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WASTEWATER TREATMENT FOR WATER SECURITY IN INDIA

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Abstract

With rapid and unplanned urbanisation and economic growth, the demand for fresh water for various purposes is on the rise in India. However, spatio-temporal variations in fresh water availability, vagaries of the monsoon and variability in climate, as well as human, development and management challenges pose great threats to water supplies in the country. While excessive withdrawal from surface and underground sources and inefficient use of water were recognised as reasons for reduced availability of fresh water with respect to space and time, the role of pollution of water sources, both surface and ground water, in reducing the quantum of available fresh water for various uses, has not received due importance. It is estimated that 75-80 per cent of water pollution in terms of volume of water polluted is from domestic sewage.

This paper analyses the quality of water in surface water bodies across India. The data on water quality in rivers upstream and downstream of selected cities over a period of time was analyzed to understand the changes in crucial water quality parameters over time. The status of sewage treatment across Indian states was also studied, to understand the gaps in waste water treatment. The existing institutional and legal measures available for the control of water pollution were also analysed.

Health and economic prosperity being very much dependant on clean water supply and good sanitation, an integrated approach balancing infrastructure and socio-economic measures for water quality management is proposed. The paper further argues for construction of new wastewater treatment infrastructure, improvement of the existing wastewater treatment systems, upgrading of wastewater treatment technologies and renovation of the sewer system, all with an accent on economic viability and environmental sustainability. It is also necessary to create awareness on sanitation and pollution issues among users to ensure their cooperation in maintaining their own environments.

Total sanitation cannot be achieved by building toilets alone. The waste water generated must be treated and the same along with the sludge reused or properly disposed-off so that it does not pollute fresh water sources and the soils. It is high time that the elected representatives, government agencies and people work together to keep our water sources clean and achieve water security.

Keywords: Water pollution, Water Quality, Wastewater treatment, Reuse, Sewage, Faecal sludge, Sanitation, Water security, Sustainability, Environment, Swachh Bharat

1. Introduction

It is well known that the demand for water for different uses is on the rise in India. While the Standing Subcommittee of the Ministry of Water Resources, Government of India estimates that the total water demand across all sectors in India will rise from 813 Billion Cubic Metres (BCM) in 2010 to 1093 BCM in 2025 and 1447 BCM in 2050, the National Commission on Integrated Water Resources Development puts these figures at a maximum of 843 BCM and 1180 BCM compared to a maximum of 710 BCM in 2010. While the usable water resources in India

were estimated to be 1123 BCM in 2015, its availability is not uniform across the country (Compendium of Environment Statistics-2016). In addition to the spatio-temporal variations in availability, vagaries of monsoon and the predicted variability of climate in the future, human, development and management challenges pose the greatest threat to water availability (WRIS, 2016). In many parts of India, extraction of large volumes of ground water without equivalent replenishment has led to rapid lowering of the water table.

Water security is the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water related risks to people, environments and economies. Achieving water security is the only way for a poor country to grow and lift its people out of poverty (Grey and Sadoff, 2007). A condition of water stress is said to exist when there is not enough water for all uses, whether agricultural, industrial or domestic. According to Falkenmark, countries experience regular or periodic water stress when annual per capita renewable freshwater availability falls below 1,700 cubic meters with economic development and human health and well-being beginning to be hampered below 1000 cubic metres (WBCSD, 2005). Factors that contribute to water stress are excessive withdrawal from surface and underground sources, inefficient use of water, and pollution of fresh water bodies.

Total annual ground water draft in India is only 22.72 BCM for domestic and industrial purposes against 222.36 BCM for irrigation (Central Ground Water Board, 2014). However, many Indian cities have to rely on water sources so far away that considerable costs are incurred including for energy used for pumping water to these cities. Cities with larger populations rely more on surface water as opposed to groundwater sources and this leads to conflicts with other uses too. In cities where ground water is the source of water supply, aquifers are getting depleted as pumping taking place within small geographical areas creates "cones of depression" (Mukherjee, Shah, and Kumar, 2010).

The situation is made worse by the pollution of water sources. Discharge of untreated sewage into water bodies - both surface and groundwater- may be responsible for polluting about three-fourth of surface water resources; the extent of surface water pollution in India may be as high as 80%. Unfortunately, sanitation has not kept pace with water supply in India so much so that almost 80% of the water supplied for domestic use comes back as waste water to pollute fresh water and soil. It is estimated that 75-80 per cent of water pollution in terms of volume of water polluted is from domestic sewerage (Wateraid, 2016).

The World Bank estimates that the water demand for industrial uses and energy production in India would grow at an annual rate of 4.2 per cent (IDFC, 2011). The waste water discharged by industries further pollutes fresh water when discharged into freshwater bodies as do agricultural runoff. Lowering of ground water table also results in deterioration of ground water quality. Thus, the actual amount of fresh water available for various uses is on the decline due to pollution and contamination from domestic, industrial and agricultural sources.

Take the case of Bengaluru (Bangalore). Bengaluru has been experiencing rapid urbanization during the past two decades due to unplanned and concentrated economic activities. In Bengaluru, the annual ground water pumping is higher than the recharge, resulting in depletion of the shallow aquifers. Improper management of sewage is causing nitrate pollution in the ground water. 90% of the lakes in Bengaluru are sewage-fed. Sustained inflow of untreated sewage has increased the organic content beyond the threshold of remediation capability of the

respective water bodies.¹ At the same time, the water table in the area has fallen considerably over the years. Bengaluru is supplied with 1310 million litres of water every day from river Cauvery located 120 km away, lifting it about 500m and incurring huge energy costs in the process. The Bangalore Water Supply and Sewerage Board paid Rs 39498 Lac for electricity in 2014-15. Yet, the Cauvery water is not enough to cater to the needs of the whole city and in many areas, residents are paying high price for water delivered in tankers, the unchecked ground water withdrawal taking the water table deeper and deeper each year.

