Health hazards due to pollution of rivers assessed by population in Nasik and Solapur districts of Maharashtra

Interim Report prepared by

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Abstract

Environmental contamination by different toxic chemicals has become a major concern around the world today. There are numerous hazards of water pollution with an array of health problems such as cholera, diarrhoea, typhoid, etc. and others like various diseases of the nervous system and skin. This study originated with reference to the increased waterborne disease in Maharashtra as per report of Public Health Department and said report referred by Auditor General and their assessment of civil report 2005. In view of this, it is proposed to conduct health studies in the catchment area of River Bheema, Ujani dam, Solapur and Godavari river in Nashik. The study primarily aims at exploring the correlation between the water quality and waterborne disease outbreaks during the reference period 2006 to 2011. Data from SPHL/DPHL was used to assess the excess (more than permissible limit) of both household and chemical waste in water and its likely health effects. Principal component analysis correlated with three parameters, namely Biochemical Oxygen Demand (BOD), Faecal Coliform and Dissolved Oxygen (DO) suggests that increase in BOD and Faecal Coliform and lack of Dissolved Oxygen in the water.

I Background

Water is an essential element for life without which living being cannot survive. With environmental degradation and pollution, this most required resource is getting polluted. Water pollution is the contamination of water bodies such as lakes, rivers, and groundwater. One of the main reasons of water contamination is pollutants getting discharged directly or indirectly into water bodies without adequate required processing or treatment to remove its harmful constituents. Water from such sources cannot serve to humans and natural biological communities. There are numerous hazards of water pollution with an array of health problems. To list a few, the waterborne disease like cholera, diarrhoea, typhoid, etc. and others like various diseases of the nervous system and skin.

The Millennium Development Goals (MDGs) – the framework that has been a key part of efforts to build a better world for the past 15 years – challenged the global community to reduce by half the proportion of the population without safe drinking water and basic sanitation (WHO 2015).

As many as 220 million Indians do not have access to safe drinking water. About 86 percent of total communicable diseases in the country are directly and indirectly related to the poor quality of drinking water, which is a major cause of diseases including jaundice, typhoid and diarrhoea (UNICEF 2008). As per World Health Organization (WHO) estimates, 3.4 million people, mostly children die every year due to diseases arising because of water (WHO 2007).

It is estimated that around 37.7 million Indians are affected by waterborne diseases annually, 1.5 million children are estimated to die of diarrhoea alone and 73 million working days are lost due to the waterborne disease each year.

Hence, it is utmost important to focus on understanding the magnitude of the water pollution along with its various pathways and its health hazards.

Justification:

There are various mechanisms to ensure water quality, however, the quality of drinking water has been an issue of concern. This proposal originated with reference to the increased water borne disease in Maharashtra as per report of Public Health Department and said report referred by Auditor General and their assessment of civil report 2005. Wherein, it was recorded, that the increase in water borne diseases is the result of improper or no treatment of effluent by respective stakeholders e.g. Local bodies and industries. In view of this, it is proposed to conduct health studies in the catchment area of River Bheema, Ujani dam, Solapur and Godavari river in Nashik.

It is thus necessary to explore the factors affecting the rise of waterborne disease cases in the state by designing a systematic study. The study is proposed to be conducted in two phases using both primary and secondary sources of data.

Phase I would be based on secondary data to understand the correlation between water quality and diseases profiling through mapping, risk analysis and trends in waterborne diseases. Phase II would be based on the primary data including water sample testing at various places along with the interviews of the inhabitants in the selected areas.

II) Current mechanisms for ensuring water quality:

Maharashtra Pollution Control Board (MPCB), being the state nodal agency under Central Pollution Control Board (CPCB), monitors and documents data for water quality under two programs of NWMP (National Water Quality Monitoring Program) titled GEMS (Global Environment Monitoring System) and MINARS (Monitoring of Indian National Aquatic Resources) under these there are a totals of 250 WQMS (Water Quality Monitoring Stations), the highest among all states and Union Territories in India.

Out of these stations, 156 are on rivers, 34 on sea/creeks, 10 on drains and 50 for ground water. These monitoring program analysis the water samples for 9 core quality parameters including pH, BOD (Biochemical Oxygen Demand), Nitrate, Fecal Coliform, Total Coliform and 19 general parameters like turbidity, COD (Chemical Oxygen Demand), Magnesium, Sulphate, Sodium and so on.

b) Department of water supply and Public health department jointly conduct a biannual survey, one during pre-monsoon period and the other post-monsoon. It is a detailed study of each potable water source in each village involving actual water sample examination along with the survey. Results are reported in the grading system. Each examined the water body is graded as low-risk, medium-risk and high-risk with the colour code as Green, Yellow and Red respectively. These results are conveyed to the respective authorities in the meetings and Gramsevak of the respective villages has to take urgent compliance for the same.

c) Similarly, under Public health department, State Public Health Labs (SPHL) also undertake to test the sample from various water bodies and provides the remarks based on the quality of water.

III) Objectives and Methodology of the study:

The study primarily aims at exploring the correlation between the water quality and waterborne disease outbreaks (incidences and deaths) during the reference period 2006 to 2011. However, in order to have a more comprehensive picture, during phase I, secondary data analysis will be performed on available data from 2006 till 2015.

The specific objectives of the study are

Objectives:

Phase I:

1. To identify all possible point and non-point sources of water pollution, nature and regions with high concentration of water pollution and waterborne diseases. (Assessed by Public health labs/MPCB/ other Surveys) in a given reference period in Solapur district of Maharashtra
2. To evaluate water quality trends over a period and to examine the trend of waterborne disease in a given reference period in Solapur district of Maharashtra
3. To examine the relationship between water quality and disease profile in Solapur district of Maharashtra

Phase II:

4. To study the demoFigureic and background characteristics of selected population severely affected by water contamination and are at a high risk of health hazard
5. To study the waterborne disease outbreak pattern in high risk and low-risk water bodies areas in Solapur district of Maharashtra
6. To examine the risks to human health from waterborne diseases caused by pollution of rivers assessed by population in Solapur district of Maharashtra.

Methodology:

The study is conducted in the basins of two prime rivers of Maharashtra; Godavari and Bheema in Nashik and Solapur districts respectively.

Phase I: Study based on secondary data

The first phase is secondary data analysis, to understand the relationship between water quality and waterborne disease outbreaks in the given reference years i.e. from 2006 to 2011 up to 2015.

• Year wise detailed water quality data (from SPHL, Water and sanitation Dept, and MPCB)

• Detailed year-wise waterborne disease outbreaks, sporadic cases and deaths provided by NWBDCP, Public health department, Maharashtra

Data from SPHL/DPHL was used to assess the excess (more than the permissible limit) of both household and chemical waste in water and its likely health effects; and the trend or seasonal variation and the probable level of risk to health.

Phase II: Study based on primary data

Phase II will be based on the primary data collected to establish the linkage between the excess constituent of pollutant in water and its health effects in the selected population. Water will be collected and tested in finite duration, during three seasons to measure and observe the quality of water. Water will be principally collected from geoFigureical location wherever the water is treated or purified. GeoFigureical location will be described either by the radius or by the longitude and latitude of the sampling or measurement site.

To undertake this, first, the mapping of various water bodies and potable water sources will be done to clearly understand about sources of water contamination. Similarly, the sewage water treatment mechanism in these areas will be explored. This will lead to identifying the high-risk and low-risk areas as well as the relationship of sewage discharge in the river and health status of the inhabitants in the close-by areas.

Villages will be grouped as per the distance/vicinity in terms of radius/distance to Bhima river. Then, we will collect the list of villages residing within a closer and farther radius area on the banks of the river. 50 Villages will be selected from each residing within a range and control group residing far away. Villages will be arranged as population size and from this list of villages, 50 villages from case and control group will be selected for our study. A Household survey of the inhabitants residing in the areas from different levels of risk of water pollution would be carried out to affect water pollution. Monitoring of water quality by seasonal variation in chemical constituents will be considered.

The area notified as high, medium and low risk regarding the quality of drinking water and population exposed to those sources. The health camps will be organized in these areas to find out the causes of excess chemical contaminant effects and through the scrutiny, to establish the link between the contamination and health hazard.

We will find the major source of water supply in villages like, well, tube wells, ponds, hand pump, tanks, rivers and municipal taps. The water sample will be collected and send to lab test to examine the level of contamination (if any) and unfit for human consumption. The next step would be to collect water from households used for direct consumption as well as indirect consumption and will be sent for testing to identify the level of contamination.

IV) Progress to date

Analysis of secondary data is in progress. This section gives the detailed analysis, giving trends, and findings from principal component analysis on the quality of water during the period 2007 to 2014 at Bheema river.

Preliminary Analysis

CPCB in collaboration with concerned SPCBs/PCCs established a nationwide network of water quality monitoring comprising 2500 stations in 28 States and 6 Union Territories. The monitoring is done on a monthly or quarterly basis in surface waters and on half yearly basis in case of ground water.

Water samples are being analysed for 28 parameters consisting of 9 core parameters, 19 other physical-chemical and bacteriological parameters apart from the field observations. Besides this, 9 trace metals and 15 pesticides are also analysed in selected samples.

Water Quality Indicators

Water temperature is one of the most important characteristics of an aquatic system, affecting:

• Dissolved oxygen levels. The solubility of oxygen decreases as water temperature increases.

• Chemical processes. Temperature affects the solubility and reaction rates of chemicals. In general, the rate of chemical reactions increases with increasing water temperature.

• Biological processes. Temperature affects metabolism, growth, and reproduction.

• Species composition of the aquatic ecosystem. Many aquatic species can survive only within a limited temperature range.

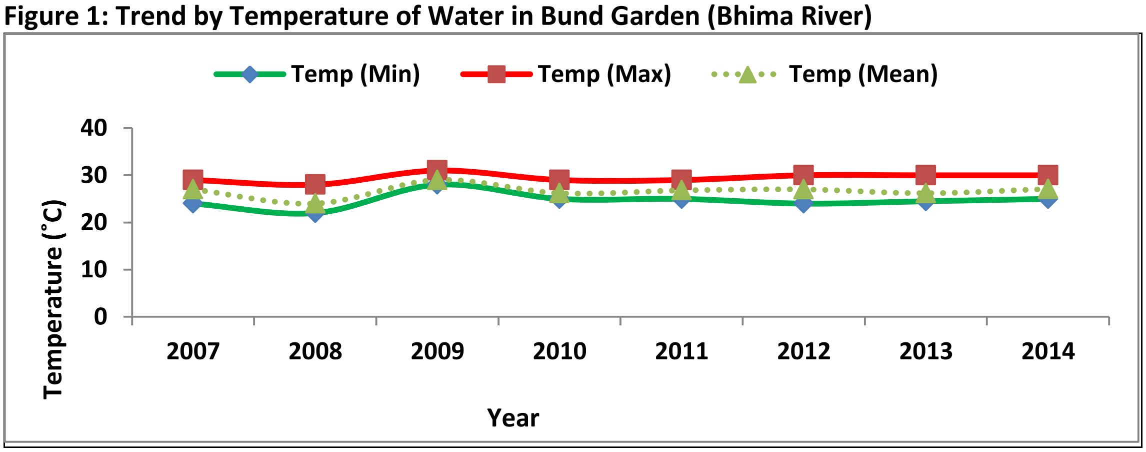
• Water density and stratification. Water is most dense at 4ºC. Differences in water temperature and density between layers of water in a lake leads to stratification and seasonal turnover.

• Environmental cues for life-history stages. Changes in water temperature may act as a signal for aquatic insects to emerge or for fish to spawn.

Water temperature varies along the length of a river with latitude and elevation, but can also vary between small sections only meters apart, depending on local conditions. The temperature of surface water is usually between 0ºC and 30ºC, although the temperature of hot springs may exceed 40ºC.

