***Original Research Article***

**Assessing the Role of Urbanization and Government Interventions on the Water Quality of Shahpura Lake, Bhopal, India**

**ABSTRACT**

Urbanization comprises planned infrastructure development to cater to the growing population and economic activities by ensuring efficient and sustainable spatial land use, creating a liveable environment. A well-planned urban development improves infrastructure, healthcare, education, economic activities, and the urban environment; fast or unplanned development may lead to unfavourable changes such as environmental pollution, traffic congestion, insufficient or excess housing, and informal encroachments of natural habitats. Urban developmental activities need greater use of natural resources like water and land. This may strain the limited resources. Within this context, the study aimed to understand how urban development and related factors have impacted the available water reservoirs in an urban area and whether any planned interventions by the Government have had any impact on it. Developmental activities in Bhopal, India are still in a nascent phase. In 2016, 'City of Lakes' Bhopal was included in the 'Smart Cities Mission'. Hence, an attempt has been made to understand how urban development has impacted this Lake situated within the city. The Shahpura Lake, a rain-fed lake, continuously receive sewage. Also, the recently increased urban developmental activities have put tremendous pressure on its water quality. It was observed that the Government has continuously made efforts to improve the quality of lake water. The study points out that planning and management strategies specific to the lake and combined efforts by all the stakeholders are needed.

***Keywords:*** *Urbanization, Water Quality, Shahpura Lakh, National River Conservation Plan (NRCP), Lake Conservation.*

**1. INTRODUCTION**

Urbanization is crucial in economic development because it provides employment opportunities, attracts investment, and fosters innovation and entrepreneurship. Urban development has many facets and is important as it allows for industrial and infrastructure developments, technological advancements, and social integration by providing opportunities for environmental sustainability, cultural exchange, cultural and heritage preservation, and improved living standards by providing housing, healthcare, education and recreation facilities like parks, community centers, maintaining lakes etc. All these have increased the urban population almost 11-fold in the last 100 years, from 26 million to 285 million in India. Its share in the total population has also increased nearly 3 fold from 10.84% in 1901 to 28.5% in 2001, which indicates faster growth of the urban population (Jaysawal and Saha, 2014). One of the conspicuous features of urbanization in India is the skewed distribution of population, with as much as 28.3% of the urban population in 35 metro cities alone. Annual change in urbanization in India is about 1.1% against the global rate of 0.9%. It is expected that 50% of the 814 million Indian population will reside in urban areas in 2050 (Bhagat, 2014). Globally, in 2018, about 55% (4.2 billion) of the population lived in the cities. It is expected to increase to about 6.5 billion in 2050. It is also opined that about 90% of urban expansion will be in the developing countries. This will increase pressure on the urban resources (UN DESA).

India ranks thirteenth among the world's 17 'extremely water-stressed' countries. The availability of freshwater resources is also declining in India per capita due to increased population. The per capita annual water availability in India may fall to 1,235 m3 by 2050, and if it declines to around 1,000-1,100 cubic meters, then India could be declared a water-stressed country (thehindubusinessline.com). Moreover, India possesses only 4% of the world's freshwater to meet the needs of 17% of the global population. In northern India, groundwater levels declined to>8 cm/year between 1990 and 2014 (Trivedi et al., 2023). Depletion of available freshwater resources, falling groundwater levels and deteriorating water quality are all posing a variety of challenges in managing India's water resources (CPCB, 2011). This is even more problematic in the urban environment, which is already struggling to support the ever-increasing human population inflow. It should be noted that lakes play a crucial role in an urban landscape. One of the primary roles is to regulate the micro-climate of any urban area, hence acting as an ecological barometer of health (Ravinder, 2018). Lakes of all sizes are significant as not only do they provide drinking water in the cities facing water stress/scarcity or lacking other sources, but they also play a significant role in regulating the micro-climate of an urban area and, hence, act as ecological barometers of the health (Ravinder, 2018). In a study, Qi et al., 2025 found that a small lake could extend a cooling effect up to 30 m from the boundary, reducing the temperature up to 2 oC in summer. Additionally, lakes also serve to control floods by storing excess rainwater. Lakes conserve biodiversity and maintain cultural and historical heritage, as they are often associated with traditional beliefs and practices. Many have significant histories attached to them. Lakes also provide us with ecosystem services like fisheries, improve the area's scenic view or aesthetic appeal and offer many recreational activities like boating, swimming, and picnics (Deines et al., 2017).