The situation in Bengaluru is not an isolated phenomenon. Most cities in India are struggling to supply water to its residents. The situation is no better in rural areas. Rural households already spend a considerable part of their limited incomes on acquiring clean drinking water, often having to tap a range of different schemes running in their villages, in addition to private provisions like investing in bore wells, storage tanks, and so on (World Bank,2008). At the same time, sewage treatment facilities in the country are far from adequate with untreated sewage discharged directly into lakes and rivers in many places. The situation is more critical in urban areas due to the high population density when compared to rural areas. The pollution of rivers at the cities also affects the downstream rural areas.

All these facts bring us to the realization that treatment and reuse of waste water is an absolute necessity not only to reduce water demand but also to prevent our freshwater resources, both surface and underground, from getting polluted. While it is important to find ways to reduce demand by increasing water use efficiency in agricultural, industrial and domestic sectors and reducing transmission losses and pilferage, treating the waste water for reuse for different purposes and reducing pollution of our water bodies is equally important so long as it makes good economic sense.

An integrated approach to water management links water resources management across different sectors and interest groups and ranging from local to international scales (GWP & INBO, 2009). It is necessary to manage fresh water, waste water, and storm water to secure reliable and sustainable water supply in the short and long term. An integrated framework is necessary so that alternatives like water reuse projects are not ignored due to perceived infrastructure, water quality and public health constraints. Esposito et al from Metcalf & Eddy have suggested that decentralized wastewater treatment, with either satellite or cluster systems, allows for more cost-effective flexible treatment configurations with innovative technologies to reclaim water. These systems have reduced costs which include costs associated with transmission to reuse sites and necessary retrofits as well as reduced risk of effluent toxicity from mixed wastewater sources (Esposito et al, 2005)

Polluted waters and water stress will take a country backwards with regard to public health and economic development. Treatment and reuse of waste water has a major role in

¹ A classic example is that of Bellandur Lake in the suburbs of Bengaluru. One of the largest lakes in Bengaluru, it was the lifeline of surrounding villages till it became an outlet for sewage, transforming it into a sewage tank. 250 MLD of untreated water is let into the 900-acre Bellandur Lake. These days every time it rains froth rises from the lake covering people and vehicles passing by and the surface of the lake catches fire at other times. The National Green Tribunal (NGT) that took up a *suo moto* case after one such fire, issued a two-week deadline to the state government to formulate an action plan to completely prevent and control pollution in Bellandur Lake and carry out a one-time exercise to free the lake of silt, waste and chemicals. However, it is such a daunting task that the government of Karnataka decided to appeal before the NGT with alternatives and seek legal opinion (Bangalore Mirror, 2017).

achieving water security and environmental protection. The “Clean India” or “Swachh Bharat” campaign will be successful only if water is available in the toilets constructed as part of the project and if the waste water generated is also treated and the treated water reused or disposed-off in a sustainable manner in addition to keeping municipal solid waste away from our water systems.

2. Status of Water Quality in India

Water quality is one of the biggest issues the world faces today. It is an important factor for monitoring the environmental changes which have direct impacts on social and economic development. Non-availability of fresh surface and ground water resources and contamination of available water are major problems that hinder socio-economic development.

In many parts of India, water from surface or ground water sources is found to have problems with quality (CGWB, 2002). Discharge of wastewater or effluents from industrial processes and commercial establishments as well as from domestic sources are contaminating lakes and rivers. It has also been reported that the about 66 million people spread over 22 states are facing water quality risk due to high fluoride contamination in groundwater and around 10 million are facing problems due to high arsenic content in groundwater, due to overdraft of groundwater, particularly in rural areas. Groundwater also gets contaminated from salinity, iron, nitrates and others chemicals (Husain et al., 2013, 2014; Nickson et al, 2007; Srikanth, 2009; Desai, 1990). More than two lakh people are affected by poor quality of drinking water due to chemical contamination (CPCB, 1999). Pollutants that enter aquifers will remain there for several years and get dispersed further, leading to ground water over large areas becoming unsuitable for consumption and other human uses.

Understanding the characteristics and mechanisms of contamination of surface and ground water can help policy makers to evaluate the effectiveness of water management measures and create an environment for sustainable development. The Central Pollution Control Board (CPCB) in its report, “Status of Water Quality in India” (2012) identifies the locations on rivers, lakes, ponds and tanks as well as observation wells, which do not meet water quality criteria with regard to organic pollution measured in terms of Biochemical Oxygen Demand (BOD) & Coliform bacterial count. According to CPCB, about 63% of the observations indicate a BOD less than 3 mg/l while 19% of the observations indicate a BOD between 3-6 mg/l and only 18% show a BOD above 6 mg/l. About 50% observations have Total Coliforms (TC) higher than 500 MPN /100 ml and 35% observations have Faecal Coliform higher than 500 MPN /100 ml.

Yet the data portrays a picture which is far rosier than the reality in many cases. Many labs are ill equipped to measure the organic pollutant parameters and in many cases the samples are tested after a long holding period which alters the parameters (Down to Earth, 2011). Inadequate number of monitoring stations and the fact that many of them are not located in cities or immediately downstream of the points of pollution are also some of the reasons for not being able to obtain a realistic picture of the extent of water pollution in the country.

