immense socio-cultural, ecological and economical significance, like lakes and reservoirs, the present study was undertaken to highlight the crucial aspect of 'Information and Knowledge,' specifically focusing on provision of data on water quality in ILBM of Nathsagar Reservoir.

II. Material & Methods

***Water quality*:**

The collected water sample was analysed for its physico-chemical characteristics. Temperature was measured on-site using mercury thermometer. Turbidity was measured as per APHA (American Public Health Association) Standard Methods for the Examination of Water and Wastewater. Total Suspended Solids, Total Dissolved Solids, Electrical Conductivity, pH, Total Alkalinity, P Alkalinity, Total hardness, Calcium hardness, Chloride, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Nitrate, Ammonia, Phosphate, Sulphate, Sodium, Potassium, Magnesium, Fluoride and Silicate were tested as per the BIS (Bureau of Indian Standards) - IS 3025: Methods of Sampling and Test (physical and chemical) for Water and Wastewater. Copper, Iron, Zinc, Lead and Nickel were analysed as per the ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometer) method.

***ILBM*:**

Reservoir management depends on its basin characteristics and socio-economics along with natural and social impacts that it encounters. ILBM can be carried out by inputs from various disciplines differing in their subject aspects. 'Information' is a core component of the ILBM platform and the same is the crux of present investigation in the form of 'data on water quality.' This knowledge helps in the step-wise identification of the loopholes in the system and streamlining the managerial strategies for the same.

***Study Location*:**

Nathsagar reservoir, created by construction of Jayakwadi Dam, is situated in Paithan Taluka of Chhatrapati Sambhajinagar District, located at 19°29′8.7″N 75°22′12″E in Maharashtra State of India. The reservoir provided habitat to diverse aquatic organisms and provides various functional services. The sampling site of Sonwadi Khurd (Kh.) beholds a multipurpose point supporting fisheries, domestic and irrigation purposes. The study area is shown in Fig.1, and sampling site is shown in Fig. 2.