Much effort has been made to study the physical and biological aspects of lakes and manage pollution. Different lake morphologies give rise to varying productivity levels and physical effects of water retention, circulation, current and waves. The health of the aquatic ecosystem is determined by the water quality parameter, which includes the physical, chemical, and biological characteristics (Kangabam et al., 2017).

About 70% of natural wetlands have been lost globally in the last century. From 1970 to 2015, natural wetlands have reduced by almost 35%. Anthropogenic activities have affected the water quality in numerous water bodies, affecting their intended use and have accelerated the rate and amount of eutrophication in aquatic ecosystems by point-source discharges and non-point loadings of limiting nutrients like nitrogen and phosphorus. About 80% of the wastewater enters different water bodies without complete treatment (unwater.org). Urban development is altering the hydrological regimes of the lake and causing changes in the groundwater recharge and lake water levels. It also leads to the degradation of lake water quality from stormwater runoff and industrial and domestic wastewater discharge, leading to changes in nutrients, heavy metals, and pesticide contents. All this leads to bio-magnification in aquatic organisms, algal blooms, eutrophication, and loss of aquatic biodiversity. Yao et al., 2023 studied about 1972 of the world's largest lakes from 1992 to 2020 and observed that water storage has declined by about 53%.

Continuously increasing population and urban developmental activities require increasing use of natural resources like water and are adding tremendous pressure on the available water (Krishnan et al., 2024). Within this context, the present study deals with how historical urban development, population growth, and economic activities impact the available water reservoirs in an urban ecosystem. Hence, an attempt has been made through a case study of Shahpura Lake, situated within Bhopal city, to understand how urban development has affected its water quality.

**2. METHODOLOGY**

**2.1 Study Area**

The creation of Bhopal dates back to around 1010-1015 AD and is credited to the Raja Bhoj, who was also responsible for creating the Upper Lake (also known as Bhojtaal). The district, with an area of 2772 Km2,is situated in the central part of the state between latitude 23°04´ and 23°53´ North and longitude 77°12´ and 77°40´ East. Bhopal has a moderate climate, and on average, it receives about 1008.1 mm of rainfall annually. About 90% of this is received during the rainy season. Bhopal is known as the ‘City of Lakes’. Bhopal was among the first 20 cities to be included in the ‘Smart Cities Mission’ in January 2016.

Shahpura Lake, an urban lake, is also known as the third Lake of Bhopal (Fig. 1). It is a manmade reservoir (23°12'17" N and 77°25'35" E) that was formed in 1974-75 under the Betwa irrigation project (Trivedi 2012). The lake has a catchment area of 8.29 km2, a gross storage capacity of 2.29x106 m3, and a submergence area of 0.96 km2 (Munoth & Nagaich, 2015). The lake is shallow, with a mean depth of 1-2 m (Saxena, 2014) and a maximum depth of 5.60 m (Munoth & Nagaich, 2015).



Figure 1: Location of Shahpura Lake

**2.2 Data Collection**

The study is based on Secondary Data. Research literature was collected from Web of Science, Scopus, and Google Scholar. Information was also collected from various websites and reports. Data for the population was collected from different Census of India. Urban development and planning information was collected from the Bhopal Development Plans and research articles. Information related to Water quality parameters was collected from research papers and websites like Central Pollution Control Board (CPCB) and Madhya Pradesh Pollution Control Board (MPPCB).