Less than a third of the estimated 38,254 million litres of sewage generated each day in Class I & Class II towns of the country are currently being treated. The condition is made worse by the abstraction of water for irrigation, drinking, industrial use and power which leaves very little freshwater in rivers and other water bodies for the dilution of pollutants. The 3, 20,000 small-scale industrial units in India contribute to almost 40 per cent of the pollution from industrial sources in India. Urban areas in India generate more than 100,000 metric ton of solid waste every day, part of which also ends up in the water bodies either directly or by leaching. Also causing

harm are medical waste and medicines past their expiry dates which in many cases are not disposed-off in a safe manner. Run-off from mines and industrial areas are other sources of water pollution. Added to this is the pollution to surface and ground water caused by agricultural runoff which contains pesticide and fertilizer residues. An indication of the magnitude of the non-point pollution is the nitrate concentration in groundwater exceeding permissible limits in Haryana and Punjab. Comprehensive studies have not been conducted on the pollution due to run-off from agricultural land as well as from land occupied by mines and industries, and there exist no standards or legislations regarding the same (IDFC, 2011).

The Report of the Comptroller and Auditor General of India for the year ended March 2011 on the performance of statutory agencies for pollution control in India, had concluded that the overall planning for the control of pollution on part of the Ministry of Environment and Forest (MoEF) and the States falls short of an ideal situation wherein a complete inventory of rivers/lakes and keystone species associated with them are undertaken, identification of existing pollution levels in rivers and lakes in terms of biological indicators carried out, contaminants as well as human activities that impact water quality in rivers, lakes and ground water identified and quantified, risks of polluted water to health and environment assessed, a basin level approach to control of pollution adopted, and water quality goals as well as corresponding parameters for each river/lake developed and enforced. The report noted that this shortfall would have repercussions on implementation of programmes for control of pollution and their outcomes. It said that in the absence of a specific policy which would incorporate aspects of pollution prevention and treatment of polluted water for ecological restoration, government efforts in these areas would not get the required emphasis and thrust. With regard to implementation of programmes for control of water pollution, the report observed that the current programmes for control of pollution of rivers, lakes and ground water were insufficient and the institutional set-up to manage programmes for control of pollution in rivers, lakes and ground water was inadequate. The performance of projects undertaken under National River Conservation Plan was observed to be unsatisfactory and the National Lake Conservation plan ineffective in achieving the objective of conservation and restoration of lakes in India, with the inspection and monitoring of projects under NRCP and NLCP observed to be inadequate at the local, state and central levels (CAG, 2011).

In the light of the comprehensive recommendations of the CAG report, MoEF in May 2011 constituted a Committee to consider these recommendations and prepared a roadmap for implementation of recommendations/observations accepted. A time-bound action plan to address capacity issues related to sewage treatment, an amendment to the Environment (Protection) Act, 1986 to link penalties for contravention of the Act, strengthening of Water Quality Assessment Authority and constitution of a State-level Monitoring Committee were among the proposals of this committee. Seven years down the line untreated faecal sludge and septage from cities is still the single biggest source of water resource pollution in India (Ministry of Urban Development, India, 2017).

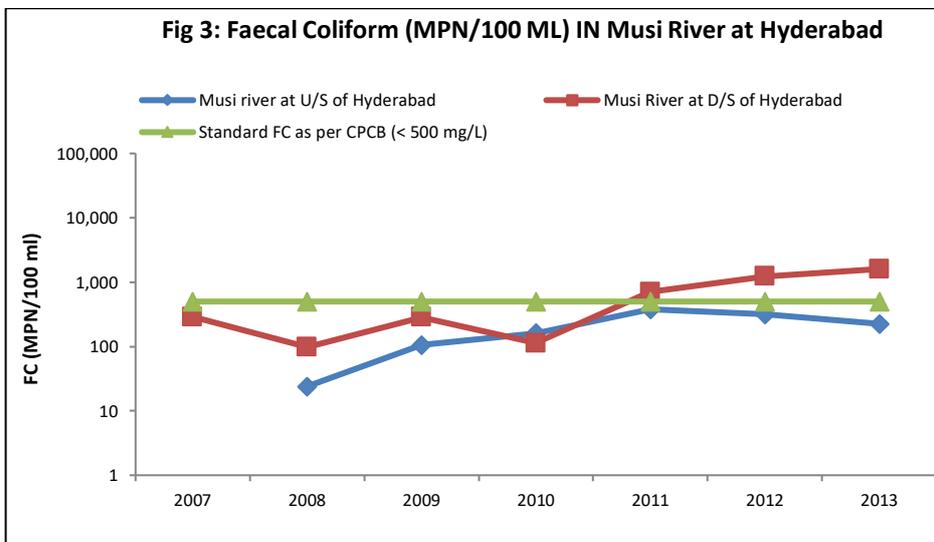
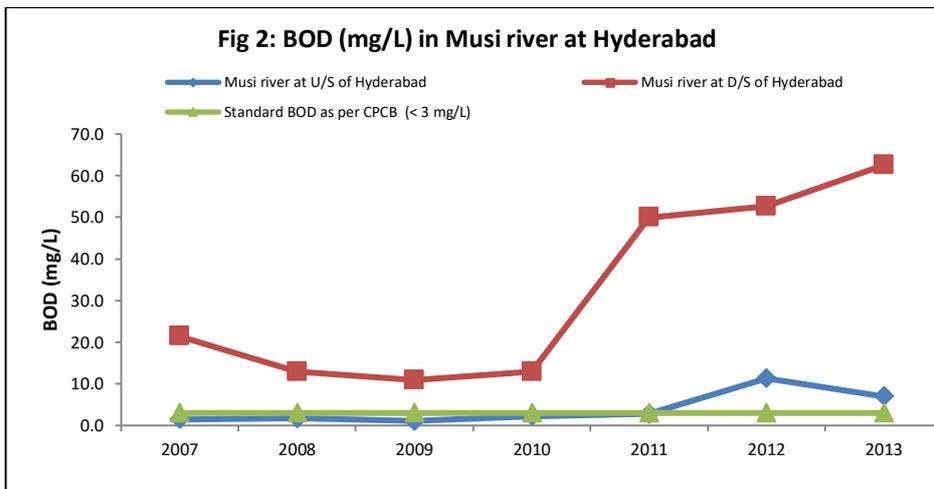
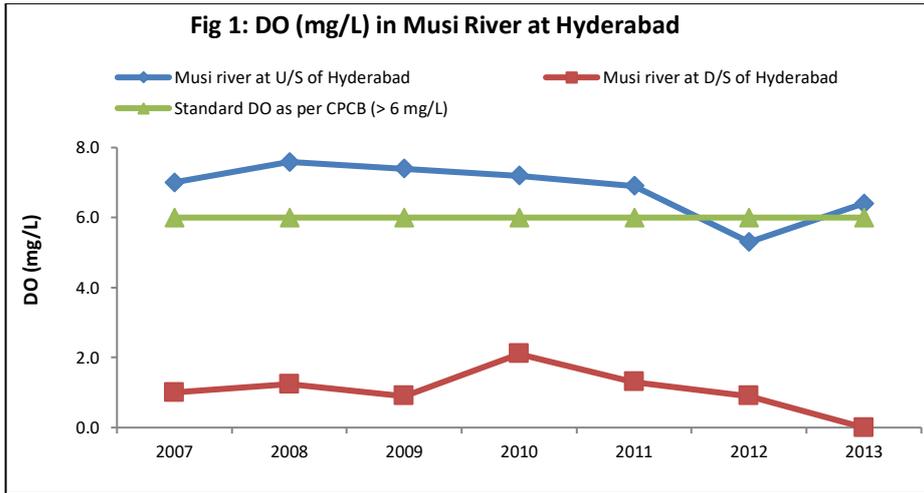
The CAG report says, "River cleaning and control of pollution programmes for our polluted rivers are being implemented since 1985. The programmes seek to address pollution from point and non-point sources through construction of Sewage Treatment Plants, low cost sanitation, electric crematoria etc. However, the data on the results of these programmes are not very encouraging" and that "Most lakes in India are under threat from nutrient overloading which is causing their eutrophication and their eventual choking up from the weeds proliferating in the nutrient-rich water. Implementation of NLCP in conserving these lakes has had no discernible

