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# Study of Water Quality of River Sabarmati and its Tributaries

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**Abstract**

The main goal of the present study is to assess the impact of urbanization on river water quality in the study area, i.e Sabarmati river basin,India. Ahmedabad city (23 02' N. 72 36E) on the bank of river Sabarmati in the state of Gujarat, India is the centre of Industrial activities in Gujarat. About 85% of the large and 87% of medium scale industrial units of the Sabarmati river basin are located in the city Ahmedabad. The population of the city occupies a metropolitan area, and has been growing at a very rapid rate during the past few decades. The Sabarmati river is dividing the city in two parts. Since major storm water outlets discharges sewage and industrial waste waters in the river, and in the light of spread of urban area, this study has been taken up to analyze the changes in river water quality in the Sabarmati river basin.

The work is aimed to examine the Sabarmati river water quality in urbanized area of city of Ahmedabad, and to compare it with river water quality in non-urbanized area on the tributaries of Sabarmati river, namely Meshwo, Khari and Shedhi. Water quality is analyzed for parameter such as pH, Dissolved oxygen, Biological oxygen demand, Chemical oxygen demand, Ammonical nitrogen, and Total Coliforms. The mean values of these parameters are compared with WHO, and Indian standards. Also, the water pollution index for site on main stream near Ahmedabad is compared to the water quality index of the site on tributaries. The result clearly shows that quality of water deteriorates as river flows further in urbanized and industrial area. There is positive correlation between rapidity of urbanization and pollution levels of urban river water. During the urban development process, urbanization and urban and industrial activities had a significant negative impact on the river water quality.

**Key words**: river water quality, water quality index, urbanization.

**Introduction**

**Sabarmati River**

The Sabarmati river is a well- known river in Western India and is approximately 371 Km in length. The Sabarmati river starts its journey in the Aravalli Range of Udaipur district in Rajasthan. In the beginning of the course, it is also known as Wakal River. The majority course of the river flows in the state of Gujarat, India.

**Sabarmati River Pollution Status**

The river is one of the most polluted rivers in the country although it is the lifeline of the State of Gujarat. The river is in a very serious state and deserves urgent attention. About 85% of the large and 87% of medium scale units of the basin are located in Ahmedabad. Besides this there are thousands of small scale industries (SSI) units engaged in diversified products mostly concentrated in various industrial areas like Naroda, Odhar, Vatva, Pilas and Chandola etc. All these industries are discharging their waste waters downstream (d/s) of Sabarmati Ashram . The river Sabarmati u/s of Ahmedabad city to Sabarmati Ashram and from Sabarmati Ashram to Vautha have been identified as polluted stretches. The immense urban and industrial growth combined with growing demand of irrigation water has taken their toll as observed by the deteriorating water quality recorded particularly from Ahmedabad city to Vautha. The total length of the stretch from Ahmedabad city to Vautha is of 52 km and in the polluted river stretch; the main contributing outfalls are the Maninagar (mixed effluent) and river Khari (industrial).

The study is aimed to examine the Sabarmati river water quality in urbanized area of city of Ahmedabad, and to compare it with river water quality in non-urbanized area on the tributaries of Sabarmati river, namely

Meshwo, Khari and Shedhi. The water quality index for site on main stream near Ahmedabad is compared to the water quality index of the site on tributaries.

**Study area**

Four stations are considered for the study. The Sabarmati river flows from the state of Rajasthan and enters the state of Gujarat. Khari, Meshwa, and Shedhi are tributaries of Sabarmati. The map of river Sabarmati along with the stations considered for study is shown in figure.1

**Station details**:

S-1 (Shedhi): Shedhi at Kheda, Gujarat.