**3. RESULTS**

**3.1 Urban Development**

**3.1.1 Population growth**

The population of Bhopal district increased by 1547 times in 110 years from 1901 to 2011. A wide variation in growth was observed in the population of Bhopal. There was a drastic in the population from 1901 to 1921; thereafter, a gradual increase in population growth was observed. It more than doubled from 1951 to 1961 (~118%), which can be attributed to Bhopal being made the Capital of Madhya Pradesh. The decreased decadal growth in the population in the Bhopal city from 1981 onwards may be due to the Bhopal Gas Tragedy (1984), slowdown in industrial growth, and the newly constituted state of Chhattisgarh in 2000. The data reveals that in 1941, only 23.2% of the Bhopal District population resided in Bhopal city, but in 2011, about 75.8% of the total population was concentrated in the city. It is interesting to note that, in 2011, almost 94% of the total urban population of the Bhopal District resided in the Bhopal city (**Table 1**).

To understand how the population growth around Shahpura Lake has impacted its water quality, the population of the 11 different wards surrounding the lake and its catchment area was studied (**Table 2**). From 2001 to 2011, only a 5.5% increment is observed in the overall population in the wards. In 2001, ward no 52 had the maximum population (16.15%), followed by ward 31 (13.67%), and then ward 49 (11.02%). In 2011, the maximum population was in Ward 52 (23.29%), followed by Ward 50 (11.59%), Ward 51 (10.69%), and Ward 28 (10.18%). A 78% increase in the decadal population of Ward 50 is seen, whereas a 55% increase in Ward no 30 and a 50% increase in the Ward 52 population is observed.

Table 1: Population growth profile of Bhopal District

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Bhopal District** | **Bhopal District Urban population**  | **Urban Population of Bhopal** |
| **Number** | **Percentage (%) (of Bhopal District)** | **Decadal growth rate (%)** |
| 1901 | 143958 | 81299 | 77023 | 53.5 |   |
| 1911 | 156354 | 58828 | 56204 | 35.9 | -27.0 |
| 1921 | 140300 | 47289 | 45094 | 32.1 | -19.8 |
| 1931 | 163747 | 63256 | 61037 | 37.3 | 35.4 |
| 1941 | 188608 | 79380 | 75228 | 39.9 | 23.2 |
| 1951 | 235665 | 102333 | 100258 | 43.4 | 36.0 |
| 1961 | 371715 | 229186 | 222948 | 60.0 | 117.9 |
| 1971 | 572169 | 392641 | 384859 | 67.3 | 72.6 |
| 1981 | 894739 | 681853 | 671018 | 75.0 | 74.4 |
| 1991 | 1351479 | 1080802 | 1062771 | 78.6 | 58.4 |
| 2001 | 1843510 | 1482718 | 1458416 | 79.1 | 37.2 |
| 2011 | 2371061 | 1917051 |  1798218  | 75.8 | 23.3 |

*Source: Census of India, BDP 1991, BDP 2031*

Table 2: Decadal population growth in Wards surrounding the Shahpura Lake

|  |  |  |  |
| --- | --- | --- | --- |
| **Ward No.** | **2001** | **2011** | **Change (2001-2011)** |
| **NH** | **TP** | **TP (%)** | **NH** | **TP** | **TP (%)** | **NH** | **TP** |
| **28** | 4869 | 23395 | 8.99 | 6607 | 27968 | 10.18 | 1738 | 4573 |
| **29** | 5391 | 25260 | 9.7 | 3997 | 17898 | 6.51 | -1394 | -7362 |
| **30** | 3275 | 15264 | 5.86 | 5323 | 23652 | 8.61 | 2048 | 8388 |
| **31** | 7374 | 35577 | 13.67 | 6521 | 26621 | 9.69 | -853 | -8956 |
| **32** | 3636 | 17507 | 6.73 | 3157 | 15832 | 5.76 | -479 | -1675 |
| **33** | 2181 | 11220 | 4.31 | 2843 | 13591 | 4.95 | 662 | 2371 |
| **48** | 4507 | 19859 | 7.63 | 1797 | 7880 | 2.87 | -2710 | -11979 |
| **49** | 6011 | 28692 | 11.02 | 4063 | 16090 | 5.86 | -1948 | -12602 |
| **50** | 3799 | 17855 | 6.86 | 7245 | 31830 | 11.59 | 3446 | 13975 |
| **51** | 5290 | 23621 | 9.08 | 7238 | 29382 | 10.69 | 1948 | 5761 |
| **52** | 9450 | 42035 | 16.15 | 14859 | 63984 | 23.29 | 5409 | 21949 |
| **Total** | 55783 | 260285 |   | 63650 | 274728 |   |   | 14443 |