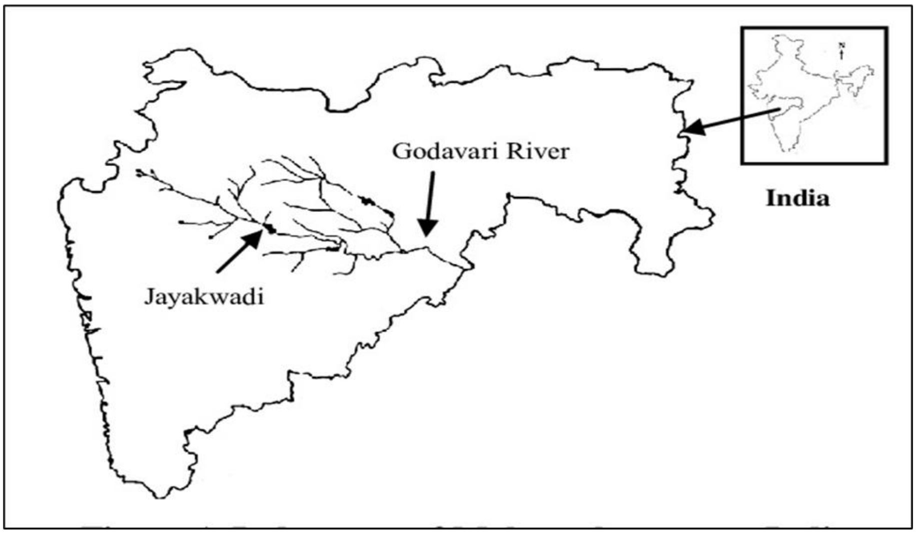

Fig no 1: Map of Study Area
Image courtesy: https://www.drishtiias.com

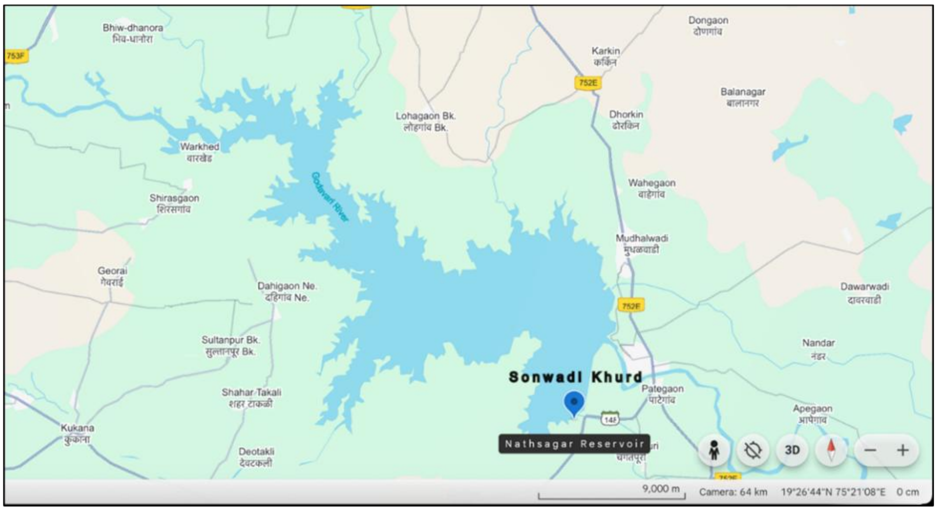

Fig no 2: Map of Study Area showing Sampling Site.
Image created using Google Earth

Study Duration:

The study extended for a period of one year from March 2024 to April 2025. The water sample was collected during post-monsoon season in October 2024, for physico-chemical analysis from Sonwadi Kh., in the early hours of the day.

Sampling Protocol:

Physico-chemical parameters of water sample were measured employing standard procedures for the analysis of water quality. The water sample was collected in acid washed plastic bottles from a depth of 5 to 10 cm of the waterbody. For calculating the Dissolved Oxygen, a separate bottle of 300 ml capacity was fixed on site, by adding Alkali Iodide reagent. The sample was analysed immediately on return to the laboratory at the Centre for Analytical Research and Studies (MIT-CARS), Chhatrapati Sambhajinagar (M.S.) India.

Data Analysis:

Upon physico-chemical analysis of the collected water sample, its observed values were compared with the permissible limits of the prescribed standards, thereby classifying the utility of the water into five categories A, B, C, D, and E. As an attempt to initiate the ILBM process, the water quality data was mirrored with the aspect of 'Information' in ILBM, that comprised of essential inflow of knowledge regarding the waterbody gained through this rapid monitoring, giving a better understanding of its hydrological status.

III. Result

Water Quality Analysis:

The values obtained as a result of physico-chemical analysis of the water sample from Nathsagar Reservoir are given in Table 1. Table 2 shows the permissible limits for each parameter studied.