S-2 (Meshwa): Sabarmati after confluence with Meshwa at Vautha (near Dholka),Gujarat

S-3 (V N Bridge): Sabarmati at Ahmedabad at V.N. Bridge,Gujarat

S-4 (Khari): Khari at Lali village near Ahmedabad

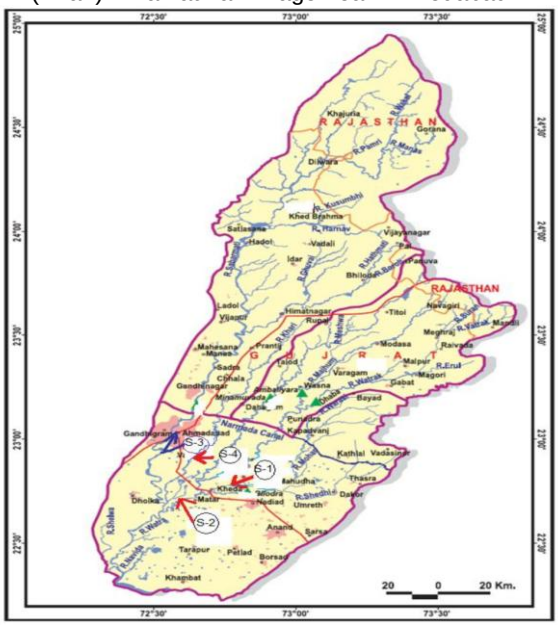



**Figure.1 Map showing River Sabarmati and tributaries Meshwa, Shedhi and Khari**.

**Selection of Indicator Parameters**

The water quality parameters viz. pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonical Nitrogen, Total Coliform, considered as indicator parameters of surface water quality in the present study. The basis of selecting these parameters is the reports of CPCB indicating high organic pollution in river Sabarmati.

**Effect of pH**

Since most of the human body consists of (50-60%) water, the pH level has profound effect on all body chemistry, health and disease. All regulatory mechanism (including breathing, circulation, digestion, hormonal production) serves the purpose of balancing pH. If pH is less assimilation of vitamins or minerals is not possible, enzymes are deactivated; digestion does not take place properly. An alkaline pH causes the water taste as bitter or soda like taste. Very low pH in the range affects the fish reproduction.(Avvannavar & Shrihari 2007, Leo & Dekkar,2000).

**Effect of dissolved oxygen**

The dissolved oxygen (DO) concentration present in water reflects atmospheric dissolution, as well as autotrophic and heterotrophic processes that respectively, produce and consume oxygen. DO is the factor that determines whether biological changes are brought by aerobic or anaerobic organisms. Thus, dissolved oxygen measurement is vital for maintaining aerobic treatment processes intended to purify domestic and industrial wastewaters. Presence of DO ensures healthy aquatic life in a water body (Sawyer et al. 1994,Leo and Dekkar 2000, Burden et al. 2002, De 2003).

**Effect of Bio Chemical Oxygen Demand**

Biochemical Oxygen Demand determines the strength in terms of oxygen required to stabilize domestic and industrial wastes. For the degradation of oxidizable organic matter to take place minimum of 2 to 7 mg/l of DO level is to be maintained at laboratory experimentation or should be available in the natural waters (De 2003).

**Effect of Chemical Oxygen Demand**

The COD is a measure of oxygen equivalent to the organic matter content of the water susceptible to oxidation and thus is an index of organic pollution in river. Level of organic matter in treated water provides an indication of the potential for regrowth of heterotrophic bacteria in reservoirs and distribution systems. Organic matter is measured by BOD, COD or Total Organic Carbon (TOC).

**Effect of Ammonical Nitrogen**

Ammonical Nitrogen in water is an indicator of possible bacterial, sewage and animal waste pollution. Ammonical Nitrogen in water originates from agricultural runoff and industrial waste, sewage treatment effluent. It is a major component of the metabolism of mammals. If ammonium nitrogen levels in surface waters are too high, they can be toxic to some aquatic organisms. If the levels are only moderately high, plant and algal growth will usually increase due to the abundance of nitrogen available as a nutrient.

**Effect of micro–organisms**

In drinking water micro-organisms can cause sensory defects (odor, color, taste). Microorganisms are an important cause of the corrosion of steel pipes. Various health related problems due to contaminated waters are diarrhea, abdominal cramps and vomiting due to salmonella, cholera is due to vibro cholerae, infection of lungs due to mycobacterium (Leo and Dekkar 2000).

**Methodology**

In view of the importance of above parameters as indicators for the measurement of water quality index, the data from year 2003 to the year 2008 have been made available for various stations namely, Shedhi, Meshwa, V. N. Bridge and Khari from Central Pollution Control Board (www.cpcb.nic).Table.1 gives the yearly average data for concentration of Parameters at these 4 Stations along the Sabarmati river. These are graphically represented in figure 2 to figure 7. Also figure 8 shows the comparision of concentration of various parameters at all stations for different years.