*NH = No of households, TP = Total Population, AP/H = Average no of persons/Household*

*\*rounded off to a single decimal*

*Data source: Census of India 2001 and 2011*

**3.1.2 Urban Sprawl in Bhopal**

The distribution of the population in the Bhopal District is highly skewed. Over 80% of the total population reside in the urban areas. Of the urban population, about 94% reside in the Bhopal city alone. Of the total 2772 km2 area of the Bhopal District, the urban area is only about 350.05 km2, of which Bhopal Municipal Corporation has an area of about 285.88 km2. Urbanization peaked after Bhopal was made the capital of Madhya Pradesh. From 5326.48 ha in 1989, urban sprawl increased to 20719.36 ha in 2018 (**Fig. 2**). Maximum increase in the sprawl can be seen from 1994 to 1999 (48.97%) and from 2005 to 2011 (40.77%).

With the rapid urbanization of Bhopal city, planned urban development was undertaken to provide the necessary infrastructure, health, education, and employment to support the requirements of the growing population. There was a change in the land use planning of the city as well. In 1961, the maximum area (1056 ha) was used for residential purposes to cater to the population, which more than doubled over the last decade. Industrial land increased by 335% from 1961 to 1994. Area under transport also tripled from 1961 to 1994 to provide for easy commute to the people, workers, and for economic development. A major land use change was seen for recreation purposes. It increased by 1323% in 33 years (from 1961 to 1994). This can be attributed to providing a good quality of life to the residents.

Figure 2. Area under urban sprawl of Bhopal city, Madhya Pradesh, India from 1989 to 2018.

**3.1.3 Industrial Development**

Heavy Electricals (India) Limited, i.e., HE(I)L (Now BHEL), was established on 29th August 1956 to manufacture heavy electrical equipment. For this, an agreement was made by the GoI with Associated Industries (AEI), UK, on 17th November 1955. Next to BHEL, in the central region of the city, an ancillary unit was developed in the Govindpura area, which was developed around 1966. It is now an identified Engineering Cluster. In the 1970s, a major industrial area was developed in the south of Bhopal city in Mandideep. In 1989, Nishatpura Coach Factory and Railway workshop for rehabilitation of Indian Railways coaches was established just 2 km away from the Bhopal Railway Station. Many dedicated industrial areas have been developed in Bhopal like Govindpura (317 ha), Acharpura (147.34 ha), Bagroda (128.02 ha), Bandikheda (78.54 ha), Kaliparad (10.22 ha), and Press Complex (0.3 ha) (Madhya Pradesh Industrial Development Corporation).

A total of 10,989 MSMEs were registered between 1984 and 2011, with an average of 407 registration per year. From July 2020 to October 2023, a total of 9,28,327 Micro, Small, and Medium Enterprises (MSMEs) were registered in Madhya Pradesh, of which 62,410 (6.72%) no MSMEs were registered in the Bhopal District itself. Almost 96.68% of the MSMEs, i.e., 60,337, were Micro enterprises. The remaining 3.06 % (1912) were Small Enterprises, and 0.26% (161) were Medium Enterprises.

**3.1.4 Sewage and Storm water discharge**

No underground sewerage existed in the city of Bhopal until the 1950s, except for the Ahmedabad area. Around 1973, only two areas, namely TT Nagar and BHEL, had well-planned sewerage systems. There were two sewage treatment plants in TT Nagar, namely in 'Char-imli' and behind the Shahpur hills. The sewage treatment plant in BHEL was maintained by its own management. By 2011, about 240 MLD of sewage was being generated in the Bhopal District, but the treatment capacity was limited to only 67 MLD, being carried out from the five STPs located at Maholi Damkheda, Badwai, Singpur Bhadhada, Gandhinagar, and Bawadiya Kalan. This catered to only about 30% of the population. The remaining sewage (~173 MLD) was being disposed of untreated.