effect". With respect to ground water, 17 States had identified existing pollution levels in terms of arsenic, nitrate, salinity etc.

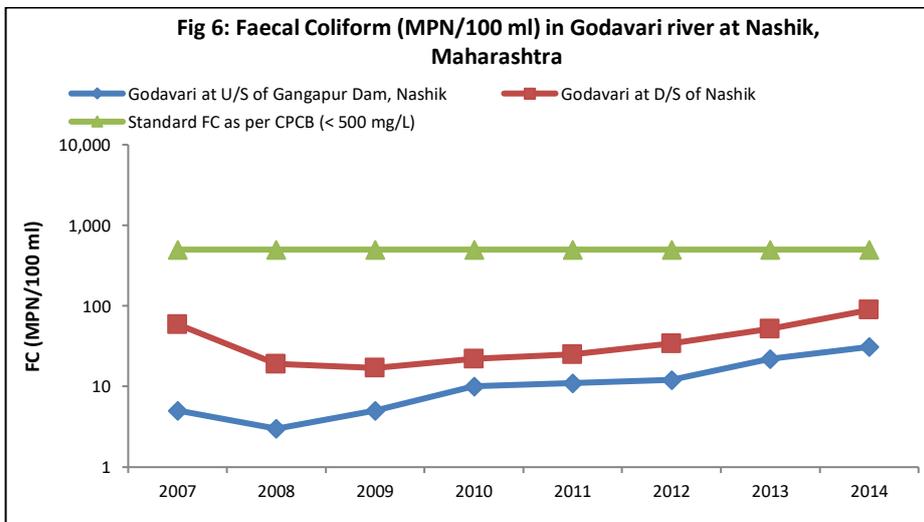
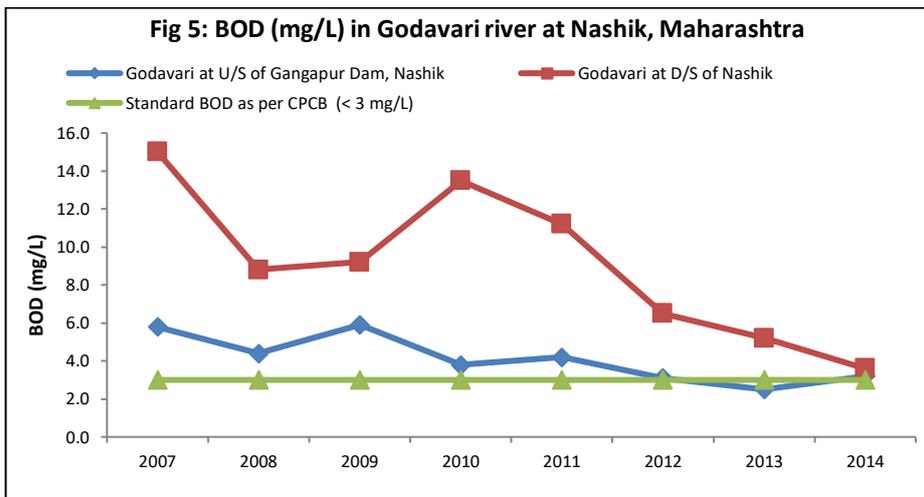
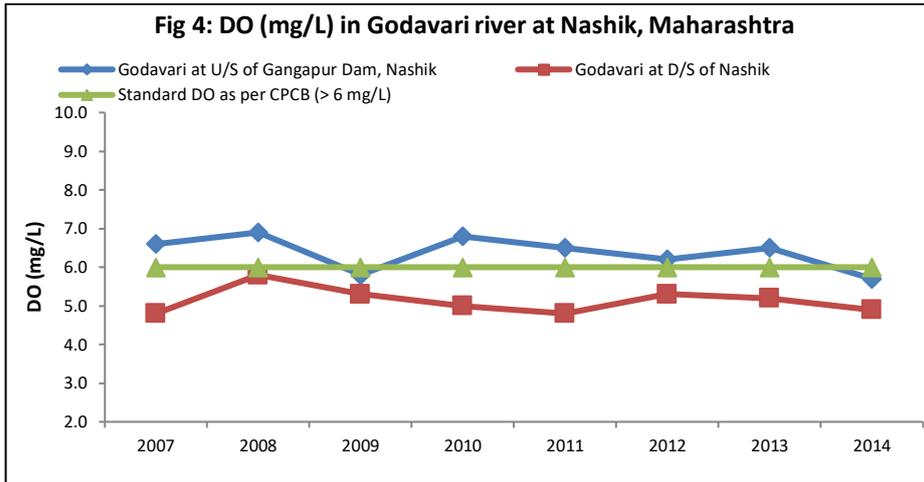
The norm for Dissolved Oxygen (DO) is 6 mg/litre or more and that for Biochemical Oxygen Demand (5-day BOD at 20 degrees Celsius) is 3 mg/litre or less for drinking water sources without conventional treatment but after disinfection. Faecal Coliform(MPN/100m1) should be less than 500 for treated water disposed on water or land and in class B water fit for outdoor bathing (http://www.cpcb.nic.in/Water_Quality_Criteria.php). The water quality in rivers upstream and downstream of selected cities over a period of time was analyzed. It is seen that mostly the BOD and faecal coliform are well above and DO well below the norms, especially downstream of the cities. What is of particular significance is that there has been no improvement in these values over the period from 2007 to 2013 in spite of the many programmes for the rejuvenation of rivers. The faecal coliform in Ganga downstream of Varanasi is a staggering 1, 00,000 while the norm is 500! If this is the situation in the Ganga with a national mission for cleaning the river, what can be said of the other rivers in the country?