**Water Quality Index**

Several reports on river water quality assessment using physico–chemical and biological parameters have been published elsewhere[2].

Different water quality parameters are expressed in different units. For example temperature is expressed in degree Celsius, coliforms in numbers and most chemicals in milligram per litre etc. In other words different parameters occur in different ranges are expressed in different units, and have behaviour in terms of concentration–impact relationship. Before an index can be formulated all this has to be transformed into a single scale. Some index scales have the range 0–100. The water quality index is a unitless single dimensional number between 0 to 100 (Avvannavar & Shrihari 2007). A higher index value represents good water quality (Pandey & Sundaram 2002, Cude 2001). Therefore a numerical index is used as a management tool in water quality assessment. In this study, the method for calculating water quality index is modified version of index calculation as suggested by Tiwari and Mishra (1985), Ashwani Kumar and Anish Dua (2009).

**Weight Assigned and Rating Scale**

Weighing means the relative importance of each water quality parameter that play some significant role in overall water quality and it depends on the permissible limit in drinking water set by National and International agencies viz., World Health Organisation (WHO),Indian Standards IS-10500, etc.(ISI 1991) . For parameters such as pH (7.0 – 8.5) and DO ( > 5 mg/l) the limits are considered as per the guidelines set by the above agencies. For BOD (< 3 mg/l) and Total Coliform (MPN/100 ml <500), reference is made to primary water quality criteria for various uses of fresh waters as laid down by the Central Pollution Control Board (CPCB) considering the desired class- B & C of Sabarmati river as per use- based classification given by CPCB (CPCB, ADSORBS/3: 1978–1979). For parameters such as COD and Ammonical – Nitrogen, whose drinking water guidelines are not specified by WHO and IS, reference is made to treated effluent disposal standards of CPCB. Surface water treated effluent disposal standards IS-general standards for discharge of environmental pollutants Part-A specifies COD limit of 250 mg/l and Ammonical Nitrogen limit of 50 mg/l . Assuming about 6 times dilution in surface water body, a COD value of 40 mg/l and Ammonical Nitrogen value of 8 mg/l is considered for weightage division (Table 2).Those parameters, which have low permissible limits and can influence the water quality to a large extent even fluctuate a little, allocate high weighing while parameter having high permissible limit and are less harmful to the water quality allocate low weighing (Ashwinikumar & Anish Dua,2009). After allocation of weight, the unit weight for each parameter was calculated by the following formula.

Therefore, $W_i \propto 1 / S_i$ or $W_i = k / S_i$ .....(1)

Value of K was calculated as:

$$K = 1 / \sum_{i=1}^{6} 1 / Si \quad \text{..... (2)}$$

Where, K = constant of proportionality
Wi = unit weight of parameter.
Si = maximum permissible limits of the parameter.

**Rating Scale**

Rating scale (Table 3) was prepared for range of values of each parameter. The rating varies from 0 to 100 and is divided into five intervals. The rating scale ($S_r$) = 0 implies that the concentration of the parameter in water remained exceeded by the standard maximum permissible limits and water is highly polluted, the rating scale ($S_r$) = 100 denotes the excellent water quality since the parameter remained within the prescribed permissible limit for drinking water. The other ratings fall between these two extremes and are $S_r$ = 40, $S_r$ = 60 and $S_r$ = 80 standing for excessively polluted, moderately polluted and slightly less polluted respectively. This scale is modified version of rating scale given by Tiwari and Mishra .