V) Water Quality Trends by temperature

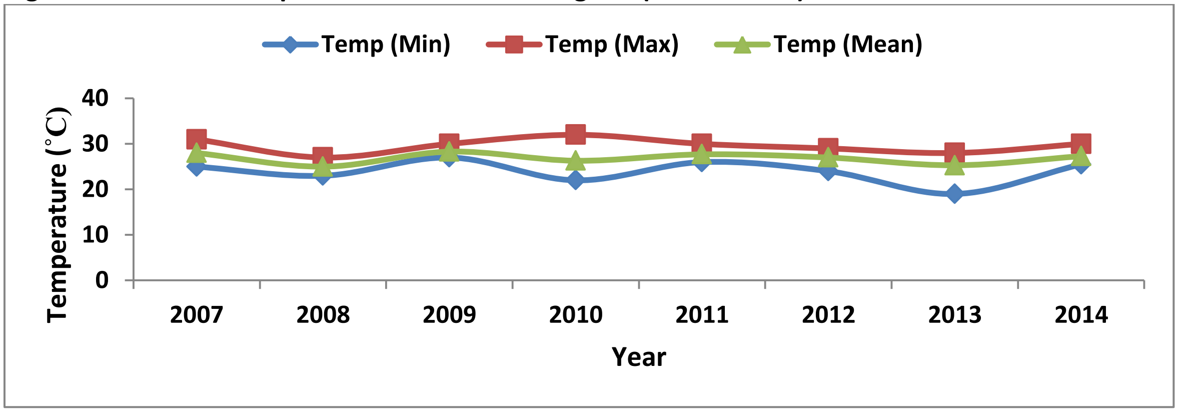
Figure 1: Trend by Temperature of Water in Bund Garden (Bhima River)



Source: Central Pollution Control Board (2007-14); Ministry of Environment, Forest and Climate Change

The above Figure shows the temperature of water in the Bund Garden area of the Bhima river in the range of 22 degree Celsius to 31 degree Celsius. The lowest temperature was recorded in the year 2008 of 22 degrees Celsius and the following year recorded a high of 31 degree Celsius.

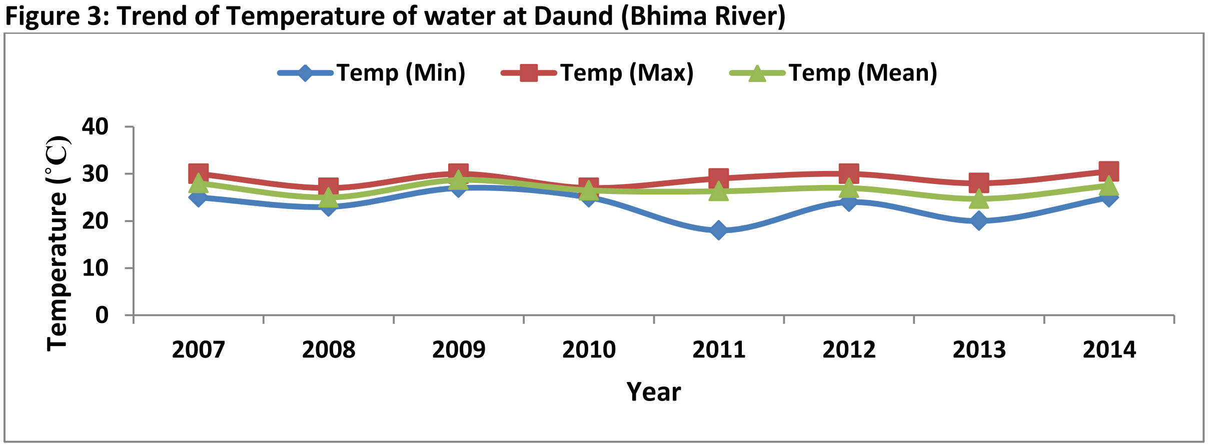
Figure 2: Trend of Temperature of water at Pargaon (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The above Figure shows the temperature of water in Pargaon area of the Bhima river in the range of 25 degrees Celsius to 32 degree Celsius. The lowest temperature was recorded in the year 2013 of 19 degrees Celsius and in the year 2010 recorded a high of 32 degree Celsius.

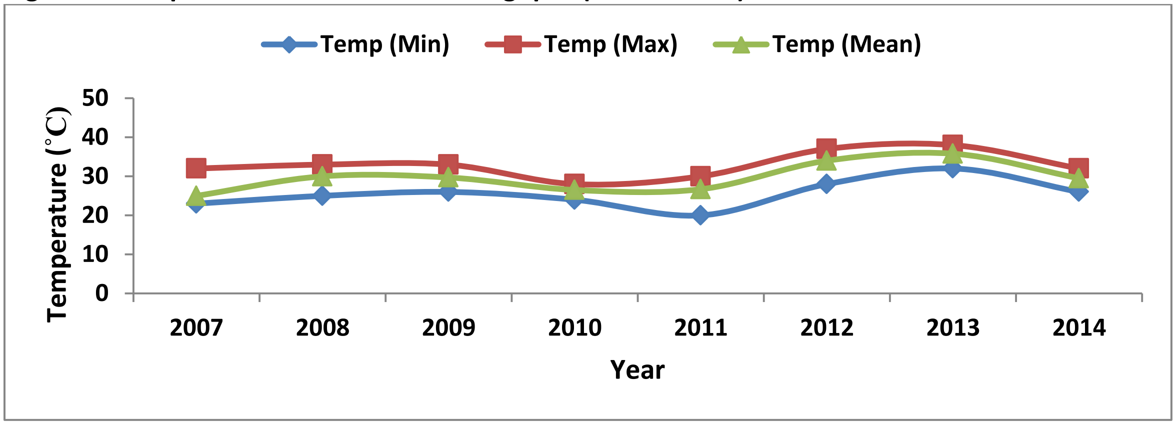
Figure 3: Trend of Temperature of water at Daund (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

Similar to other areas of Bhima river the temperature of the water in Daund, Bhima river was in the range of 18 degree Celsius to 30 degree Celsius with the lowest temperature recorded in the year 2011 of 18 degrees Celsius and in the year 2014 recorded a high of 32 degree Celsius.

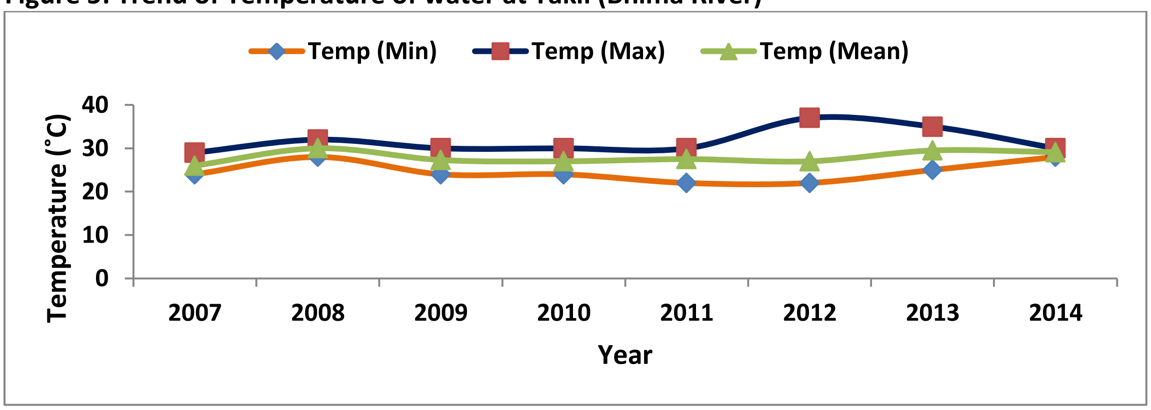
Figure 4: Temperature of water at Narsinghpur (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

As compared to other areas in Bhima river the temperature was a bit higher in the water at Narsinghpur, Bhima river in the range of 23 degree Celsius to 38 degree Celsius. The lowest temperature was recorded in the year 2011 of 20 degrees Celsius and in the year 2013 recorded a high of 38 degree Celsius.

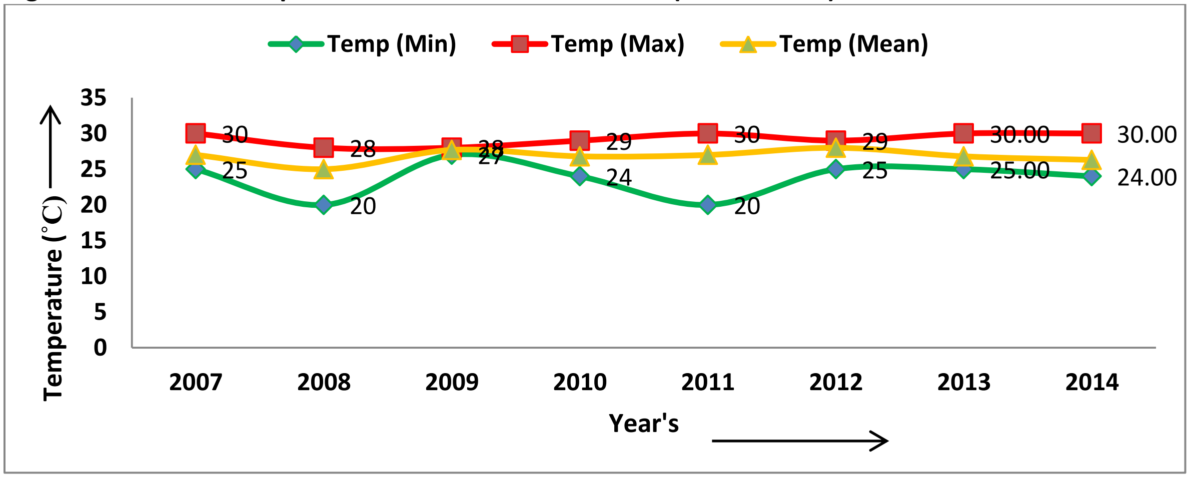
Figure 5: Trend of Temperature of water at Takli (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The above Figure shows the temperature in the water at Takli, Bhima river in the range of 22 degree Celsius to 37- degree CelsiusThe lowest temperature recorded in the year 2012 of 22 degrees Celsius and in the same year recorded a high of 37 degree Celsius.

Figure 6: Trend of Temperature of water at Vithalwadi (Bhima River)



Source: Central Pollution Control Board

The above Figure shows the temperature in the water at Vithalwadi area of the Bhima river in the range of 20 degree Celsius to 30 degree Celsius. The lowest temperature recorded in the years 2008 and 2011 of 20 degrees Celsius and in the years 2007, 2011,2013 and 2014 recoded a high of 30 degree Celsius.

Overall, the temperature of the water was moderate in the range of 18 degree Celsius to 37 degree Celsius and may not act as a catalyst in terms of chemical reaction.

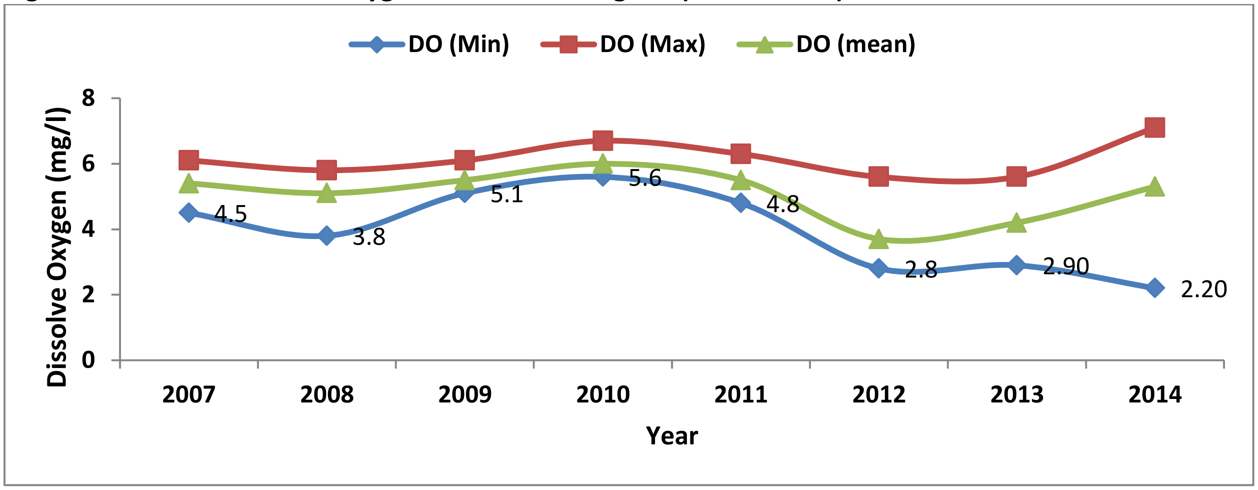
VI Water Quality Trends by Dissolved Oxygen:

Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water.