A similar trend can also be noticed in the case of lakes. With respect to lakes, no basin wise planning is undertaken and no water quality goals established. As for the projects undertaken under NLCP for restoration and conservation of lakes, only in a few lakes like Nainital Lake in Uttarakhand, Kotekere and Sharanabasaveshwara lakes in Karnataka and Mansagar in Rajasthan, the water quality improved after completion of conservation programmes. Bellandur Lake in Bengaluru which remains extremely polluted till date was one of the lakes included in the programme. The project had to be suspended due to the inability of authorities to stop the huge inflow of sewage into the lake which made the lake non-conducive to bio remedial treatment. Figures 1 to 18 indicate the water quality in selected polluted river stretches of India.

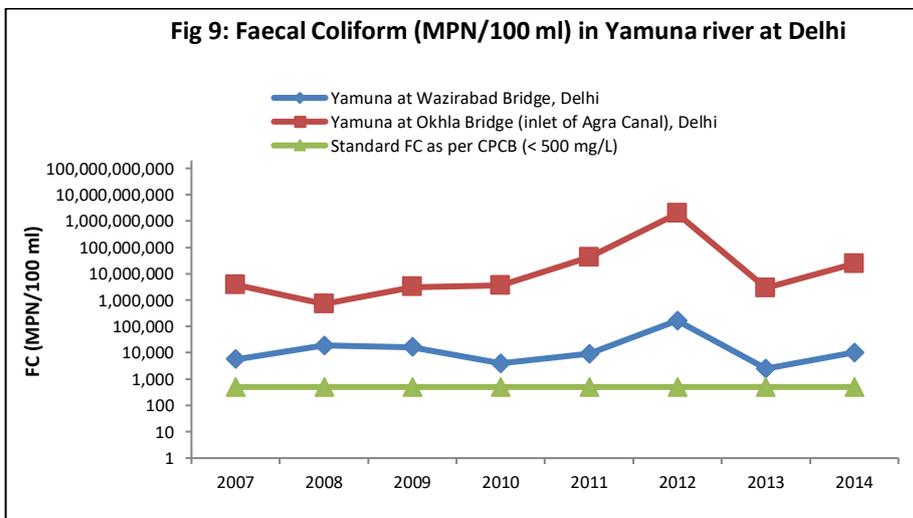
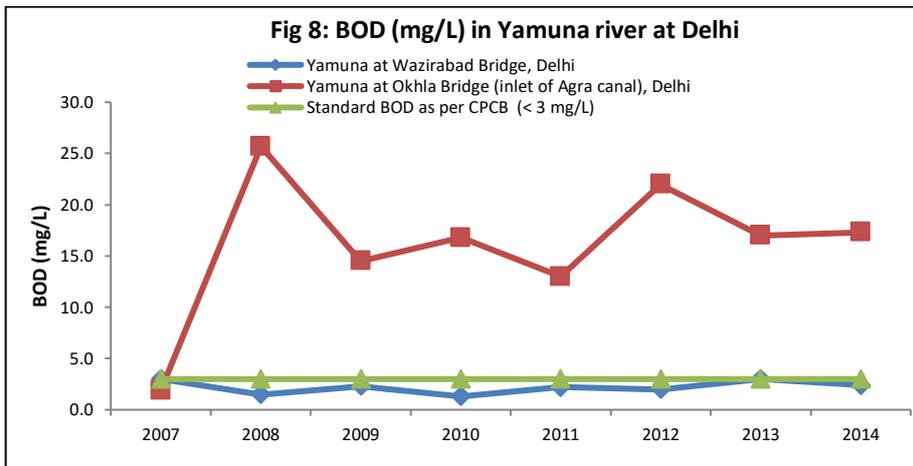
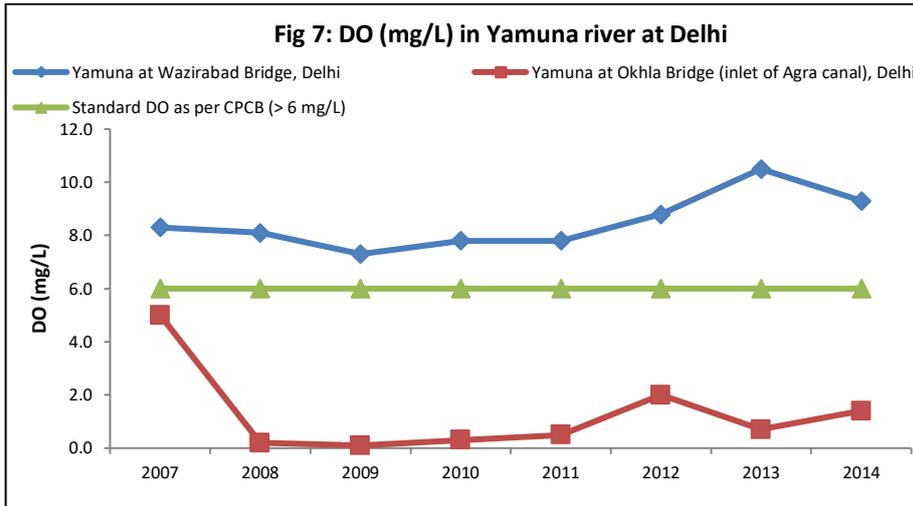
1. Musi River at Hyderabad