**Water Quality Index (WQI) calculation**

Water Quality Index is equal to the sum of product of rating ($S_r$) and unit weight (Wi) of all the factors. Based on the value of WQI obtained, the river water quality can be judged (Table 4).

$$WQI = \sum_{i=1}^{6} (Wi \times Sr)$$

The WQI at various stations have been computed and shown in Table.5. Figure 9 represents the same in graphical form

**Table. 1 Yearly average data for concentration of Parameters at Stations:**

| Parameters* | | | | | | |
|---|---|---|---|---|---|---|
| **STATION** | BOD | **COD** | **DO** | **pH** | **Ammonical Nitrogen** | **Total Coliform MPN /100ml** |
| 2003 | | | | | | |
| Shedhi | 20.6 | 101.3 | 11.5 | 8.5 | 1.013 | 79395 |
| Meshwa | 80.0 | 346.1 | 3.7 | 7.6 | 26.880 | 607530 |
| v n bridge | 130.5 | 391.8 | 6.1 | 7.1 | 27.907 | 1588627 |
| Khari | 958.8 | 662.4 | - | 7.6 | 104.610 | 12783333 |
| 2004 | | | | | | |
| Shedhi | 9.4 | 58.0 | 7.1 | 8.0 | 4.480 | 1158 |
| Meshwa | 48.5 | 218.0 | 3.0 | 7.7 | 22.400 | 45598 |
| v n bridge | 100.3 | 793.0 | 2.8 | 7.2 | 29.120 | 81201 |
| Khari | 229.0 | 626.0 | 5.0 | 8.0 | 109.760 | 574500 |
| 2005 | | | | | | |
| Shedhi | 5.0 | 29.0 | 6.0 | 7.63 | 1.11 | 12438 |
| Meshwa | 41.3 | 76.0 | 3.5 | 7.40 | 10.06 | 450208 |
| v n bridge | 110.6 | 41.0 | 5.4 | 7.02 | 7.42 | 285678 |
| Khari | 112.5 | 43.0 | 4.9 | 7.50 | 1.78 | 862500 |
| 2006 | | | | | | |
| Shedhi | 6.7 | 20 | 5.6 | 8.14 | 0.75 | 443 |
| Meshwa | 55.8 | 168 | 0.5 | 7.8 | 15.68 | 495813 |
| v n bridge | 115.1 | 825 | 2.3 | 7.34 | 14.98 | 1590900 |
| Khari | 30.7 | 148 | 4.2 | 7.91 | 9.73 | 552500 |
| 2007 | | | | | | |
| Shedhi | 2 | - | 3.7 | 7.2 | 1.1 | 7500 |
| Meshwa | 20.6 | - | 2 | 7.4 | 4.4 | 5982.9 |
| v n bridge | 34.3 | 78 | 3.3 | 7.6 | 6.2 | 3765 |
| hari | 19 | - | 5.3 | 7.3 | 0.6 | 15000 |
| 2008 | | | | | | |
| Shedhi | 14.25 | 42.88 | 8.14 | 7.9 | 0.5 | 23.5 |
| Meshwa | 57.63 | 54.63 | 5.1 | 7.74 | 11.7 | 6263.6 |
| v n bridge | **210** | 365 | 0 | 7.6 | 23.52 | 1500 |
| Khari | **36.67** | 31.85 | 3.29 | 7.92 | 7.3 | 22550 |
| * All parameters are in mg/l except pH and Total Coliform | | | | | | |