The actual amount of dissolved oxygen (in mg/L) will vary depending on temperature, pressure and salinity. Water at lower altitudes can hold more dissolved oxygen than water at higher altitudes. As such, dissolved oxygen levels can range from less than 1 mg/L to more than 20 mg/L depending on how all of these factors interact. In freshwater systems such as lakes, rivers and streams, dissolved oxygen concentrations will vary by season, location and water depth.

If dissolved oxygen concentrations drop below a certain level, fish mortality rates will rise. Sensitive freshwater fish like salmon can't even reproduce at levels below 6 mg/L (Carter, 2005).

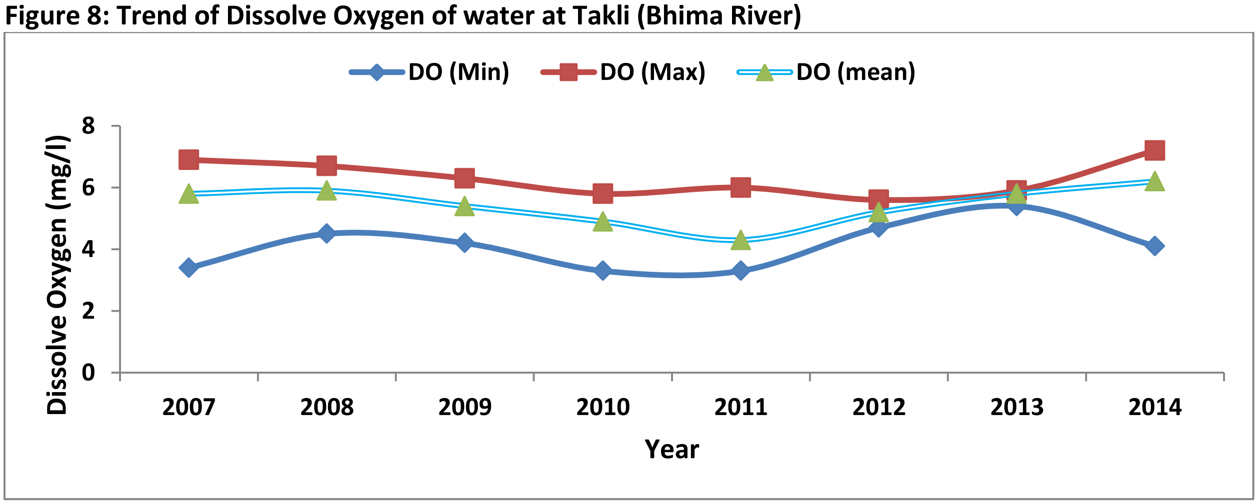
Figure 7: Trend of Dissolve Oxygen of water at Pargaon (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

Figure 7 shows dissolved oxygen with a maximum average value of 6 in the year 2010 to an alarming minimum value of 3.7 in the year 2012 of water in Pargaon, Bhima river. The maximum value of dissolved oxygen was 7.1 in the year 2014 with a minimum value of 2.2 in the same year, which indicates an unfavourable condition for aquatic life in the Bhima river (paragon) during the year 2007 to 2014.

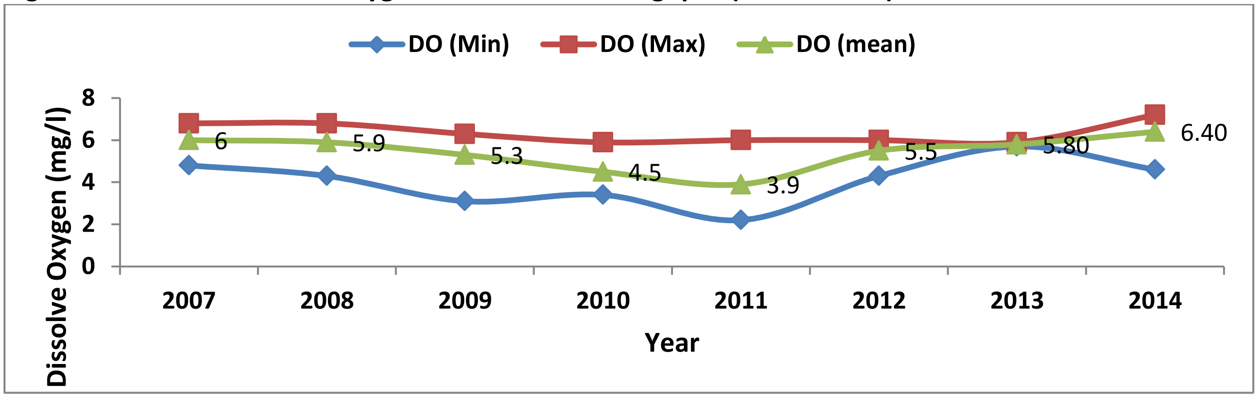
Figure 8: Trend of Dissolve Oxygen of water at Takli (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The trend of dissolved oxygen in the water of Takli, Bhima river shows a maximum average value of 7.2 in the year 2014 to an alarming average minimum value of 3.4 in the year 2007. The average high value of 6.2 in the year 2014 to a minimum value of 4.3 in the same year, which indicates an unfavourable condition for aquatic life in the Bhima river (takli) during the year 2007 to 2014.

Figure 9: Trend of Dissolve Oxygen of water at Narsinghpur (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The mean, maximum and minimum values of dissolved oxygen is 5.8 in the year 2013 of the Bhima river (Narsinghpur). Trend of dissolved oxygen in the water as shown in the above Figure shows a maximum average value of 6.4 in the year 2014 to an alarming minimum value of 3.9 in the year 2011 to a high value of 7.2 in the year 2014 to a minimum value of 2.2 in the year 2011 which indicates an unfavourable condition for aquatic life in the Bhima river (Narsinghpur) during the year 2007 to 2014.

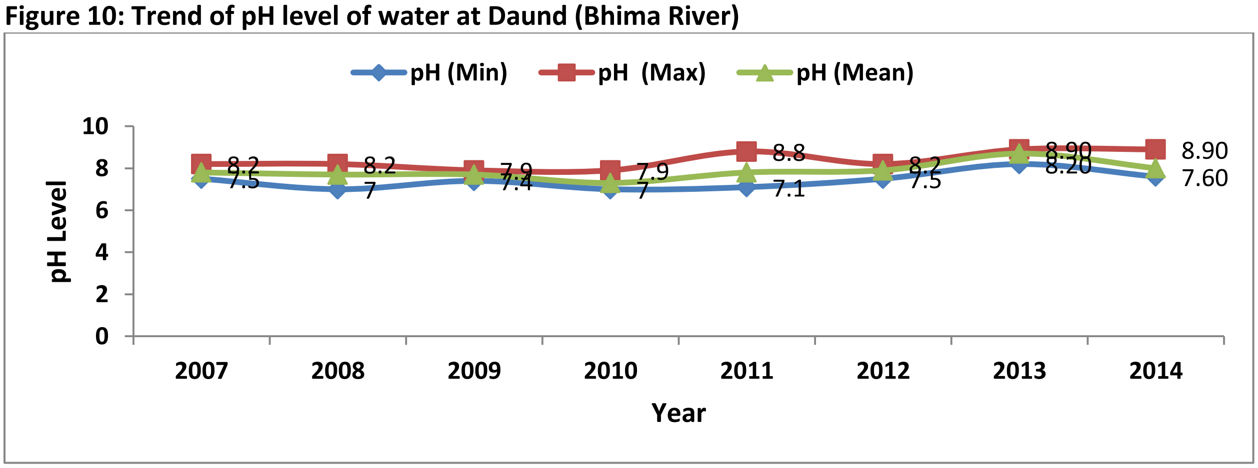
Overall, the values of dissolved oxygen in the water of the Bhima river indicate an unfavourable condition for aquatic life during the period 2007 to 2014. Notably, Vithalwadi and Bund garden side of the Bhima river reported the lowest temperature, which is a unfavourable condition for aquatic life.

VII Water Quality Trends by PH level

The pH of pure water is 7. In general, water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5, and the pH range of groundwater systems is between 6 to 8.5.

The ideal pH level of alkaline ionized water for long term human consumption is between 8.5 and 9.5.

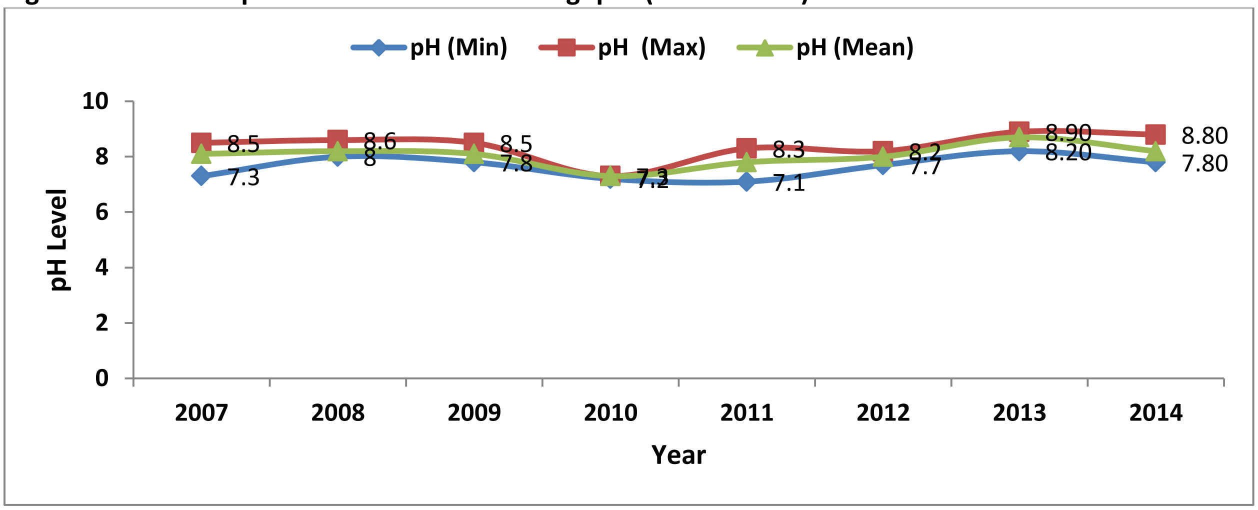
Figure 10: Trend of pH level of water at Daund (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

Values of pH level in the water of Daund, Bhima river as shown in the above Figure is in the range of minimum value of 7 in the year 2008 to a maximum value of 8.9 in the years 2013 and 2014 indicating a normal water. It also indicates pH values does not pose any major risk in consumption of water during the period 2007 to 2014.