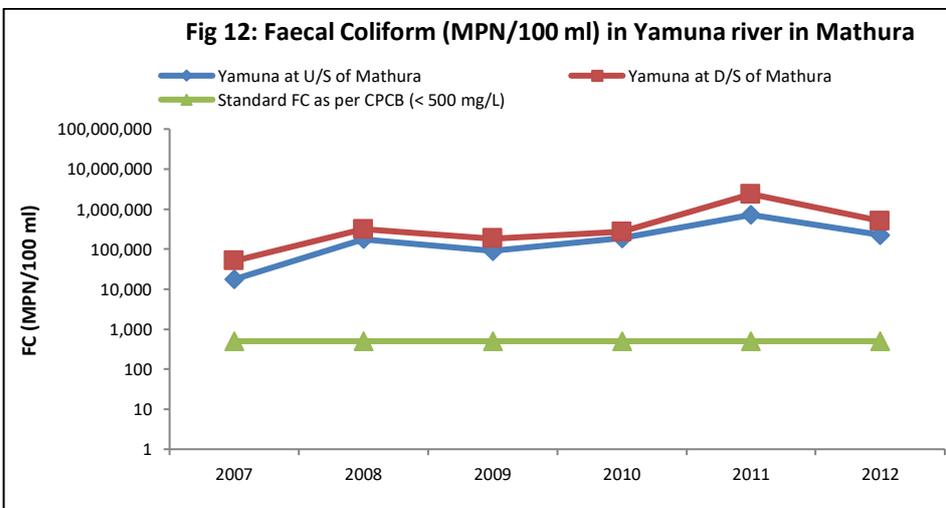
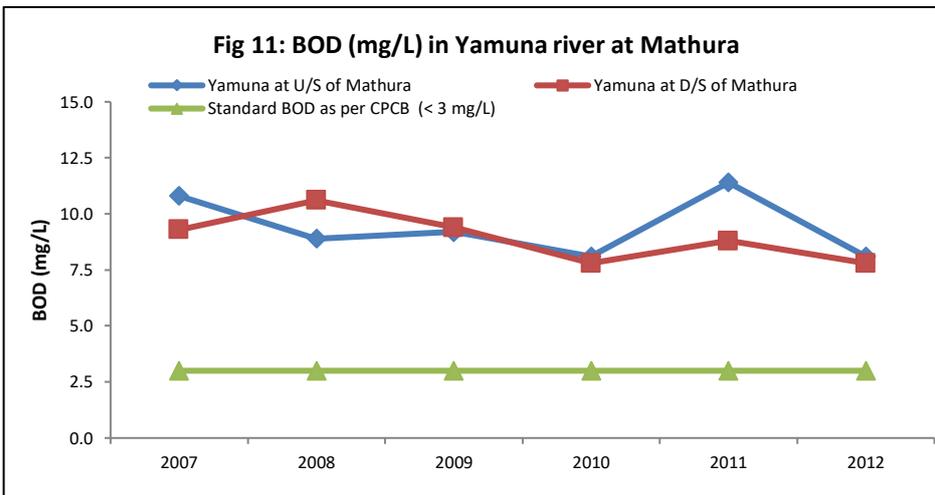
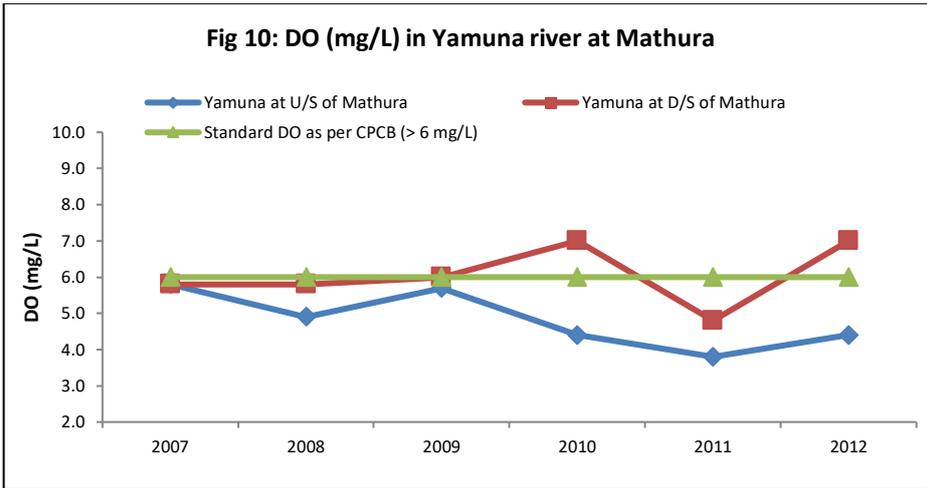
2. Godavari River at Nashik