Table no 1: Physico-chemical Characteristics of Water from Nathsagar Reservoir

Sr. No.	Parameter	Unit	Test Method	Requirement as per CPCB Guidelines			Observed Value
				Inland Surface Water	Public Sewers	Land of irrigation	
1	Temperature	°C	Thermometer	-	-	-	25
2	Turbidity	NTU	APHA Part 2130-B	-	-	-	0.2
3	Total Suspended Solids (TSS)	mg/L	IS 3025 (Part 17)	100	600	200	4.0
4	Total Dissolved Solids (TDS)	mg/L	IS 3025 (Part 16)	-	-	-	280.30
5	Electrical Conductivity (EC)	μS/cm	IS 3025 (Part 14)	-	-	-	580.5
6	pH@25°c	-	IS 3025 (Part 11)	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	7.17
7	Total Alkalinity as $CaCO_3$	mg/L	IS 3025 (Part 23)	-	-	-	115.0
8	P Alkalinity as HCO_3	mg/L	IS 3025 (Part 23)	-	-	-	25.0
9	Total hardness as $CaCO_3$	mg/L	IS 3025 (Part 21)	-	-	-	97.0
10	Calcium hardness	mg/L	IS 3025 (Part 40)	-	-	-	77.60
11	Chloride (Cl)	mg/L	IS 3025 (Part 32)	-	-	-	69.97
12	Dissolved Oxygen (DO)	mg/L	IS 3025 (Part 38)	-	-	-	2.1
13	Biological Oxygen Demand (BOD) (3 days @27°c)	mg/L	IS 3025 (Part 44)	30	350	100	30.0
14	Chemical Oxygen Demand (COD)	mg/L	IS 3025 (Part 58)	250	-	-	121.80
15	Nitrate (NO_3^-)	mg/L	IS 3025 (Part 34)	-	-	-	4.06
16	Ammonia (NH_3)	mg/L	IS 3025 (Part 34)	5.0	-	-	0.50
17	Phosphate (PO_4^{3-})	mg/L	IS 3025 (Part 31)	-	-	-	3.65
18	Sulphate SO_4	mg/L	IS 3025 (Part 24)	-	-	-	7.45
19	Sodium (Na)	mg/L	IS 3025 (Part 45)	-	-	-	36.70
20	Potassium (K)	mg/L	IS 3025 (Part 45)	-	-	-	3.20
21	Magnesium (Mg)	mg/L	IS 3025 (Part 46)	-	-	-	4.71
22	Fluoride (F)	mg/L	IS 3025 (Part 60)	2.0	15	-	0.10
23	Silicate (SiO_2)	mg/L	IS 3025 (Part 35)	-	-	-	10.05
24	Copper (Cu)	mg/L	ICP-OES Method	3.0	3.0	-	0.042
25	Iron (Fe)	mg/L	ICP-OES Method	3.0	3.0	-	0.013
26	Zinc (Zn)	mg/L	ICP-OES Method	5.0	15	-	0.012
27	Lead (Pb)	mg/L	ICP-OES Method	0.1	1.0	-	BDL
28	Nickel (Ni)	mg/L	ICP-OES Method	-	-	-	BDL

BD: Below detection limit

CPCB: Central Pollution Control Board

Table no 2: Permissible Limits as per Prescribed Standards of Water Quality

Sr. No.	Parameter	Unit	A	B	C	D	E
1	Temperature	°C	-	-	-	-	-
2	Turbidity	NTU	5	30	-	-	-
3	Total Suspended Solids (TSS)	mg/L	-	-	-	-	-
4	Total Dissolved Solids (TDS)	mg/L	500	-	1500	-	2100
5	Electrical Conductivity (EC)	μS/cm	1400	-	-	1000	2250
6	pH@25°c	-	6.5 - 8.5	6.5 - 8.5	6.0 – 9.0	6.5 - 8.5	5.89 – 6.0
7	Total Alkalinity as $CaCO_3$	mg/L	600	-	-	-	-
8	P Alkalinity as HCO_3	mg/L	-	-	-	-	-
9	Total hardness as $CaCO_3$	mg/L	600	-	-	-	-
10	Calcium hardness	mg/L	75	-	-	-	-
11	Chloride (Cl)	mg/L	250	-	600	-	600
12	Dissolved Oxygen (DO)	mg/L	6	5	4	4	-
13	Biological Oxygen Demand (BOD)	mg/L	2	3	3	6	-
14	Chemical Oxygen Demand (COD)	mg/L	10	-	-	-	-
15	Nitrate (NO_3^-)	mg/L	20	-	50	-	-
16	Ammonia (NH_3)	mg/L	0.5	-	-	1.2	-
17	Phosphate (PO_4^{3-})	mg/L	1	-	-	-	1
18	Sulphate SO_4	mg/L	400	-	400	-	1000
19	Sodium (Na)	mg/L	200	-	-	-	-
20	Potassium (K)	mg/L	55	-	-	-	-
21	Magnesium (Mg)	mg/L	100	-	-	-	-