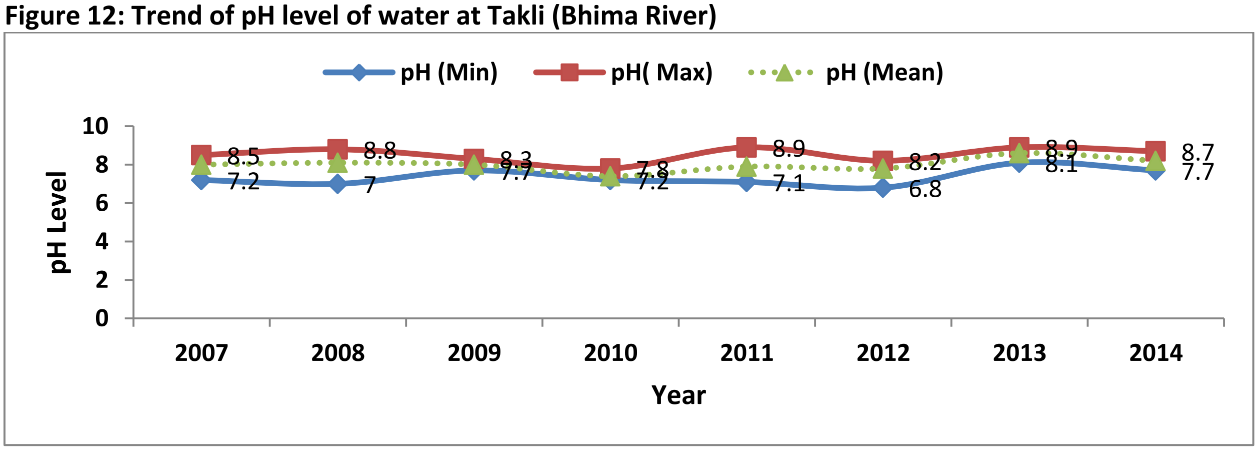
Figure 11: Trend of pH level of water at Narsinghpur (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

Values of pH level in the water of Narsinghpur region as shown in the above Figure is the range of minimum value of 7.1 (acidic) in the year 2011 to a maximum value of 8.9 in the year 2013 indicating a normal water. It also indicates pH values does not pose any major risk in consumption of water during the period 2007 to 2014. The mean, maximum and minimum values converge to a value of 7.2 in the year 2010.

Figure 12: Trend of pH level of water at Takli (Bhima River)



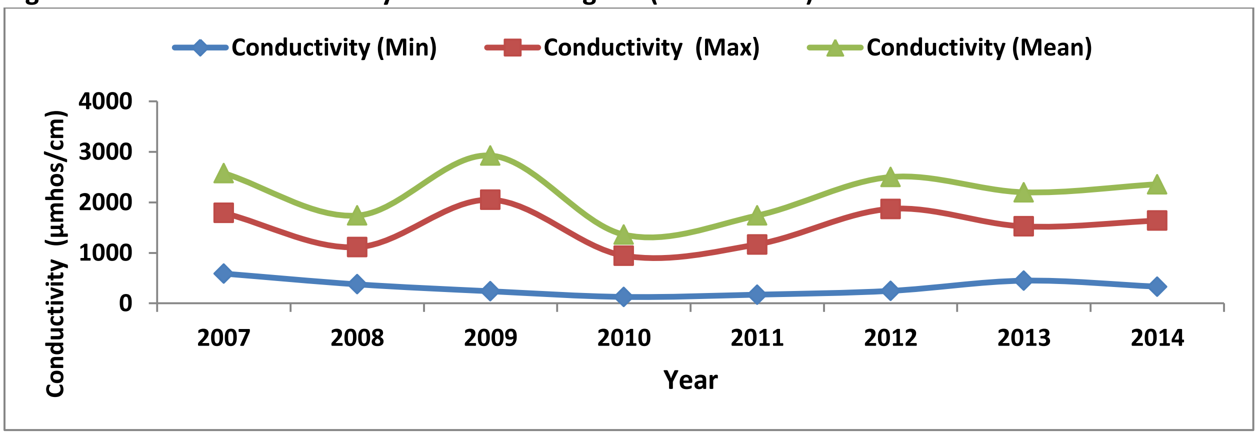
Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

Values of pH level in the water of Takli, Bhima river as shown in the above Figure is in the range of minimum value of 7 in the year 2008 to a maximum value of 8.9 in the years 20111 and 2013 indicating a normal water. It also indicates pH values does not pose any major risk in consumption of water during the period 2007 to 2014.

VIII Water Quality Trends by Conductivity

While freshwater sources have a low conductivity and seawater has a high conductivity, there is no set standard for the conductivity of water. This is because conductivity and salinity can differ not only between oceans and fresh water but even between neighbouring streams.

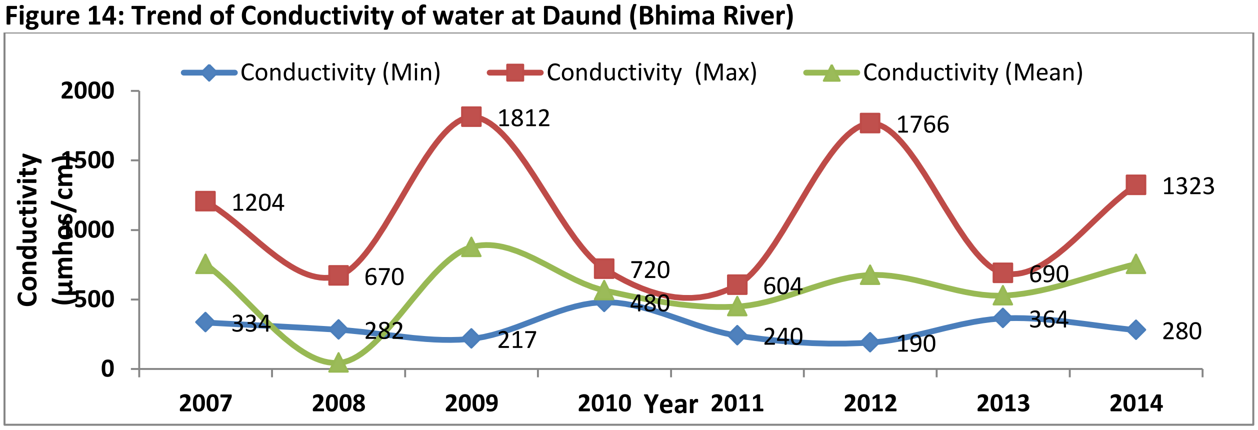
Figure 13: Trend of Conductivity of water at Pargaon (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

During the period 2007 to 2014, the trend of Conductivity of water at Pargaon (Bhima River) as shown in the above Figure is in the range 818 to 1812 (µmhos/cm) equivalent to freshwater streams.

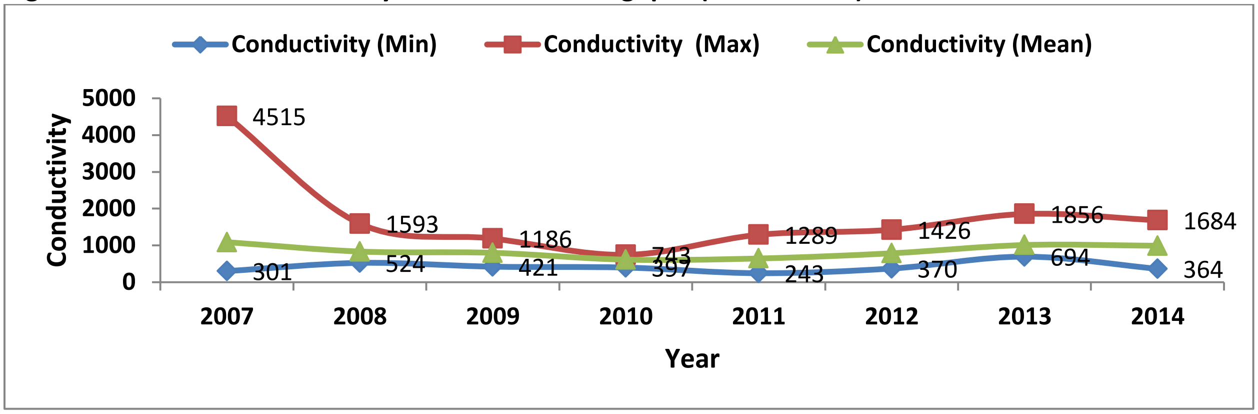
Figure 14: Trend of Conductivity of water at Daund (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

Trend of Conductivity of water at Daund (Bhima River) as shown in the above Figure is in the range 190 to 1812 (µmhos/cm) equivalent to freshwater streams.

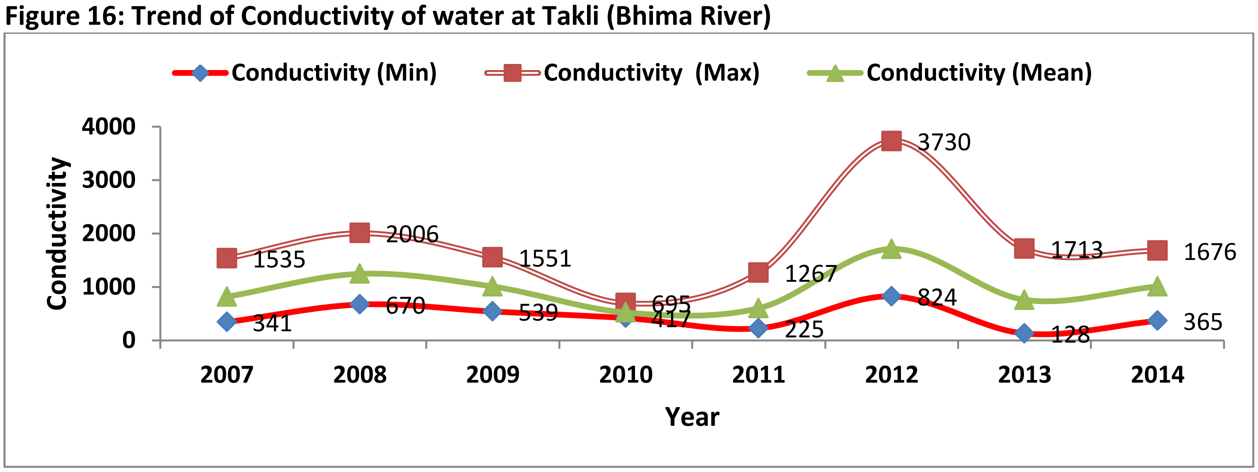
Figure 15: Trend of Conductivity of water at Narsinghpur (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The trend of Conductivity of water at Narsinghpur (Bhima River) as shown in the above Figure is in the range 243 to 4515 (µmhos/cm) equivalent to freshwater streams and **Industrial wastewater** respectively. However, it also shows a spike with a high value of 4515 **µmhos/cm** in the year 2007.

Figure 16: Trend of Conductivity of water at Takli (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

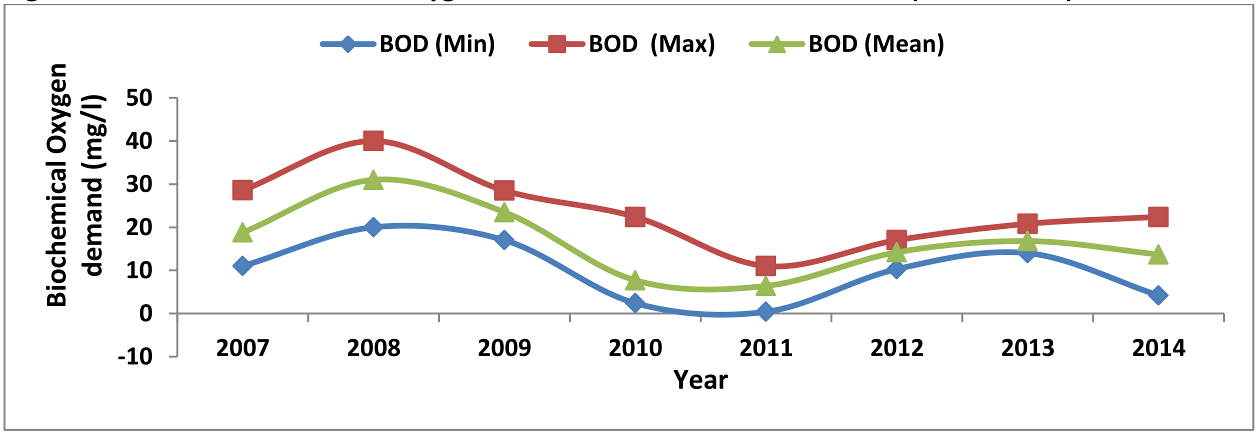
The trend of Conductivity of water at Takli (Bhima River) as shown in the above Figure is in the range 128 to 3730 (µmhos/cm) equivalent to freshwater streams. However, it also shows unusually a high value of **3730 µmhos/cm** in the year 2012.

Overall the values of conductivity are somewhat equal to the conductivity present in freshwater streams except in Narsingpur and takli areas which had a high value in certain years, indicating the conductivity of water during that years was equivalent to industrial wastewater.