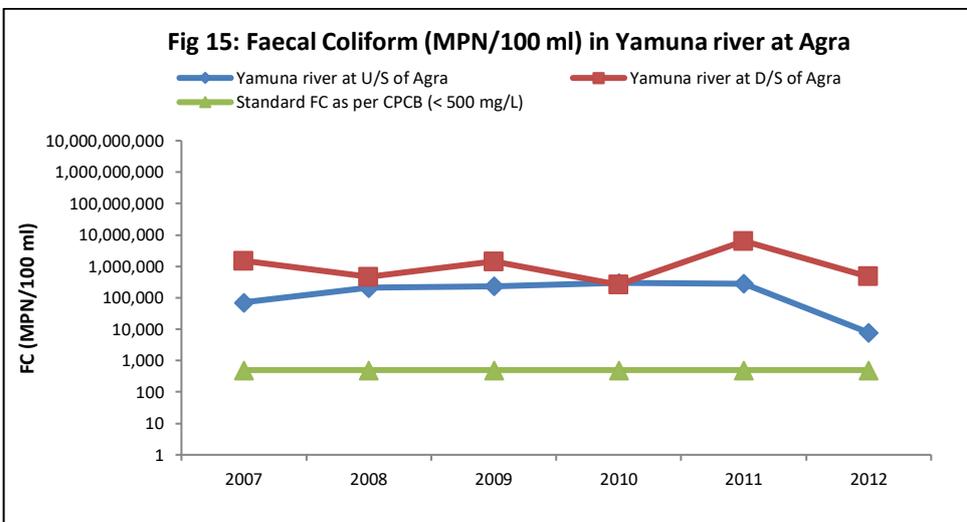
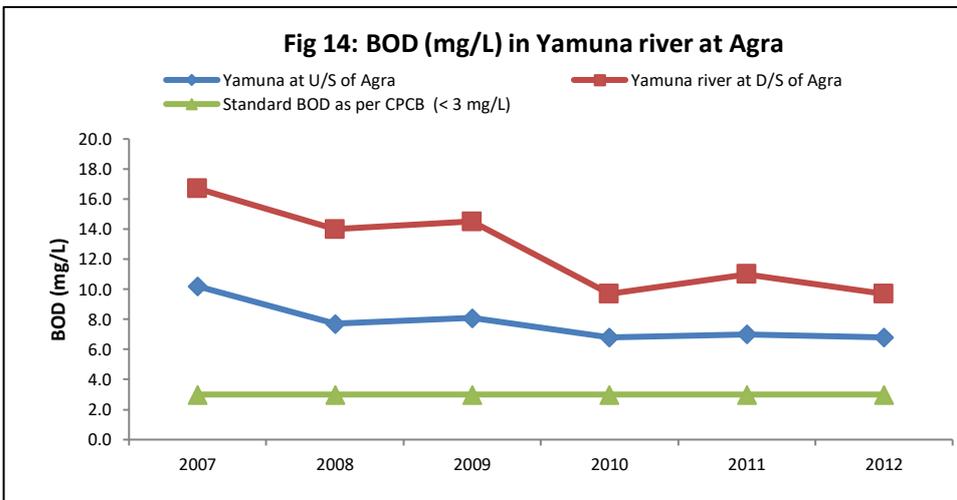
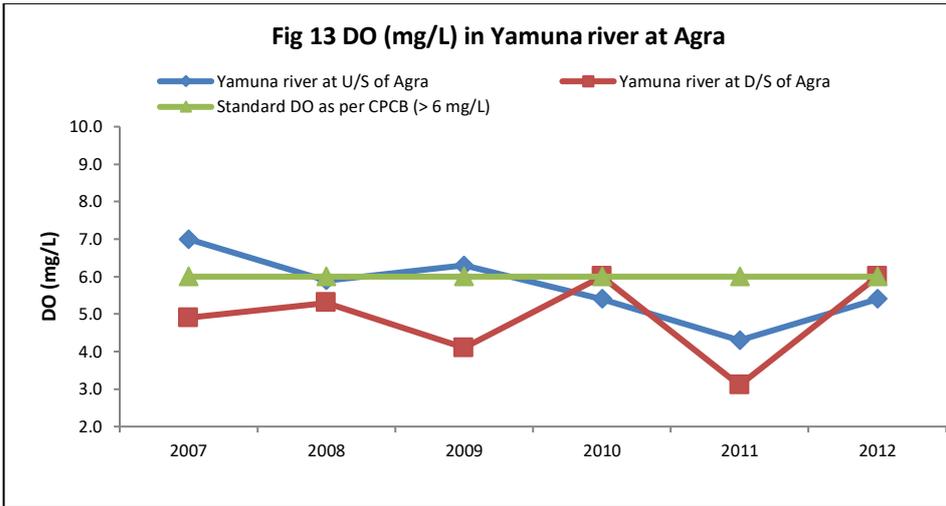
3. Yamuna River at Delhi