22	Fluoride (F)	mg/L	1.5	1.5	1.5	-	-
23	Silicate (SiO_2)	mg/L	-	-	-	-	-
24	Copper (Cu)	mg/L	1.5	-	1.5	-	-
25	Iron (Fe)	mg/L	0.3	-	50	-	-
26	Zinc (Zn)	mg/L	15	-	15	-	-
27	Lead (Pb)	mg/L	0.1	-	0.1	-	-
28	Nickel (Ni)	mg/L	0.02	-	-	-	-

(Kodarkar et al. 1989; Trivedy and Goel, 1998; NEERI, 2007; APHA, 1975; Guzmán et al., 2010; Gissi et al., 2016)

Where,
A: Drinking water source without conventional treatment but after disinfection
B: Outdoor bathing (organised)
C: Drinking water source with conventional treatment followed by disinfection
D: Propagation of wildlife, fisheries
E: Irrigation, industrial, cooling, controlled waste disposal

IV. Discussion

We can understand biological phenomena in water only when we have water quality data on physico-chemical characteristics (Tiwari, 1992; Khadse et al., 2023). Various physico-chemical parameter of water from Sonwadi Kh. Area of Nathsagar Reservoir were studied and following inferences were made.

1. Temperature: Alters metabolic rate by influencing the enzyme systems; regulates distribution and survival of flora and fauna (Kodarkar et al., 1989). The water with the value of temperature was suitable for drinking without conventional treatment but after disinfection, outdoor bathing, drinking with conventional treatment followed by disinfection, propagation of wildlife, fisheries, and irrigation, industrial, cooling, controlled waste disposal.
2. Turbidity: Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. Turbidity in water is caused by the presence of suspended matter, such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms (APHA, 1975). Turbidity value was found to be within permissible limits for drinking without conventional treatment but after disinfection, and outdoor bathing.
3. Total Suspended Solids (TSS): The Total Suspended Solids cause turbidity, limit eutrophic zone, influence primary productivity, food chain/web and energy cycles (Kodarkar et al., 1989). Its value did not have any limits prescribing its permissibility.
4. Total Dissolved Solids (TDS): The TDS control hardness and reactivity (Kodarkar et al., 1989). The value of TDS was within permissible limits for drinking without conventional treatment but after disinfection, drinking with conventional treatment followed by disinfection, and irrigation, industrial, cooling, controlled waste disposal.
5. Electrical Conductivity (EC): It is an indicator of free ions (Kodarkar et al., 1989). Conductivity if measured of a cube with each side of 1 cm at 25°C is called specific conductance. In water, it is the property caused by the presence of ions (Trivedy and Goel, 1998). Its value was found to be within permissible limits, and was suitable for drinking without conventional treatment but after disinfection, propagation of wildlife, fisheries, and irrigation, industrial, cooling, controlled waste disposal.
6. pH: The value of pH influences the enzyme systems (Kodarkar et al., 1989). The pH value was found to be within permissible limits and was suitable for drinking without conventional treatment but after disinfection, outdoor bathing, drinking with conventional treatment followed by disinfection, and propagation of wildlife, fisheries.
7. Total Alkalinity: Alkalinity of the water is its capacity to neutralise a strong acid and is characterised by the presence of all hydroxyl ions capable of combining with the hydrogen ion. Alkalinity in natural waters is due to free hydroxyl ions and hydrolysis of salts formed by weak acids and strong bases such as carbonates and bicarbonates (Trivedy and Goel, 1998). The Total alkalinity was found to be within permissible limits for drinking without conventional treatment but after disinfection.
8. P Alkalinity as HCO_3: The estimation of this parameter is essential for buffering and regulation of pH, exoskeleton of microfauna (Kodarkar et al., 1989). There was no permissible limit for the P Alkalinity value.
9. Total hardness as $CaCO_3$: The total hardness controls salinity and influence osmoregulatory process (Kodarkar et al., 1989). The value of total hardness was within the permissible limits for drinking without conventional treatment but after disinfection.
10. Calcium hardness: Calcium is one of the most abundant elements found in the natural water. It is an important in imparting the hardness to the water. At high pH, much of its quantities may get precipitated as $CaCO_3$ (Trivedy and Goel, 1998). The calcium hardness value exceeded the permissible limits for drinking.