VIII Water Quality Trends by Biochemical Oxygen Demand - BOD

Biochemical oxygen demand or BOD is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at a certain temperature over a specific time period. In general, maximum allowable concentration for direct environmental wastewater discharge, fall around 10 mg/L BOD and maximum allowable concentrations for discharge to sewer systems around 300 mg/L BOD.

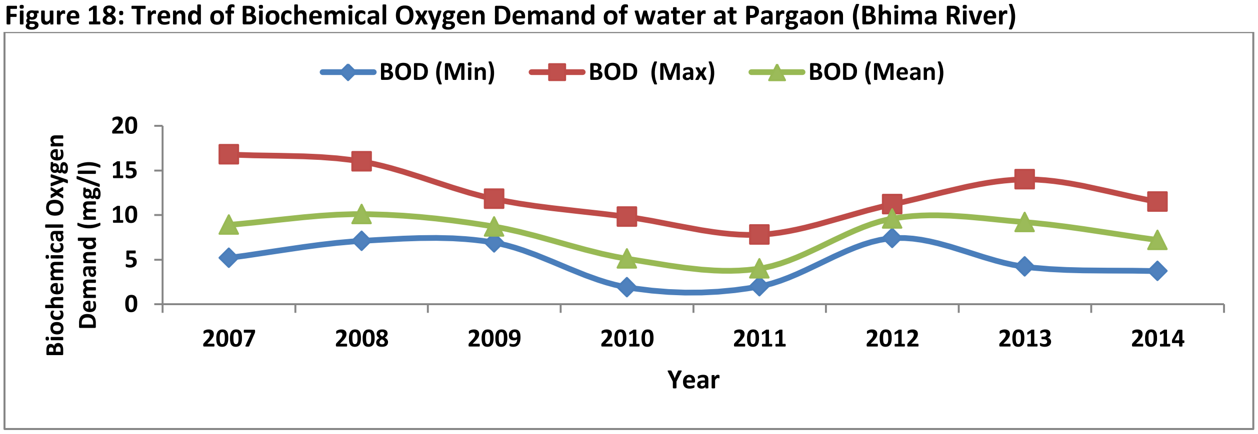
Figure 17: Trend of Biochemical Oxygen Demand of water in Bund Garden (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

As shown in the above Figure Trend of Biochemical Oxygen Demand of water in Bund Garden (Bhima River) is in the range 4 to 40 (mg/l) with a maximum in the year 2008 with an average value of 31 (mg/l) to a minimum value of zero in the year 2011.

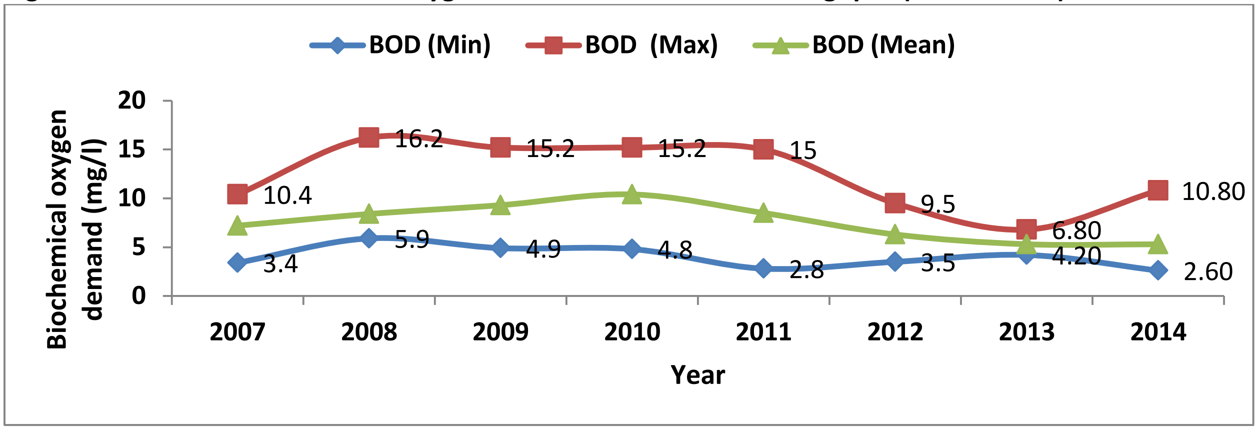
Figure 18: Trend of Biochemical Oxygen Demand of water at Pargaon (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

As shown in the above Figure Trend of Biochemical Oxygen Demand of water in Pargaon (Bhima River) is in the range 4 to 9.6 (mg/l) with a maximum in the year 2007 with a value of 16.8 (mg/l) to a minimum value of 2 (mg/l)in the year 2010 and 2011.

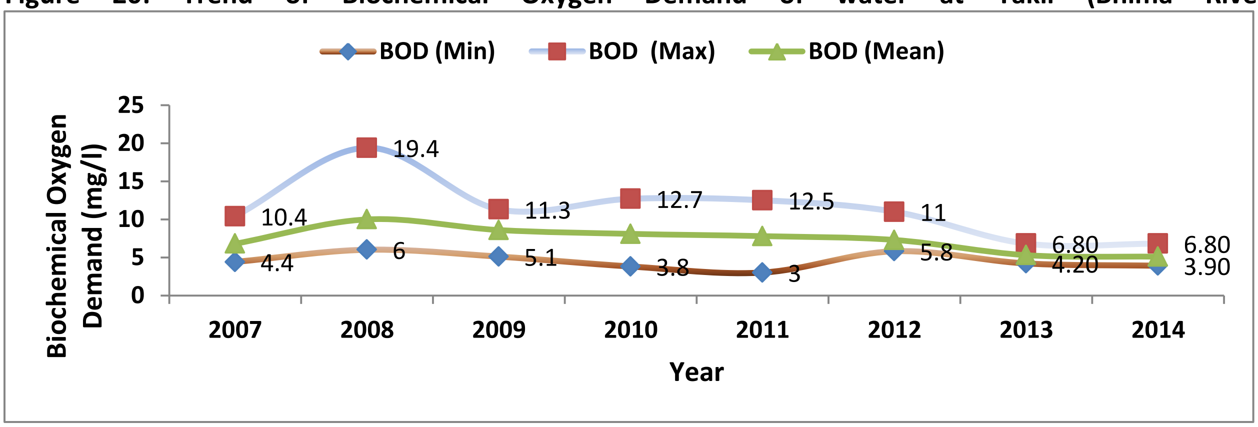
Figure 19: Trend of Biochemical Oxygen Demand of water at Narsinghpur (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

As shown in the above Figure Trend of Biochemical Oxygen Demand of water in Narsingpur (Bhima River) is in the range 2.6 to 16.2 (mg/l) with is same as the maximum value in the year 2008 to a minimum value of 2.6 in the year 2014.

Figure 20: Trend of Biochemical Oxygen Demand of water at Takli (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

As shown in the above Figure Trend of Biochemical Oxygen Demand of water in Daund (Bhima River) is in the range 3 to 19.4 (mg/l) and is the maximum value in the year 2008 to a minimum value of 3 in the year 2011.

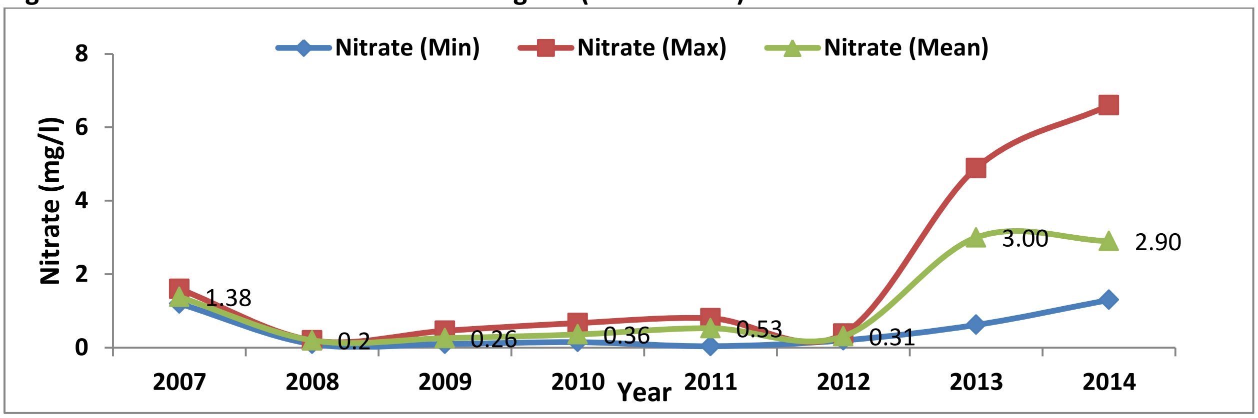
Overall, the values of Biochemical oxygen demand of water do not pose any major threat to any areas of the Bhima river during the period 2007 to 2014.

IX Water Quality Trends by Nitrogen

The primary health hazard from drinking water with nitrate-nitrogen occurs when nitrate is transformed to nitrite in the digestive system. The Environmental Protection Agency (EPA) has since adopted the 10 mg/L standard as the maximum contaminant level (MCL) for nitrate-nitrogen and 1 mg/L for nitrite-nitrogen for regulated public water systems.

It is advisable that pregnant women should not drink water containing more than 10 mg/L NO_3-N. It also is recommended that nursing mothers use water that has an NO_3-N concentration below 10 mg/L since nitrate may be passed to infants in breast milk.

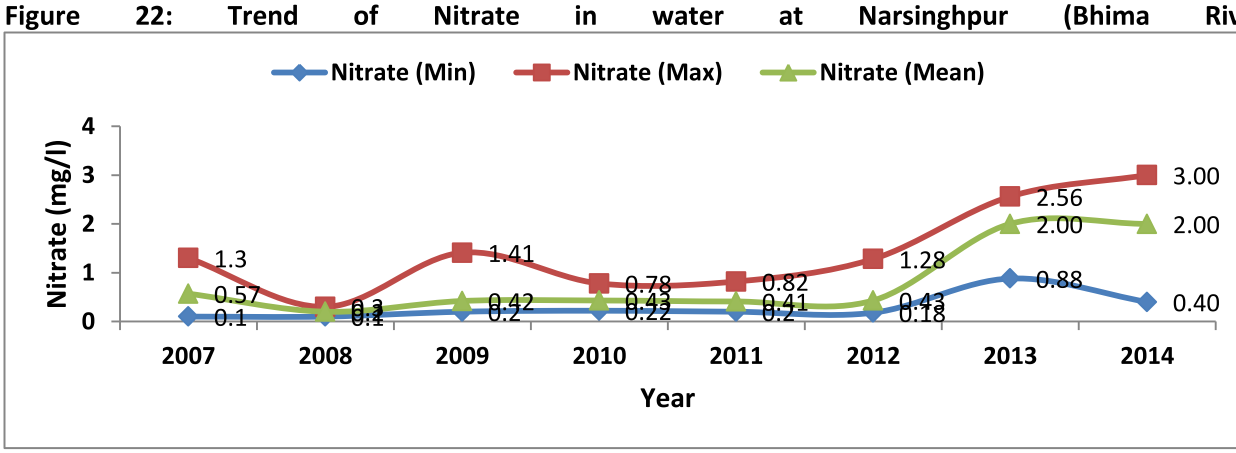
Figure 21: Trend of Nitrate in water at Pargaon (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The maximum value of nitrate in water in paragon, Bhima river of value 6.6 mg/l was in the year 2014 with an average value of 3 (mg/l) as shown in the above Figure which is well within the safe limit. The mean, maximum and minimum values converges with a value of 0.2 and 0.3 (mg/l) in the years 2008 and 2012 respectively.