With the launch of Atal Mission for Rejuvenation and Urban Transformation (AMRUT) in 2015, a total of 9 new STPs were added, making a total of 17 operational STPs all over Bhopal City with a total capacity of about 174 MLD **(Table 3)**. Additionally, with the renovation of existing and construction of new sewage pumping stations, laying 320 Km of sewerage network, and connecting them with the households across the city, now about 45% of the population of Bhopal City is connected to the sewerage network (NGT).

**Table 3. STPs operational in the Bhopal City**

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Location** | **STP Capacity (MLD)** |
| 1 | STP Badwai, Village Badwai  | 16.67 |
| 2 | STP Bawadiya Kalan, Jhuggi Basti, Shahpura | 13.56 |
| 3 | STP Gondarmau, Airport Road | 2.36 |
| 4 | STP Mata Mandir, T.T. Nagar | 4.56 |
| 5 | STP Kotra, Bhadbhada road | 10 |
| 6 | Bhopal BHEL, Barkheda  | 4.5 |
| 7 | Bhopal BHEL, Piplani | 2.27 |
| 8 | STP Ekant Park# | 8 |
| 9 | STP Shirin River Beside Koh-e-fiza Square, VIP Road\* | 5 |
| 10 | STP Misrod, Misrod, Bhopal\* | 20.5 |
| 11 | Professor Colony, Bhopal\* | 2 |
| 12 | STP Sankhedi, BMC\* | 32 |
| 13 | STP Maholi Damkheda, Itkhedi Sadak\* | 35 |
| 14 | STP Neelbad, BMC\* | 6 |
| 15 | STP Char Imli, BMC\* | 4.5 |
| 16 | STP Bansal Hospital, Chuna Bhatti, Bhopal\* | 9.5 |
| 17 | Jamunia Jheer (Kalukhedi), Bhopal\* | 3.5 |

*#Constructed under NRCP, \*Constructed under AMRUT*

**3.1.5 Water Quality of Shahpura Lake**

In 2003-2004, Dixit *et al.* studied the nutrient load (nitrate and phosphate) of the lake and found that although the nitrate content was within the permissible limits, phosphate concentration was very high. Moreover, the nitrate content increased sharply from 2003 to 2004. Whereas the phosphate concentration decreased from 2003 to 2004, although, throughout the study period, it was still more than the critical limit of 0.08 ppm as suggested by USEPA, beyond which eutrophication may occur in lakes. The concentrations were least during the rainy season due to the dilution effect of accrued rainwater. Joshi *et al.*, 2008 observed the nitrate value of 4.58 to 5.60 ppm and Phosphate 6.11 to 7.93 ppm during the study period of Jan to June 2007. During winter, Trivedi and Kataria (2012) observed the total phosphorus value to range between 0.1 to 1.9 mg P/l. Recently, Wani and Dixit (2018) observed the level of orthophosphate to range from 2.28 ˗ 2.84 mg/l in summer to 2.18 ˗ 2.65 in Monsoon. They found the nitrate concentration to be within 2.31 – 2.76 mg/l.