11. Chloride (Cl): Control salinity and influence osmoregulatory process (Kodarkar et al., 1989). The value of Chlorine was found to be within the permissible limits for drinking without conventional treatment but after disinfection, drinking with conventional treatment followed by disinfection, and irrigation, industrial, cooling, controlled waste disposal.
12. Dissolved Oxygen (DO): Dissolved Oxygen is essential for biological oxidation and consequent release of energy (Kodarkar et al., 1989). The DO value was found to be within permissible limits for drinking without conventional treatment but after disinfection, outdoor bathing, drinking with conventional treatment followed by disinfection, and irrigation, industrial, cooling, controlled waste disposal.
13. Biological Oxygen Demand (BOD): BOD is an empirical standardised laboratory test which measures oxygen requirement for aerobic oxidation of decomposable organic matter and certain inorganic materials in water, polluted waters and wastewater under controlled conditions of temperature and incubation period. (NEERI, 2007). High BOD indicates organic pollution, high load of anaerobic microbes and level of eutrophication (Kodarkar et al., 1989). The value of BOD was found to be exceeding the prescribed permissible limits, determining pollution with organic matter. Thus, it is unsuitable for drinking without conventional treatment but after disinfection, outdoor bathing, drinking with conventional treatment followed by disinfection, and propagation of wildlife, and fisheries.
14. COD: The COD test determines the oxygen requirement equivalent of organic matter that is susceptible to oxidation with the help of a strong chemical oxidant. It is an important, rapidly measured parameter as a means of measuring organic strength for streams and polluted water bodies (NEERI, 2007). The value of COD was found to be exceeding the permissible limits, therefore indicating organic pollution. It is unsuitable for drinking.
15. Nitrate (NO_3^-): Nitrate stimulates nutrient linked eutrophication; stimulate blooms of blue greens (Kodarkar et al., 1989). The value of nitrate was found to be within the permissible limits for drinking without conventional treatment but after disinfection, and drinking with conventional treatment followed by disinfection.
16. Ammonia (NH_3): Ammonia of mineral origin is rare in natural waters. Occurrence of ammonia can be accepted as the chemical evidence of organic pollution (Trivedy and Goel, 1998). The value was found to be within permissible limits for drinking without conventional treatment but after disinfection, and drinking with conventional treatment followed by disinfection.
17. Phosphate (PO_4^{3-}): Phosphate is generally considered as the critical nutrient for the growth of algae in water. The enrichment of this nutrient leads to the process of eutrophication (Trivedy and Goel, 1998). The value of phosphate was found to be exceeding the permissible limits, and was hence unsuitable for drinking, irrigation, industrial, cooling, and controlled waste disposal.
18. Sulphate SO_4: The sulphate in water indicate pollution from industrial effluents; on reduction are converted into H_2S (Kodarkar et al., 1989). The value of sulphate was found to be within the permissible limits for drinking without conventional treatment but after disinfection, drinking with conventional treatment followed by disinfection, and irrigation, industrial, cooling, controlled waste disposal.
19. Sodium (Na): It is one of the important cations occurring naturally. Domestic sewage is one of the important sources of sodium to the fresh waters. A water with a high sodium content is not suitable for agriculture as it tends to deteriorate the soil for crops. Sodium associated with chlorides and sulphates make the water unpalatable (Trivedy and Goel, 1998). The value of sodium was found to be within permissible limits for drinking without conventional treatment but after disinfection.
20. Potassium (K): Potassium is a naturally occurring element. It has got a more or less similar chemistry like sodium and remains mostly in solution without undergoing any precipitation (Trivedy and Goel, 1998). The value of potassium was found to be within permissible limits for drinking without conventional treatment but after disinfection.
21. Magnesium (Mg): Magnesium occurs in all kinds of natural waters and is one of the important cations imparting hardness to the waters (Trivedy and Goel, 1998). The Magnesium value was found to be within permissible limits for drinking without conventional treatment but after disinfection.
22. Fluoride (F): Fluoride concentration of approximately 1 mg/l effectively prevents dental caries without harmful effects on health. Some fluorosis may occur when the fluoride level is exceeds the recommended limits (APHA, 1975). The value of Fluoride was found to be within permissible limits for drinking without conventional treatment but after disinfection, outdoor bathing, and drinking with conventional treatment followed by disinfection.
23. Silicate (SiO_2): Silica is found in abundance in the earth's crust, appearing as the oxide in many rocks and combined with metals in the form of many silicate minerals, particularly the igneous and metamorphic rocks. Degradation of these silica-containing rocks results in the presence of silica in natural waters as suspended particles, in a colloidal or polymeric state, and as the silicate ion (APHA, 1975). There was no prescribed permissible limit for Silicate value.