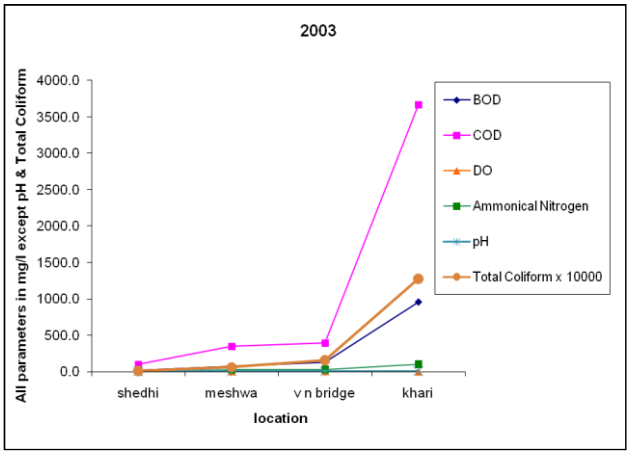



**Figure. 2 Chart showing concentration of parameters for stations for year 2003.**

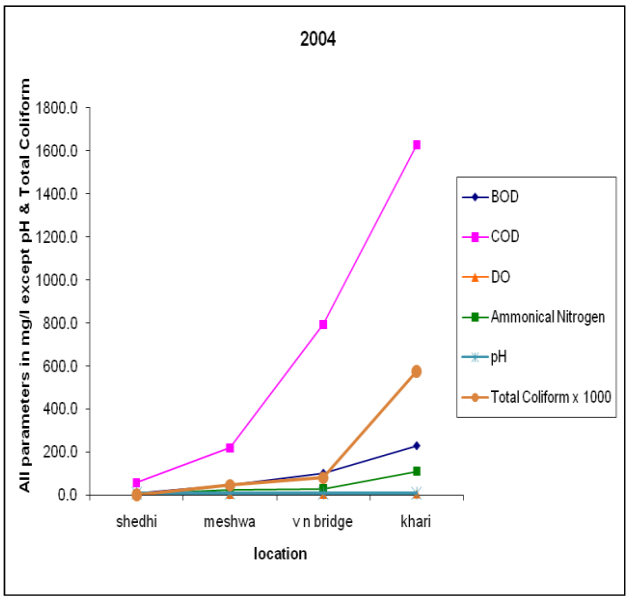



**Figure. 3 Chart showing concentration of parameters for stations for year 2004.**

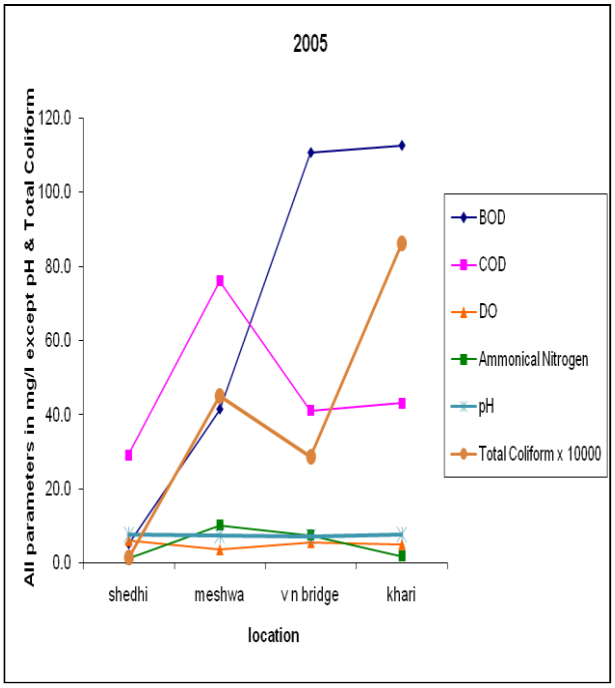



**Figure. 4 Chart showing concentration of parameters for stations for year 2005.**

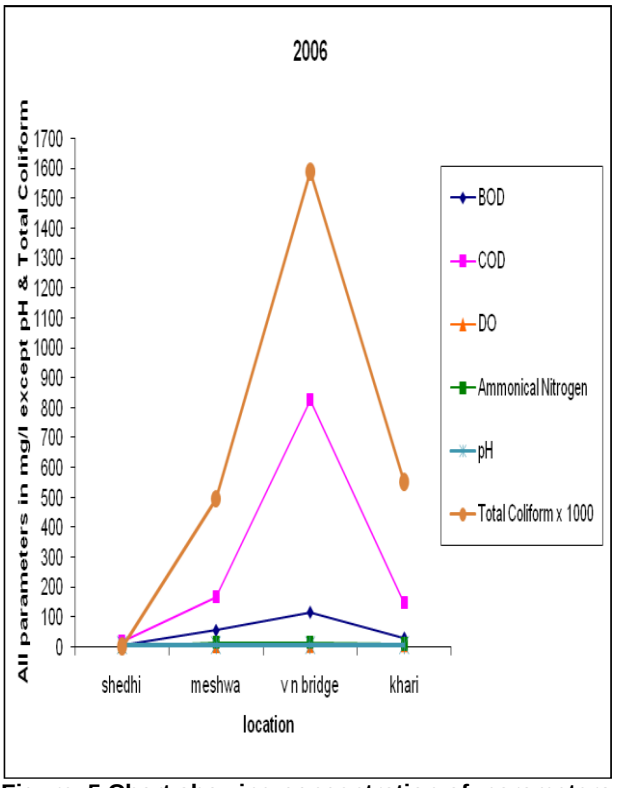



**Figure. 5 Chart showing concentration of parameters for stations for year 2006**

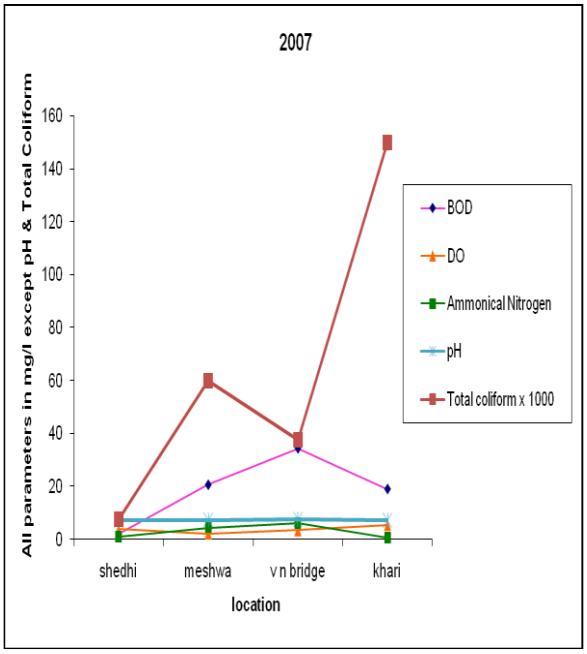



**Figure. 6 Chart showing concentration of parameters for stations for year 2007**

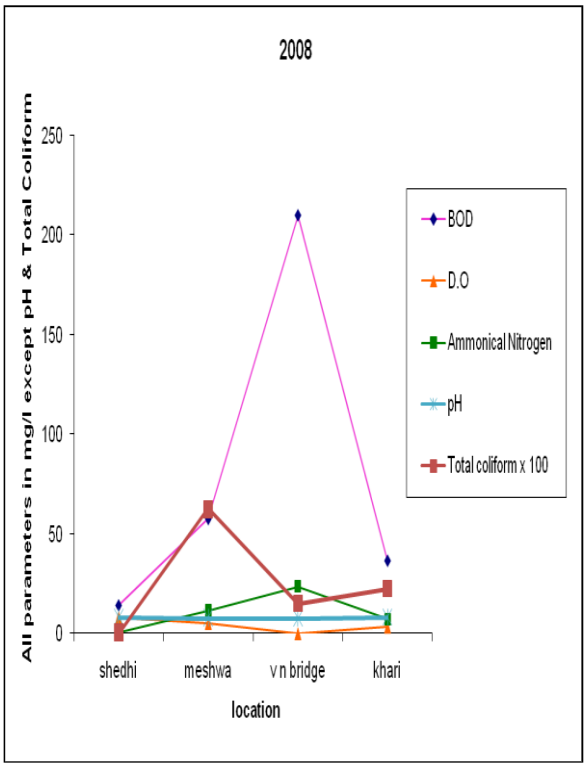