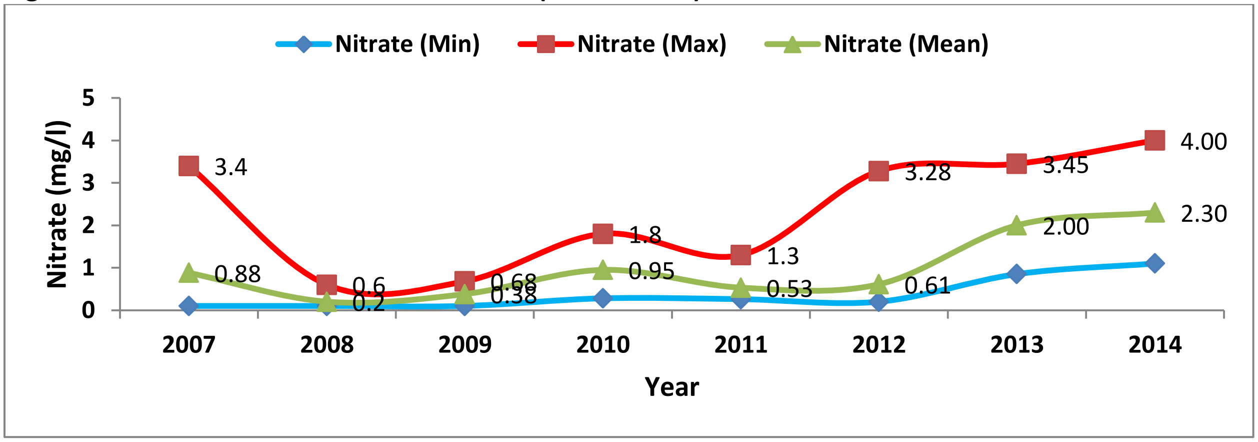
Figure 22: Trend of Nitrate in water at Narsinghpur (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate

The maximum value of nitrate in water in Narsinghpur of Bhima river of value 3.0 mg/l was in the year 2014 with an average value of 0.5 to 2 (mg/l) as shown in the above Figure which is well within the safe limit.

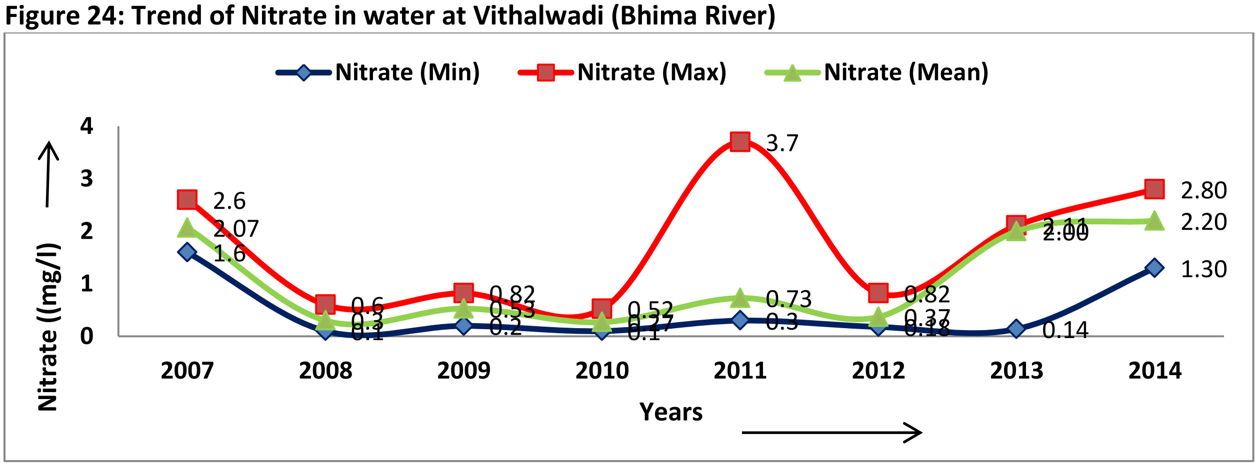
Figure 23: Trend of Nitrate in water at Takli (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The maximum value of nitrate in water in Takli of Bhima river of value 4 mg/l was in the year 2014 with an average value of 0.8 to 2 (mg/l) as shown in the above Figure which is well within the safe limit.

Figure 24: Trend of Nitrate in water at Vithalwadi (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

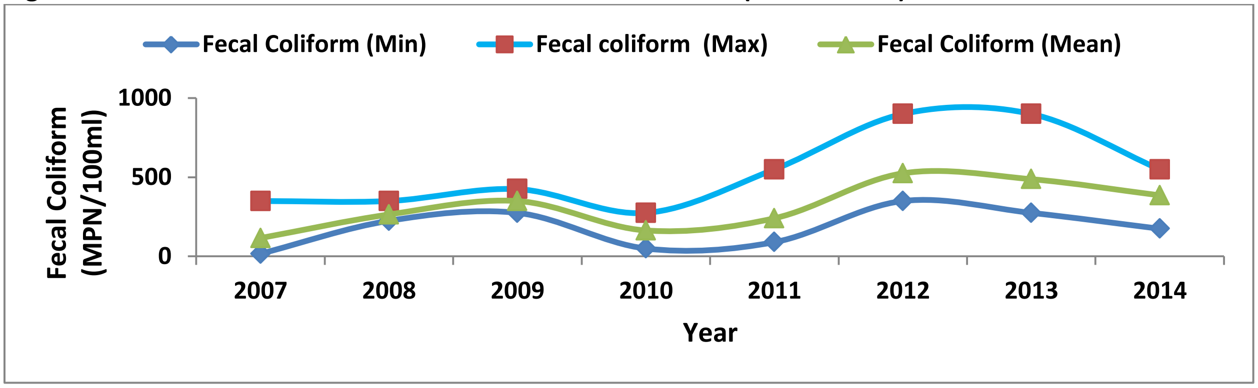
The maximum value of nitrate in water in Vithalwadi of Bhima river of value 3.7 mg/l was in the year 2011 with an average value of 0.2 to 2.2 (mg/l) as shown in the above Figure which is well within the safe limit. Hence, the Nitrate content is well within the permissible limit in the Bhima river during the period 2007 to 2014.

X Water Quality Trends by Total coliform bacteria

Coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm- and cold-blooded animals.

The current USEPA recommendations for body-contact recreation is fewer than 200 colonies/100 ml; for fishing and boating, less than 1000 colonies/100 ml; and for domestic water supply, for treatment, fewer than 2000 colonies/100 ml. The drinking water standard is less than 1 colony/ 100ml.

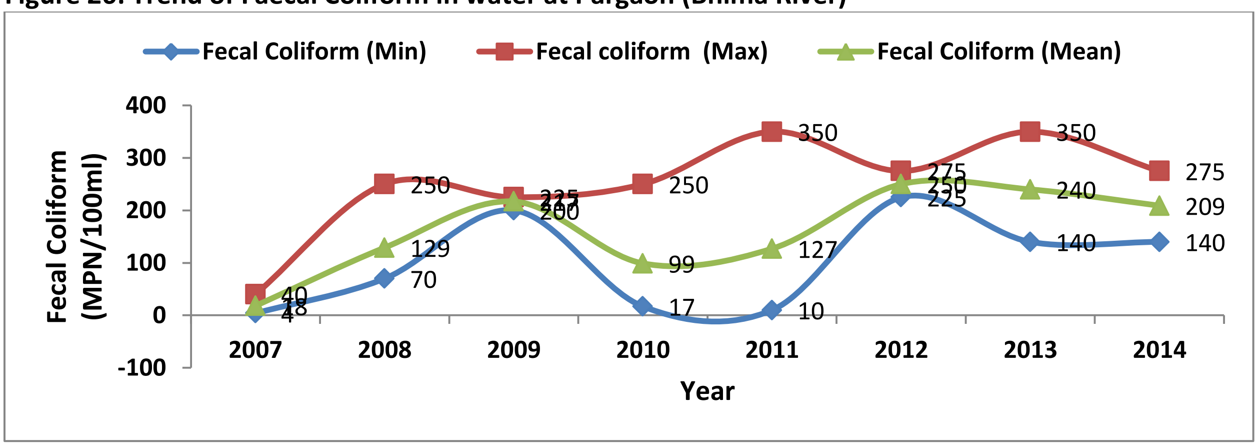
Figure 25: Trend of Faecal Coliform in water at Bund Garden (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The average value of faecal coliform in water of Bund garden, Bhima river as shown in the above Figure is in the range of 116 to 386 MPN/100ml which is well above the standard level for drinking purpose.The maximum value of faecal coliform in water of 900 MPN/100ml was observed in the year 2014 which is well above the safe limit.

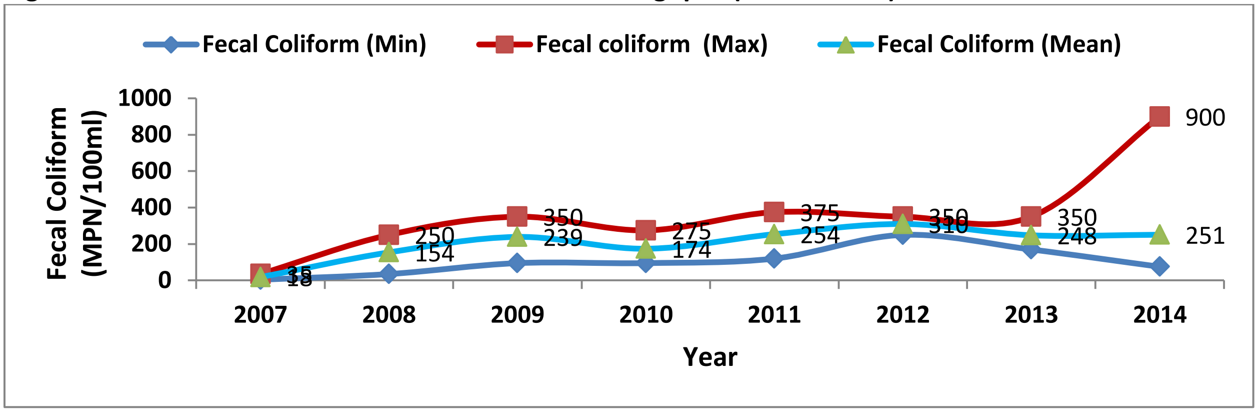
Figure 26: Trend of Faecal Coliform in water at Pargaon (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The average value of faecal coliform in the water of Paragon, Bhima river as shown in the above Figure is in the range of 4 to 250 MPN/100ml which is well above the standard level for drinking purpose.The maximum value of faecal coliform in water of 350 MPN/100ml was observed in the years 2011 and 2013 which is well above the safe limit.

Figure 27: Trend of Faecal Coliform in water at Narsinghpur (Bhima River)

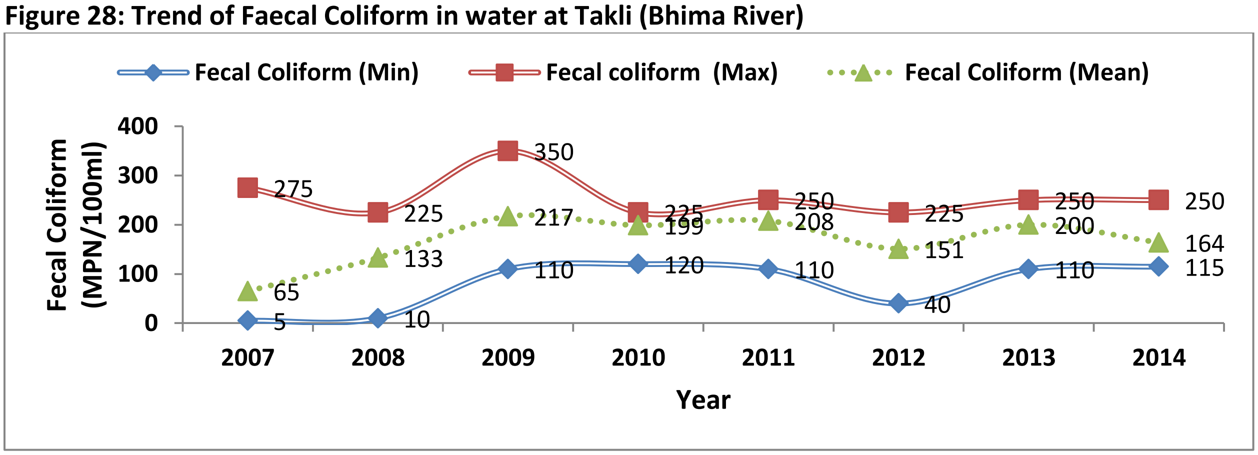


Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The average value of faecal coliform in water in Narsingpur, Bhima river as shown in the above Figure is in the range of 18 to 900 MPN/100ml which is well above the standard level for drinking purpose.