24. Copper (Cu): Copper salts are used in water supply systems for controlling biological growths in reservoirs and distribution pipes and for catalysing the oxidation of manganese (APHA, 1975). The value of Copper was found to be within the permissible limits for drinking without conventional treatment but after disinfection, and drinking with conventional treatment followed by disinfection.
25. Iron (Fe): Because iron is an important micronutrient used by most organisms, and is required for important cellular processes such as respiration, oxygen transport in the blood, photosynthesis, nitrogen fixation, and nitrate reduction, its bioavailability is of concern for Earth's living organisms, especially in aquatic ecosystems. This is because, despite its relatively high abundance on Earth, iron is a minor component of aquatic systems because of its relative insolubility in water at circumneutral pH (Guzmán et al., 2010). The value of Iron was found to be within the permissible limits for drinking without conventional treatment but after disinfection, and drinking with conventional treatment followed by disinfection.
26. Zinc (Zn): Zinc is an essential and beneficial element in body growth. It most commonly enters the domestic water supply from the deterioration of galvanized iron and the dezincification of brass. Zinc may also result from industrial waste pollution (APHA, 1975). The value of Zinc was found to be within the permissible limits for drinking without conventional treatment but after disinfection, and drinking with conventional treatment followed by disinfection.
27. Lead (Pb): Lead is a serious cumulative body poison. Lead in a water supply may come from industrial, mine, and smelter discharges, or from the dissolution of old lead plumbing (APHA, 1975). The value of Lead was below detection limit (BDL).
28. Nickel (Ni): Elevated levels of Ni in aquatic (both freshwater and seawater) ecosystems, caused by both natural sources and anthropogenic inputs, may lead to adverse toxic effects to organisms (Gissi et al., 2016). Within the aquatic environment, studies have shown that Nickel toxicity can affect multiple endpoints in various organisms across trophic levels (Wang et al., 2020). The value of Nickel was below detection limit (BDL).

The Concept of ILBM:

An enormous amount of information and data has already been generated, and will continue to be generated, on a wide range of thematic subjects pertaining to lake basin management, on both a national and international basis. Much of it pertains to natural science topics, including physical, chemical and biological aspects (limnology, hydrology, climatology, ecology, biochemistry, etc.), all of which contribute to a better understanding of the state of lakes, reservoirs and other lentic water bodies. There is also a growing number of studies on the managerial aspects of aquatic, terrestrial and riparian ecosystems, including water quality, sediment quality, and shoreline environments, in addition to the inflowing and outflowing water systems, extending out to the upper watershed tributaries. (RCSE and ILEC, 2014) Figure 3 shows the six pillars of ILBM.