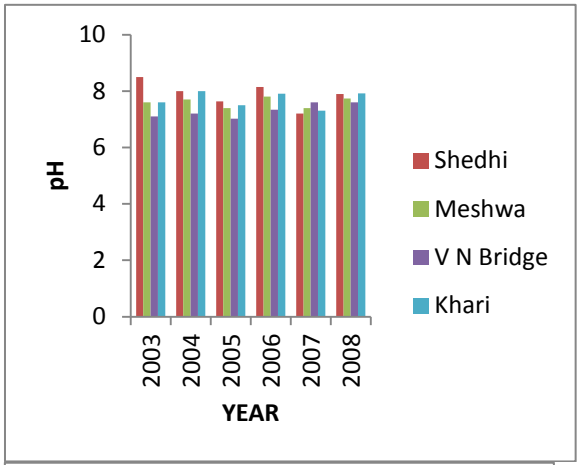

**Figure. 7 Chart showing concentration of parameters for stations for year 2008**

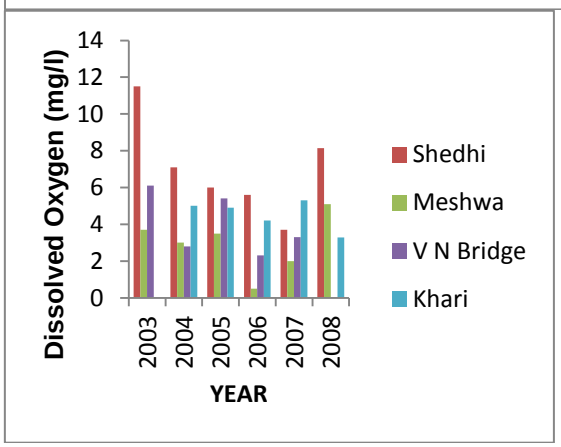
**Table.2 Water quality parameters and their assigned unit weights**

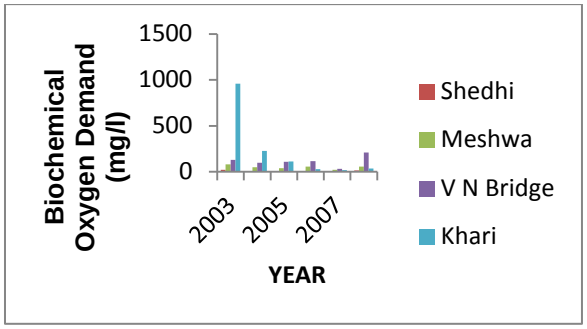
| Parameter | Unit weight |
|---|---|
| pH | 0.147 |
| DO (mg/l) | 0.249 |
| BOD (mg/l) | 0.415 |
| COD (mg/l) | 0.031 |
| Ammonical Nitrogen (mg/l) | 0.156 |
| Total Coliform (MPN/100 ml) | 0.002 |

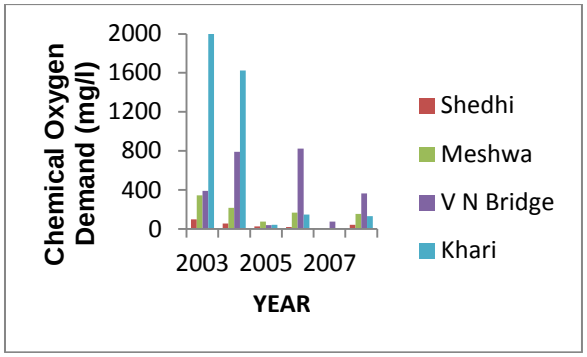
**Table.3 Rating Scale for Calculating WQI**

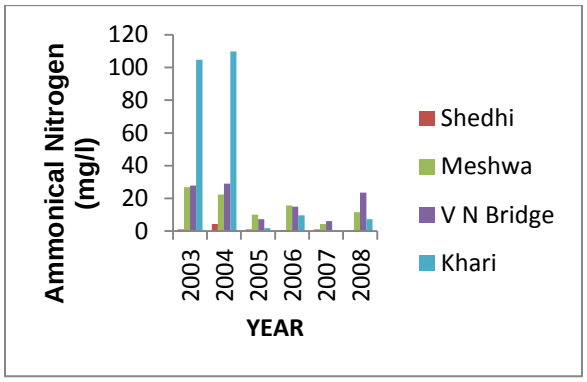
| Parameter | Ranges | | | | |
|---|---|---|---|---|---|
| pH | 7-8.5 | 8.6-8.7<br>6.8-6.9 | 8.8-8.9<br>6.7-6.8 | 9.0-9.2<br>6.5-6.7 | >9.2<br><6.5 |
| DO (mg/l) | >5.0 | 4.0-5.0 | 3.5-4.0 | 3.0-3.5 | <3 |
| BOD (mg/l) | 0-3.0 | 3.0-6.0 | 6.0-80.0 | 80.0-125 | >125 |
| COD (mg/l) | 0-40 | 40-250 | 250-500 | 500-1000 | >1000 |
| Ammonical Nitrogen (mg/l) | 0-8.0 | 8.0-50 | 50-100 | 100-200 | >200 |
| Total Coliform (MPN/100 ml) | 0-500 | 500-1000 | 1000-5000 | 5000-100000 | >100000 |
| $S_r$ | 100 | 80 | 60 | 40 | 0 |
| Extent of pollution | Clean | Slight pollution | Moderate pollution | Excess pollution | Severe pollution |