The maximum value of faecal coliform in water of 900 MPN/100ml was observed in the year 2014 which is well above the safe limit.

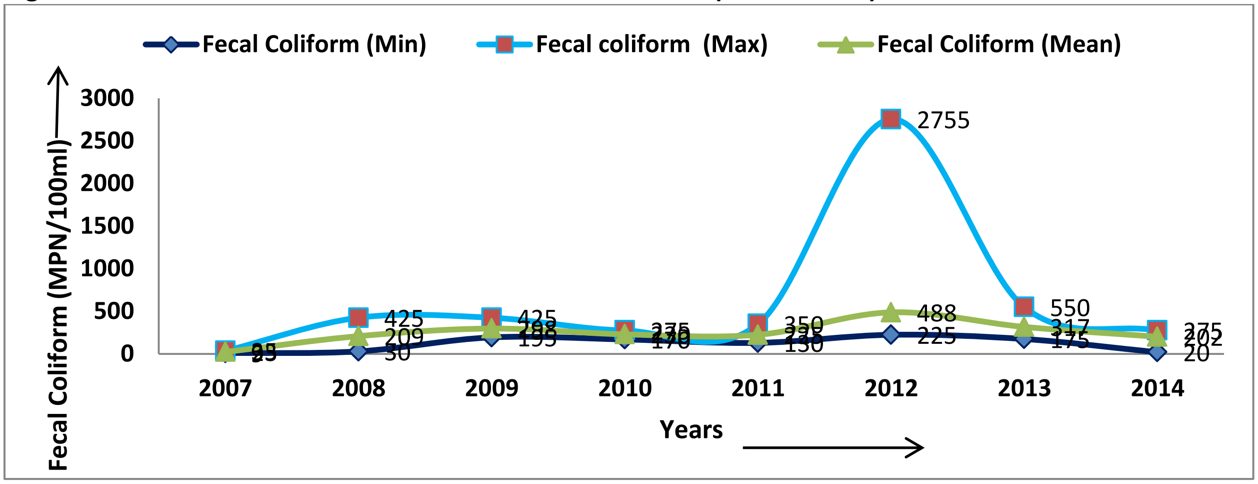
Figure 28: Trend of Faecal Coliform in water at Takli (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The average value of faecal coliform in water in Takli, Bhima river as shown in the above Figure is in the range of 5 to 350 MPN/100ml which is well above the standard level for drinking purpose.The maximum value of faecal coliform in water of 350 MPN/100ml was observed in the year 2009 which is well above the safe limit.

Figure 29: Trend of Faecal Coliform in water at Vithalwadi (Bhima River)



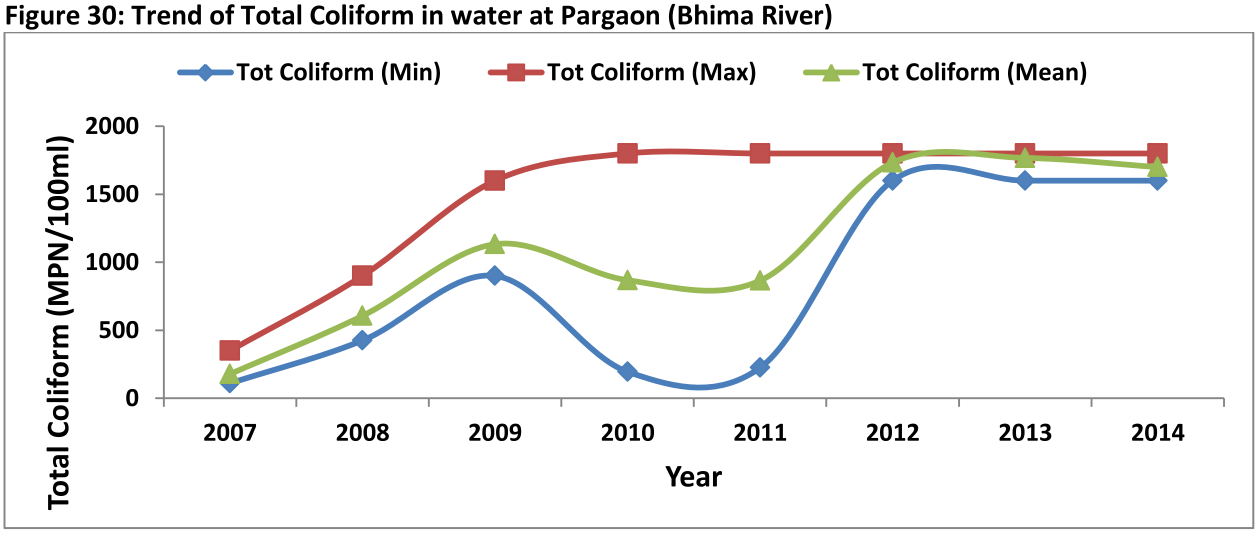
Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The average value of faecal coliform in water in Vithalwadi, Bhima river as shown in the above Figure is in the range of 20 to 2755 MPN/100ml which is well above the standard level for drinking purpose.The maximum value of faecal coliform in water of 2755 MPN/100ml was observed in the year 2012 which is well above the safe limit.

Faecel coliform is well above the permissible limit in the waters of Bhima river and is unusually high in water of Narsingpur and Vithalwadi was observed in the year 2014 and 2012which is well above the safe limit.

Total coliforms are a group of related bacteria that are (with few exceptions) not harmful to humans. A variety of bacteria, parasites, and viruses, known as pathogens, can potentially cause health problems if humans ingest them. EPA considers total coliforms a useful indicator of other pathogens in drinking water. Total coliforms are used to determine the adequacy of water treatment and the integrity of the distribution system.

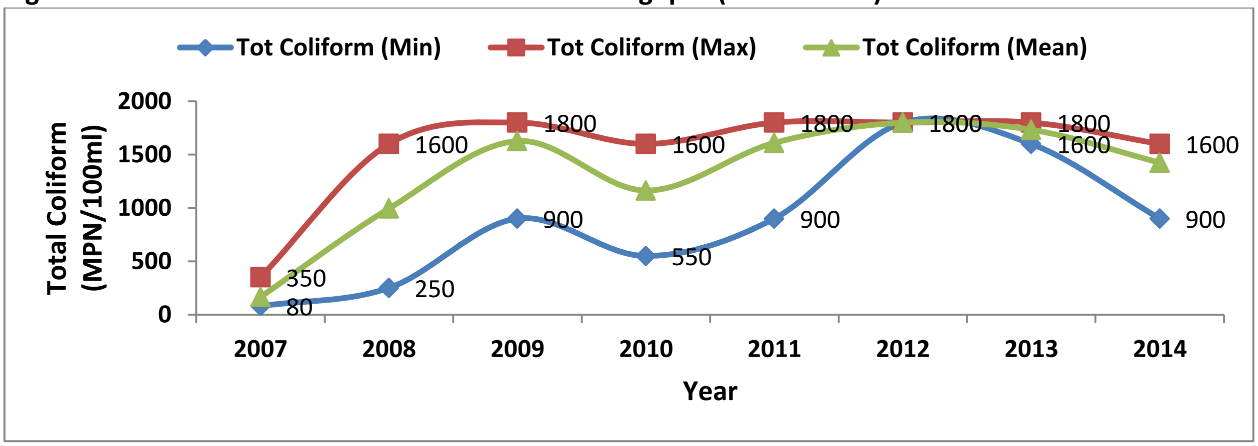
Figure 30: Trend of Total Coliform in water at Pargaon (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The average value of total coliform in the water as shown in the above Figure in Pargaon (Bhima river) is in the range of 110 to 1800 MPN/100ml which is well above the standard level for drinking purpose.The maximum value of total coliform in water of 1800 MPN/100ml was observed from the year 2010 onwards remained high. The lowest value of total coliform in the water was in the year 2007 of 110 MPN/100ml.

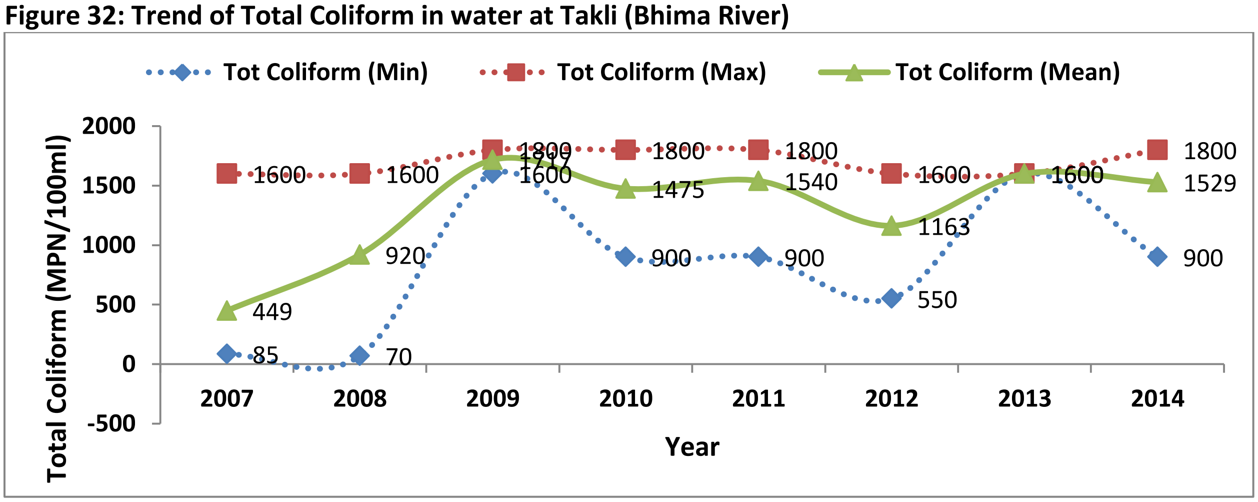
Figure 31: Trend of Total Coliform in water at Narsinghpur (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The average value of total coliform in the water as shown in the above Figure in Narsingpur (Bhima river) is in the range of 80 to 1800 MPN/100ml which is well above the standard level for drinking purpose.The maximum value of total coliform in water of 1800 MPN/100ml was observed from 2011 onwards remained high till 2013 and dropped to 1600 in the year 2014. The lowest value of total coliform in the water was in the year 2007 of 80 MPN/100ml. The mean, maximum and minimum values converge to a value of 1800 MPN/100ml in the year 2012.

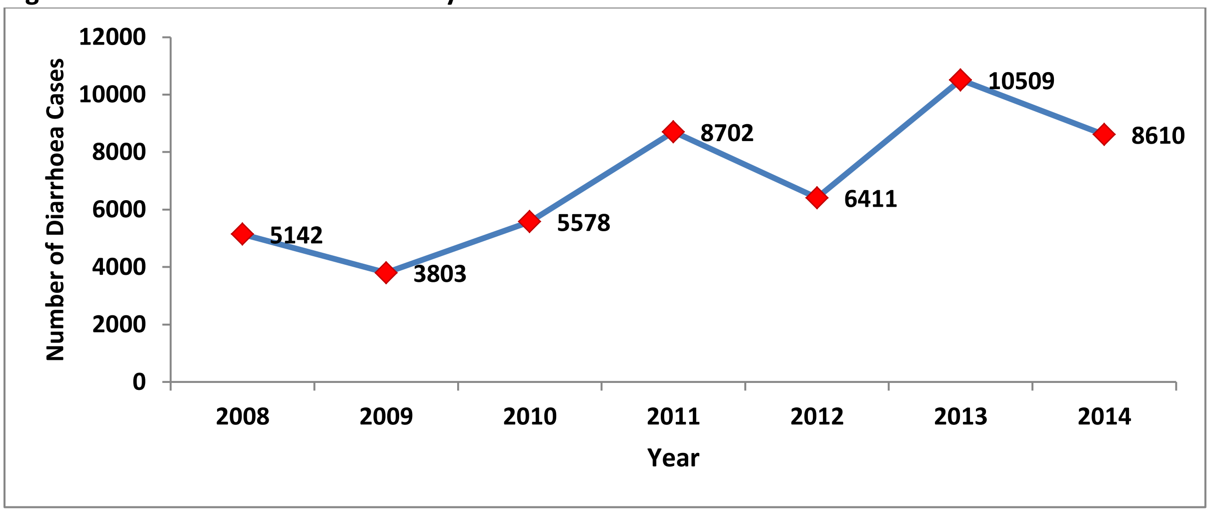
Figure 32: Trend of Total Coliform in water at Takli (Bhima River)



Source: Central Pollution Control Board (2007-12); Ministry of Environment, Forest and Climate Change

The average value of total coliform in the water as shown in the above Figure in Takli (Bhima river) is in the range of 70 to 1800 MPN/100ml which is well above the standard level for drinking purpose.The maximum value of total coliform in water of 1800 MPN/100ml was observed from 2009 onwards and slightly dropped to 1600 in the year 2013 and rose to 1800 in the year 2014. The lowest value of total coliform in the water was in the year 2007 of 70 MPN/100ml. The mean, maximum and minimum values converge to a value of 1600 MPN/100ml in the year 2013.