In a study conducted from January to June 2007, Joshi et al., 2008 observed very high BOD and COD in the months from March to June, indicating organic pollution. Based on the hardness value (222.00+2 mg/l) observed in 2008, Chouhan et al., classified Shahpura Lake water as Hard. Trivedi and Kataria (2012) also observed that all the sampling locations had the total hardness value of more than 220 mg/l. During the winter, Trivedi and Kataria (2012) observed the DO value to range from 0.8 to 7.0 mg/l, and COD ranged between 8.0 to 130 mg/l. In another study carried out at different locations of the lake in the month of December, Dixit and Rahi (2017) observed the DO value to range between 5.0 ˗ 5.7 mg/l and the BOD value ranged between 100 to 200 mg/l. They found TDS ranged between 573 ˗ 596 mg/l and pH ranged from 7.2 ˗ 7.9. Wani and Dixit (2018) found that the average value of BOD and COD was lesser in Monsoon than in the Summer season. Earlier in the Winter of 2011, Trivedi and Kataria (2012) found the pH value between 7.5 and 8.4, TDS between 369 and 580 mg/l and EC between 655 and 980 µmho/cm. In a study, Dixit & Tiwari, (2008) found that Cu, Cr, Pb, Cd, and Mn were present in concentrations above the permissible limits (USPH). In another study, Anu et al. (2011) found that the Pb and Cu were found more during the monsoon season than in summer.

MPPCB tests the Shahpura Lake water at the spillover site near Bansal Hospital, Shahpura Lake, on a monthly basis. The data was collected for a period from 2016 to 2022. A compilation of observed values of various physicochemical and biological parameters as observed in various studies and MPPCB is given in **Table 4**. The pH value is seen to vary from 6.8 to 8.8. Overall, a gradual decrease in the minimum and maximum values of pH was observed from 2016 to 2022. Value is found to be within the range for the class D designated use of water for the Propagation of wildlife and Fisheries. The minimum value of conductivity has also gradually decreased from 2016 to 2022, but no clear trend has been observed in the maximum value. The maximum amount of DO is observed to be gradually increasing over the years. Recently, in 2021 and 2022, the minimum value of DO has fallen below the recommended value of >4.0 mg/l. The recommended value of BOD is <3.0 mg/l, but the maximum value throughout (2016-2022) remained more than that with the maximum in 2020, i.e. 20 mg/l. Also, in 2020, the maximum load of Faecal coliform and Total coliform was way too high, which decreased gradually in 2021 and 2022.

Data was collected from the CPCB from 2016 to 2022 to understand the recent changes in the water quality of Shahpura Lake. CPCB and MPPCB calculate the Water Quality Index (WQI) by using the four parameters, namely DO, BOD, FC, and TC and categorize the water quality as satisfactory or not satisfactory. while analyzing the water quality, it was observed that the water quality was not satisfactory from 2017 to 2021. In 2022 and 2023, in a few months, the water quality was found to be satisfactory.

Table 4. Physicochemical and biological parameters of the water of Shahpura Lake, Bhopal, India

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Temperature (°C) | pH | Conductivity (μmhos/cm) | Dissolved O2 (mg/L) | BOD (mg/L) | Faecal Coliform (MPN/100ML) | Total Coliform (MPN/100ML) | Reference |
| **Min** | **Max** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** |  |
| 2006 (June-Nov) | 24.7 | 36.6 | 7.0 | 8.6 | 280 | 380 | 3.2 | 7.5 | 2.6 | 15.2 | - | - | - | - | Dubey et al., 2013 |
| 2012-2013 | 12 | 26 | 7.21 | 8.71 | 301 | 830 | 1.6 | 16.2 | 1.3 | 20 | - | - | - | - | Shivhare et al. 2014 |
| 2015 (Summer & Monsoon) | 30.4 | 38.7 | 7.6 | 8.3 | 390 | 780 | 3 | 4 | 24 | 32 | - | - | - | - | Wani & Dixit,2018 |
| 2016\* (July-Dec) | 18.5 | 25.4 | 7.55 | 8.37 | 539.4 | 689.4 | 5.5 | 11.7 | 6.2 | 18.4 | - | - | - | - | Shukla & Thakur, 2017 |
| 2016 |  |  | 7.4 | 8.7 | 546 | 963 | 5.6 | 7 | 2.8 | 14 | 120 | 240 | 1600 | 1600 | Madhya Pradesh Pollution Control Board (MPPCB) |
| 2017 | 19 | 34 | 7.3 | 8.8 | 526 | 677 | 5.5 | 7.6 | 3.1 | 3.8 | 12 | 230 | 920 | 1600 |
| 2018 | 16 | 31 | 7.4 | 8.8 | 6 | 826 | 4.2 | 7.8 | 2.5 | 14 | 2 | 430 | 130 | 2400 |
| 2019 | 18 | 28 | 7.8 | 8.4 | 278 | 548 | 6.3 | 8.2 | 1.7 | 14 | 2 | 240 | 70 | 2600 |
| 2020 | 19 | 31 | 7.2 | 8.4 | 512 | 667 | 5.9 | 10.3 | 1.2 | 20 | 10 | 35000 | 540 | 1600000 |
| 2021 | 20 | 33 | 6.8 | 8.6 | 445 | 738 | 2.0 | 10.2 | 4.8 | 12 | 14 | 2100 | 280 | 220000 |
| 2022 | 18 | 31 | 6.8 | 8.2 | 424 | 883 | 3.3 | 9.9 | 1.8 | 11.6 | 6 | 1600 | 1600 | 1600 |  |
| CPCB WQI criteria |  |  |  |  |  |  | **> 4.0 mg/l** | **< 3.0 mg/l** | **<2500 MPN/100 ml** | **<5000 MPN/100 ml** |  |