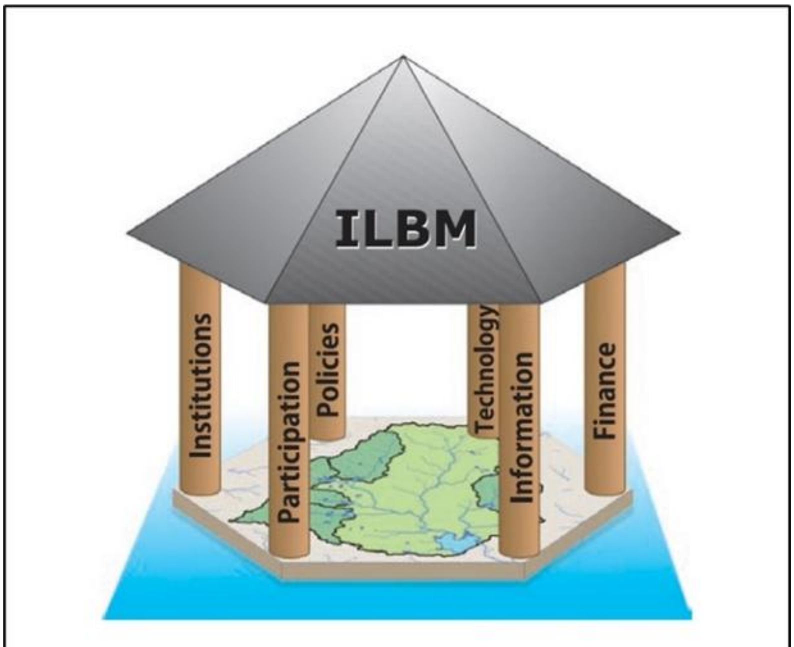

Fig no 3: ILBM Governance Pillars, founded on a Lake Basin Ecosystem Service Base Supporting the Integration Goal
Image courtesy: RCSE and ILEC, 2014

There is a potentially large role for technical interventions in development and protection of lake resources. Interventions such as sewerage development, which are often used in developed countries to address water quality problems, face the problem of not having a sufficiently large base of people in developing countries to pay for the increased utility. (ILEC, 2007)

The Pillar of 'Information' in ILBM:

There are few lakes for which continuous, or even periodic, diagnosis and surveys of the lake/reservoir environment are carried out. Indigenous knowledge, along with scientific study and investigation, play a key role in lake/reservoir basin management. Dissemination of research findings often accelerates social responses (RCSE and ILEC, 2014). There are few lakes for which continuous, or even periodic, diagnosis and surveys of the lake environment are carried out. Indigenous knowledge, along with scientific study and investigation, play a key role in lake basin management. Dissemination of research findings often accelerate social responses. Accordingly, the following questions should be considered when assessing management programs (ILEC, 2007):

- What is the status of the knowledge base?
- Is a monitoring system that can measure changes in key indicators in place?
- Is the database sufficient?
- What are the remaining key knowledge gaps?
- Are the information management tools sufficient to be effectively deployed?