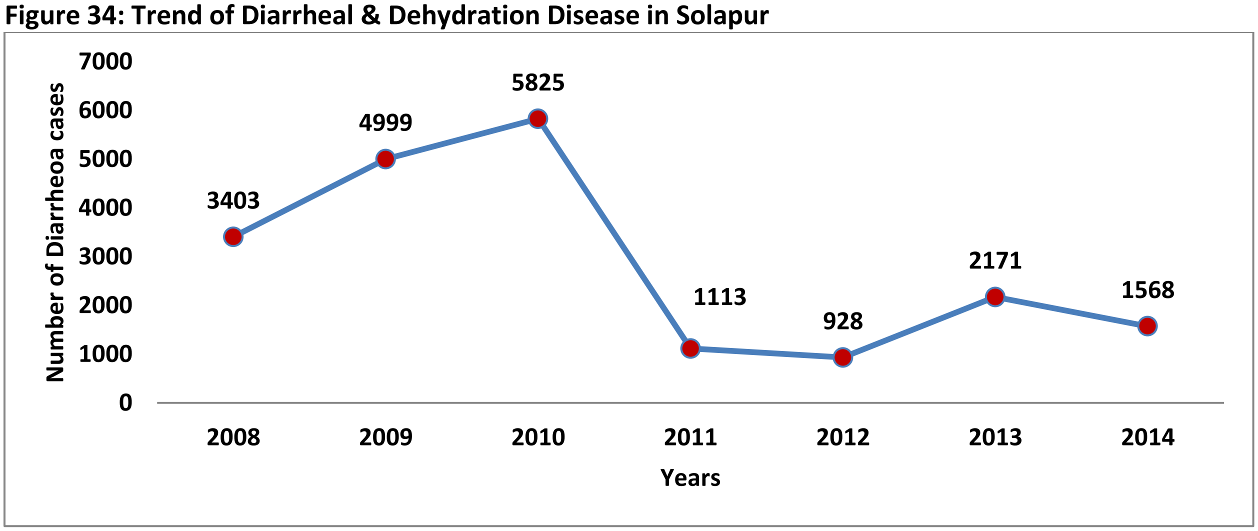
Figure 33: Trend of Diarrheal & Dehydration Disease in Pune



Source: Health Management Information System (2008-12); MOHFW

The above Figure shows the trend in diarrhoeal and dehydration disease during the period 2008 to 2014 in Pune district. The number of diarrhoeal cases in 2013 has almost doubled the number of cases in the year 2008. However, in 2014 the number of diarrhhoeal cases decreased to 8610.

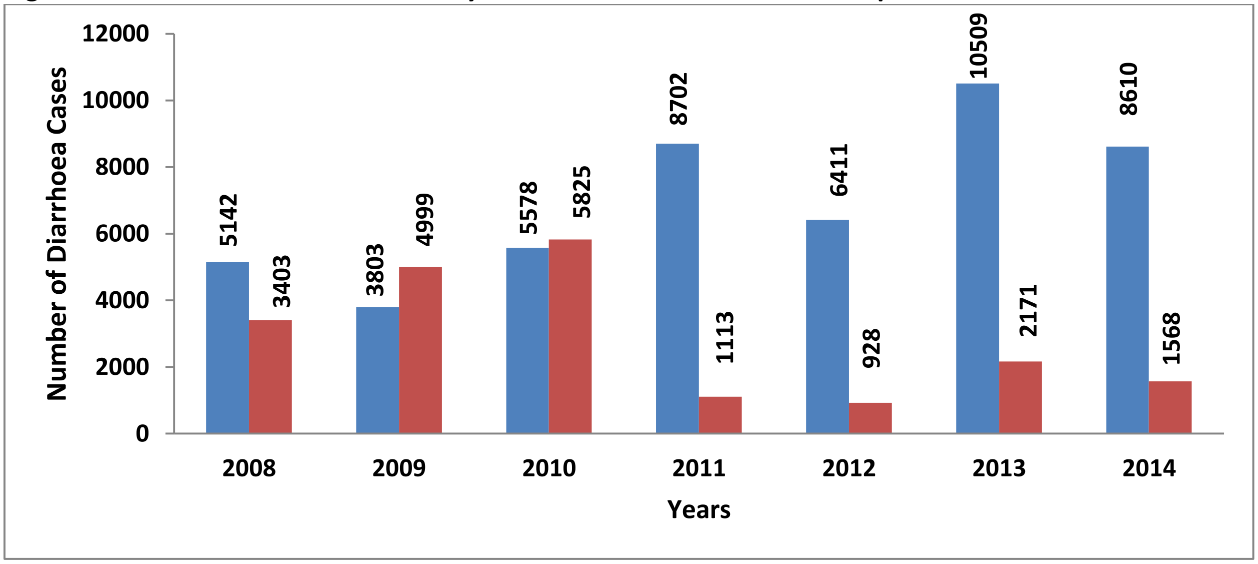
Figure 34: Trend of Diarrheal & Dehydration Disease in Solapur



Source: Health Management Information System (2008-12); MOHFW

The above Figure shows the trend in diarrhoeal and dehydration disease during the period 2008 to 2014 in solapur district. Reverse scenario is observed in Solapur district wherein the number of diarrhoeal cases in 2014 is almost half the number of cases in the year 2008. The maximum umber of diarrhoeal and dehydration cases was observed in the year 2010 and the least umber of cases was observed in the year 2012.

Figure 35: Number of Diarrheal & Dehydration Disease in Pune and Solapur



Source: Health Management Information System (2008-12); MOHFW

Except for the year 2009 and 2010 the number of diarrheal and dehydrated cases in Pune district was always higher than in Solapur district. The width in the number of cases increased from the year 2011 onwards.

XI Principal component Analysis of Water Quality Parameters

Table 1: Correlation between Water Quality Parameters (2007-2014)

Parameters (Mean)	Temperature (Mean)	D O (Mean)	PH (Mean)	Conductivity (Mean)	B O D (Mean)	Nitrate (Mean)	Faecal Coliform (Mean)	Total Coliform (Mean)
Temperature	1							
Dissolve Oxygen	**0.2799***	1						
	0.0403							
PH	0.1692	**0.3379***	1					
	0.2214	**0.0125**						
Conductivity	**0.4447***	**0.4029***	0.1966	1				
	0.0008	**0.0025**	0.1541					
Biochemical Oxygen Demand	-0.257	**-0.7814***	**-0.4309***	-0.2305	1			
	0.0606	**0**	**0.0011**	0.0936				
Nitrate	-0.0657	0.0776	**0.4879***	-0.1207	-0.149	1		

	0.6368	0.5771	**0.0002**	0.3845	0.2821			
Fecal Coliform	0.1162	**-0.6419***	0.0686	-0.1754	**0.3558***	-0.0241	1	
	0.4027	**0**	0.6219	0.2045	**0.0083**	0.8629		
Total Coliform	0.1386	**-0.3956***	0.2636	-0.0683	0.1513	0.136	**0.8080***	1
	0.3174	**0.0031**	0.0541	0.6238	0.2749	0.3267	**0**	

Table2 Principal omponent analysis between Water Quality Parameters (2007-2014)

Variable	**1**	**2**	**3**	**4**	**5**
Temperature (Mean)	-0.3182*	**0.575**	0.1502	**0.4759**	0.2823
DO(Mean)	**-0.4629**	0.0344	-0.1016	0.2322	-0.044
Conductivity (mean)	-0.3163	**0.5625**	0.0114	**-0.7465**	-0.1436
BOD (mean)	**0.4425**	0.1132	-0.2904	-0.264	**0.6055**
Nitrate (mean)	0.2791	0.0442	**0.8994**	-0.074	-0.064
Faecal Coliform (mean)	**0.4112**	0.3231	-0.2709	0.1668	**-0.7057**
Total Coliform (mean)	0.3764	**0.4824**	-0.0179	0.2435	0.1704

PCA 1: First principal component is correlated with three parameters, namely as Biochemical Oxygen Demand (BOD), Faecal Coliform and Dissolved Oxygen (DO). If BOD and Faecal Coliform increased and DO will decrease, then as a result first principal component will also increase. This suggests that, if BOD and Faecal Coliform increases, then DO will decrease. This component can be viewed as the quality measure of BOD, Fecal coliform and lack of Dissolved Oxygen in the water.

PCA2: The second principal component is strongly correlated with Temperature and Conductivity of water as well as total coliform. This suggests that, high temperature tends to be a good conductivity of water.

PCA3: The third principal component is strongly correlated with the Nitrate and viewed as the increase in Nitrate the 3^{rd} Principal Component will also increase.

PCA4: The fourth component strongly negatively correlated with conductivity of water that if the conductivity of water decreases then 4^{th} principal component will increase. This suggests that the quality of water is good for human but not for making electricity because of the low concentration of ions.

PCA5: The fifth component increase with increase in BOD and decrease in Fecal Coliform. This suggests that with lack of Fecal Coliform in water will cause the BOD.

XII Conclusions

Overall, the values of dissolved oxygen in the water of the Bhima river indicate an unfavourable condition for aquatic life during the period 2007 to 2014. Notably, Vithalwadi and Bund garden side of the Bhima river reported the lowest temperature, which is an unfavourable condition for aquatic life.

The values of conductivity are somewhat equal to the conductivity present in freshwater streams except in Narsingpur and Takli areas which had a high value in certain years, indicating the conductivity of water during that year was equivalent to industrial wastewater.

Faecel coliform is well above the permissible limit in the waters of Bhima river and is unusually high in water of Narsingpur and Vithalwadi was observed in the year 2014 and 2012 which is well above the safe limit.

Principal Component analysis shows, if BOD and Faecal Coliform increases, then DO will decrease. It also suggests a strong correlation with temperature and conductivity of water as well as total coliform as, high temperature tends to be a good conductivity of water. Although, negative correlation with conductivity of water is observed it is good for human consumption, but not for making electricity because of the low concentration of ions.

Current Analysis.

Trend Analysis and Principal component analysis of areas nearer to River Godavari is in Progress.

XIV References

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Annexure

Water Quality Criteria (CPCB)

Designated-Best-Use	Class of Water	Criteria
Drinking Water Source without conventional treatment but after disinfections	A	1. Total Coliforms Organisms MPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved oxygen 6 mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0 C 2 mg/l or less
Outdoor bathing (Organized)	B	1. Total Coliforms Organisms MPN/100 ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved oxygen 5 mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0 C 3 mg/l or less
Drinking Water Source after conventional treatment and disinfection	C	1. Total Coliforms Organisms MPN/100 ml shall be 5000 or less 2. pH between 6 and 9 3. Dissolved oxygen 4 mg/l or more 4. Biochemical Oxygen Demand 5 days20^0 C 3 mg/l or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 and 8.5 2. Dissolved oxygen 4 mg/l or more 3. Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 and 8.5 2. Electrical Conductivity at 25^0C micromhos/cm Max. 2250 3. Sodium absorption ration Max. 26 4. Boron Max. 2 mg/l