\*Average of five sites

**3.2 Government Interventions**

**3.2.1 Madhya Pradesh Pollution Control Board (MPPCB)**

MPPCB is the state-level body responsible for monitoring the quality of the water reservoirs in the state. Every month, as per the CPCB guidelines, MPPCB monitors Shahpura lake water near the spillout, which is located near the Bansal hospital.

**3.2.2 Bhopal Municipal Corporation (BMC)**

Lake Conservation Cell in the Health and Environment Division of the BMC. The budget includes provision for lakefront park development, the expenses for the lifeguards at the Lakes, expenditure for idol immersion, operation and maintenance activities like the cleaning of lakes, installation and maintenance of fountains, maintenance of machinery for lake conservation, beautification of Lake, and maintenance of STP Plant/Sewage pump. At the suggestion of the NGT in 2014, BMC installed wire mesh at certain locations of the lake to prevent solid waste from entering the lake. In the case of Shahpura Lake, a separate area has been constructed for idol immersion near the Campion School Road (**Fig. 3**).



Fig 3. A separate idol immersion site at Shahpura Lake

**3.2.3 Atal Mission for Rejuvenation and Urban Transformation (AMRUT)**

AMRUT, under the Ministry of Housing and Urban Affairs, Govt of India, was created to provide facilities like the water supply, sewage, and urban transport. Under AMRUT 1.0, four new STPs have been constructed with a collective capacity of 23.5 MLD in the catchment area of Shahpura Lake. In addition, 13 sewage pump houses have been built, and about 100 Km of sewerage network has been laid in the Shahpura Lake catchment area. Further, of the 68 drains across the city, 57 have been intercepted and diverted through the sewerage network to the STPS, thereby reducing the pollution load to the lakes. It is expected to improve the lake water quality. In AMRUT 2.0, a project, "Rejuvenation of Shahpura Lake in the city of Bhopal", has been sanctioned with the project cost of INR 12 crores for a period of two years, i.e., 2024 to 2026. Further, it is also planned to increase the sewerage coverage in Bhopal city with a project cost of INR 1177.79 crores.

**3.2.4 National River Conservation Plan (NRCP)**

NRCP is a scheme of the Ministry of Jal Shakti, Govt of India, under the Department of Water Resources, River Development & Ganga Rejuvenation. In this scheme, funds are provided to the State Government/ Local Bodies for pollution mitigation. Under this scheme, one Waste Stabilization Pond with 8 MLD capacity was built for the treatment of the sewage carried from the New Bhopal area by the Panchsheel Nallah, which leads to Shahpura Lake. The interception was done near the Patrakar Colony to a sewage line and then to WSP of the size 255 m X 140 m and the retention time of 5 days.

**3.2.5 Directorate of Town and Country Planning**

DTCP is responsible for the Bhopal Development Plan (BDP). In the BDP 2005, about 6225 ha of land was earmarked for recreational purposes. Through this, parks adjoining the Shahpura Lake, namely Shahpura and Ekant Park, were developed.