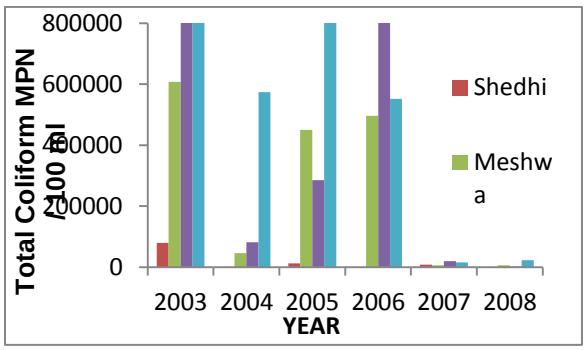




Figure 8 Comparision of concentration of parameters at all Stations.

**Table.4 Water Quality based on WQI**

| Value of WQI | Quality of Water |
|---|---|
| 90-100 | Excellent |
| 70-90 | Good |
| 50-70 | Medium |
| 25-50 | Bad |
| 0-25 | Very Bad |

**Table. 5 Average WQI for all stations**

| Station | WQI |
|---|---|
| Shedhi | 82.8 |
| Meshwa | 53.6 |
| V. N. Bridge | 47.2 |
| Khari | 45.7 |

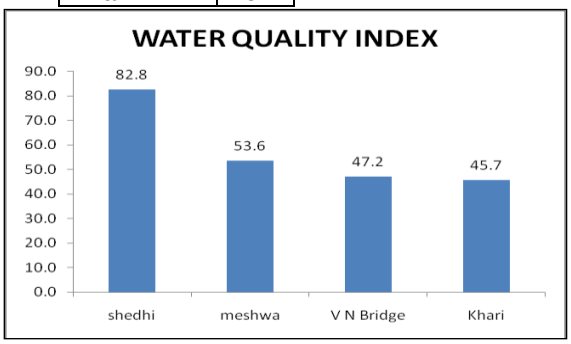



Figure 9 Average Water Quality Index for Stations**.**

**Results and Discussion**

1. The following points are observed from Figure 2 to Figure 7 :

- The concentration of parameters such as BOD, COD, Ammonical Nitrogen and Total Coliform are lowest for all the years at the monitoring station Shedhi which is located in non -urbanised area. Also, the values of pH are within the WHO limits at Shedhi and values of dissolved oxygen are high for all the years.
- The concentration of parameters BOD,COD, Ammonical Nitrogen and total Coliform are high for all the years at the monitoring station Meshwa and V.N. Bridge which are located in moderately urbanised area and in Urban area in Ahmedabad, respectively. The values of pH are also within the WHO limits for these stations.The values of dissolved oxygen are moderate at Meshwa and at V N Bridge.
- The concentration of parameters BOD,COD, Ammonical Nitrogen and total Coliform are high for all the years at the monitoring station Khari because it is located in an industrial area of the sabarmati river basin. Also the pH are within WHO limits and values of dissolved oxygen are moderate.

  Figure 8 also reveals the same pattern of the concentration of parameters through Bar-chart.

2. Figure 9 shows the water quality index of the river water at each monitoring stations located on the Sabarmati river.It is found that WQI at monitoring station Shedhi, located in non-urbanised area, is 82.8 which indicates good water quality as per table 4. While WQI value lowers to 53.6 at station Meshwa, which is located in moderately urbanised area which according to table 4 indicates Medium water quality.The WQI at station V N Bridge, which is located in the Ahmedabad city i.e, urbanised area is still lower, 47.2. This indicates bad water quality as per table 4. The WQI at station Khari located in an industrialised area is lowest, 45.7, which indicates bad water quality as per table 4.

**Conclusion**

The water quality parameters like pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonical Nitrogen, Total Coliform, considered as indicator parameters of water quality of Sabarmati river.The Sabarmati river water quality in urbanized area of city of Ahmedabad is found more deteriorated compared with river water quality in non-urbanized area on the tributaries of Sabarmati river. This indicates that there is a positive correlation between the Urbanisation and surface water quality. The water quality at industrialized area is found worse due to the industrial waste water discharges into the Sabarmati river.

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