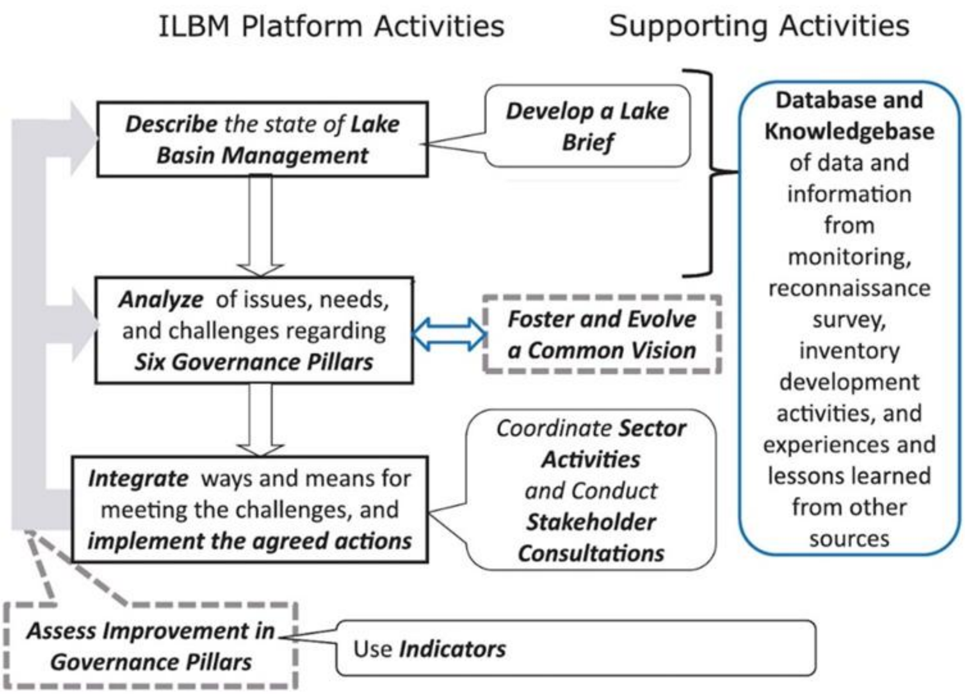

Fig no 4: Activity flow diagram of the ILBM process as a set of step-wise activities guided by the main themes of a Lake/Reservoir Brief

Image courtesy: RCSE and ILEC, 2014

Figure 4 shows the flow-chart of ILBM activities.

1) The first step is for all the Platform members to acknowledge the state of lake basin management, as part of the Lake Brief development process,

2) The second step is for all the Platform members to identify and analyse the issues, needs, and challenges regarding the Six Pillars of Governance; and

3) The third step is for all the Platform members to integrate the ways and means to meet the governance challenges and implement actions. (RCSE and ILEC, 2014)

As an essential part of the supporting activities of ILBM process, the pillar of 'Information' comprising the database and knowledgebase of concerned waterbody was strengthened by analysing and interpreting the water quality status of Nathsagar Reservoir towards determining its overall health and suggesting means for its utilitarian and conservation purposes. Data on physico-chemical characteristics of water was empirically observed and knowledge about their significance and permissibility according to prescribed standards was deduced, in order to gain insight into the present conditions of the waterbody under investigation.

Temperature, Turbidity, Total Suspended Solids, Total Dissolved Solids, Electrical Conductivity, pH, Total Alkalinity, P Alkalinity, Total hardness, , Chloride, Dissolved Oxygen, Nitrate, Ammonia, Sulphate, Sodium, Potassium, Magnesium, Fluoride, Silicate, Copper, Iron, Zinc, Lead, and Nickel values were observed to be within permissible limits, thereby reflecting the suitability of the water for various purposes like human consumption, washing and bathing, fisheries, irrigation, and industrial uses. Although this depicts a satisfactory conclusion, the values of Calcium hardness, BOD, COD, Phosphate exceeded the permissible limits implying unsuitability of the water for various purposes, but this inference does not give a broader confirmation of the incidence of pollution throughout the waterbody, as the values pertained to the specific sampling site which experienced distress due to anthropogenic impacts from the neighbouring inhabitants, along with other natural causes.

V. Conclusion

In the light of the above discussion, the overall conclusion is that the waterbody is relatively unpolluted, providing various ecosystem and utilitarian services. Continuous multidisciplinary surveys for determining the conservation and management strategies of the waterbody through holistic approaches need to be undertaken. This work of rapid and random monitoring of water quality of Nathsagar Reservoir is a concise study which facilitates to briefly comprehend the pillar of 'Information' of ILBM strategy in the wake of climate change for attaining the following Sustainable Development Goals (SDGs):
SDG 3. Good Health and Well-being: Ensure health and provide care for everyone regardless of their age.
SDG 6. Clean Water and Sanitation: Ensure and develop appropriate water supply and waste disposal systems.
SDG 11. Sustainable Cities and Communities: Develop cities and communities that are inclusive, safe, resilient and sustainable.
SDG 13. Climate Action: Make urgent efforts to combat climate change and its effects.

It is suggested that comprehensive studies involving frequent, regular, and intensive monitoring of Nathsagar Reservoir should be conducted in order to get timely and reliable data which will aid in governance and policy in the management of the waterbody. Though the present study encompasses one of the pillars of ILBM, the future research should focus equally on all the six pillars representing the plethora of Integrated Lake Basin Management.

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