**3.2.6 Environmental Planning & Coordination Organization (EPCO)**

EPCO was established in 1981 by the Housing and Environment Department of the Govt of Madhya Pradesh. It is now under the Urban Development and Environment Division. In 2007-2008, 88.26 lacs and in 2013-2014, 50 lakh for the Shahpura Lake was given to BMC for its conservation and maintenance.

**4. Discussion**

Irrigation was the primary designated use of this reservoir water, but gradually, after 1975, fisheries, Aquaculture, and recreational activities were also promoted (Munoth & Nagaich, 2015). Earlier, Shahpura Lake used to receive untreated sewage and wastewater from the Eastern, Northern and Southern parts of the lake (Wani and Dixit 2018). Areas adjoining the Shahpura Lake are also sensitive and prone to floods and water logging during the rainy seasons. Urban developmental activities may cause changes in the natural drainage of an area. Substantial rainfalls can cause floods in low-lying areas. Stormwater from the New Bhopal area, which is located in the central region of Bhopal city, is drained into the Shahpura Lake through the 8 km long Katsi Nallah. The excess water from the Shahpura Lake during the heavy rains flows through the spill outlet behind the Bansal Hospital and meets the *Kaliasote River*, which ultimately drains into *River Betwa*.

To solve the problem of untreated sewage water entering the Shahpura Lake, a waste Stabilization/Oxidation Pond was constructed in the North of the Shahpura Lake. This was done to prevent the sewage from the Panchsheel Nalla from directly entering the lake. The sewage treated at the STP located at Mata Mandir enters the Panchsheel Nalla through the Anjali Nalla and ultimately enters the Shahpura Park. Under the AMRUT (2015) scheme, a focus has been placed on sewage treatment and management in and around Shahpura Lake. It is expected that the sewage load of the lake will now be reduced. Metallic fencing around the lake has been done to prevent the dumping of solid waste and idols into the lake. Dixit & Tiwari (2007) found that following immersion of idols, there was an increase seen in the physic-chemical parameters like the pH and hardness and heavy metals like Cr, Ca and Pb. Vyas et al. (2007) also observed increased levels of heavy metals in the water of the upper lake after idol immersion. To overcome this, a separate area has been earmarked for the dispersal of idols during religious festivals (**Fig. 3**). All these interventions have contributed to some improvement in the lake water quality, as visible in Table 4. The pH of lake water is within the permissible limit of 6.5-8.5 as specified in the CPCB's designated best-use water quality for class D (Propagation of wildlife and fisheries). Improvement in DO and BOD is still needed. As fisheries are done in Shahpura Lake for human consumption, regular monitoring of fish should be undertaken. It is not enough to restrict human activity; we should also focus on dissolved contaminants and nutrient enrichment. Urbanization and population growth create pressure on available resources, including water. Chen et al., 2025 found that accelerated urbanization was one of the factors that caused a reduction in Dianchi Lake, China. Nur et al. (2024) also found that anthropogenic activities have impacted the water quality of Lake Victoria and that specific pollution control measures, along with regular monitoring, should be undertaken to prevent further deterioration of the water quality. There is a direct correlation between sewage, agricultural waste, and industrial effluent generation. To overcome this, proper urban planning (including sewage and effluent treatment) is very critical to ensure that the remaining urban water bodies' health is restored and maintained.

**5. CONCLUSION**

The study highlighted that it is of utmost importance that water resources be conserved in a water-stressed nation. It is also important that all the stakeholders come together, as concerted efforts are needed on everyone's part. The physicochemical parameters reveal that there is a need to reduce the nutrient load (nitrogen and phosphorus) and also the organic load. Regular biological monitoring may also be adopted to assess the lake water quality, as their presence is dependent on and is a reflection of the total changes in the physicochemical parameters. There is a need for further research to understand the complex interactions between urban development and lakes. As each lake has unique characteristics, measures for conservation may be specific, too.

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