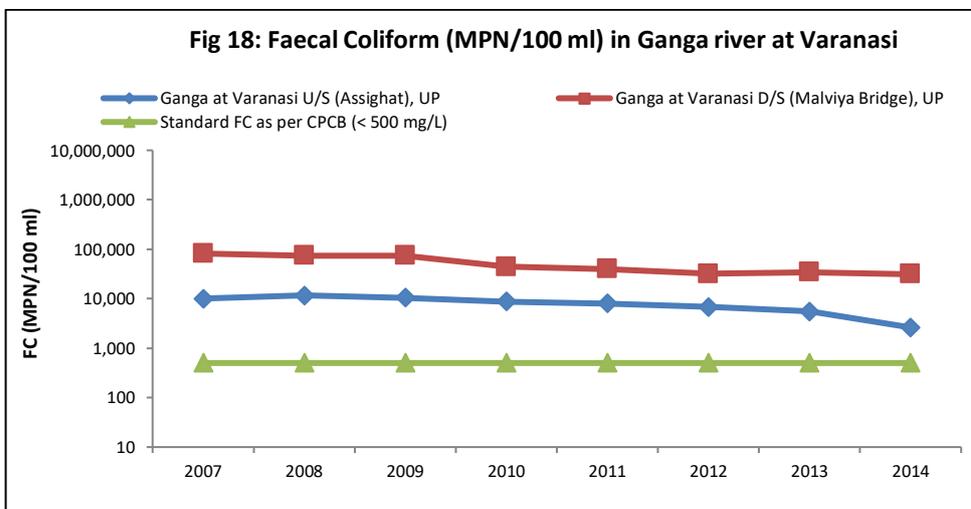
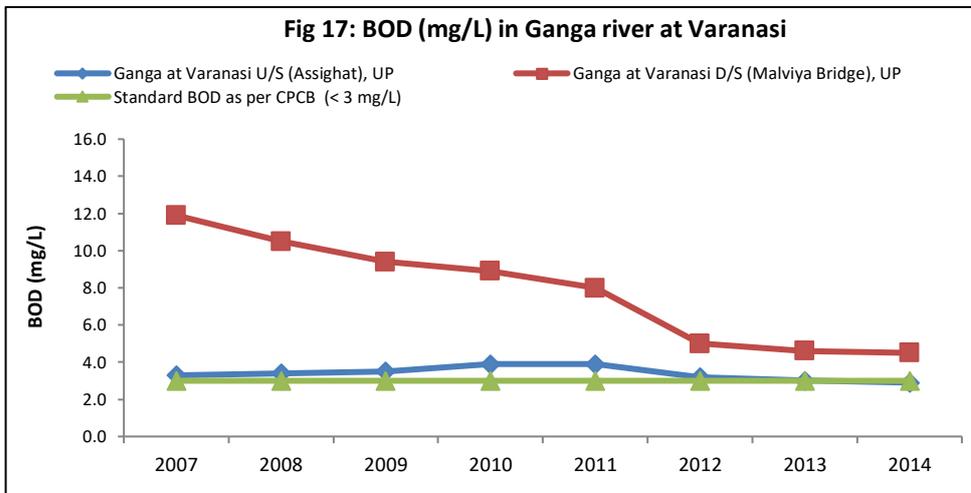
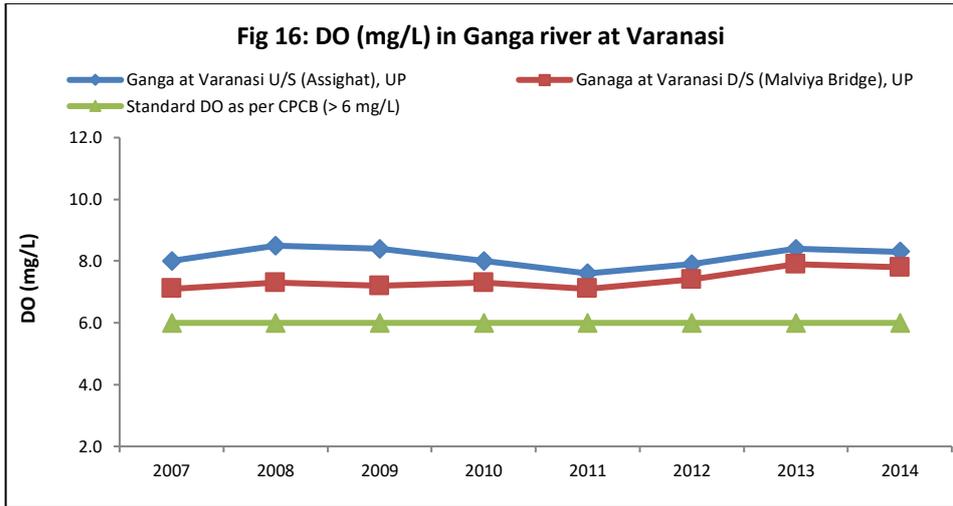
4. Yamuna at Mathura



5. Yamuna at Agra



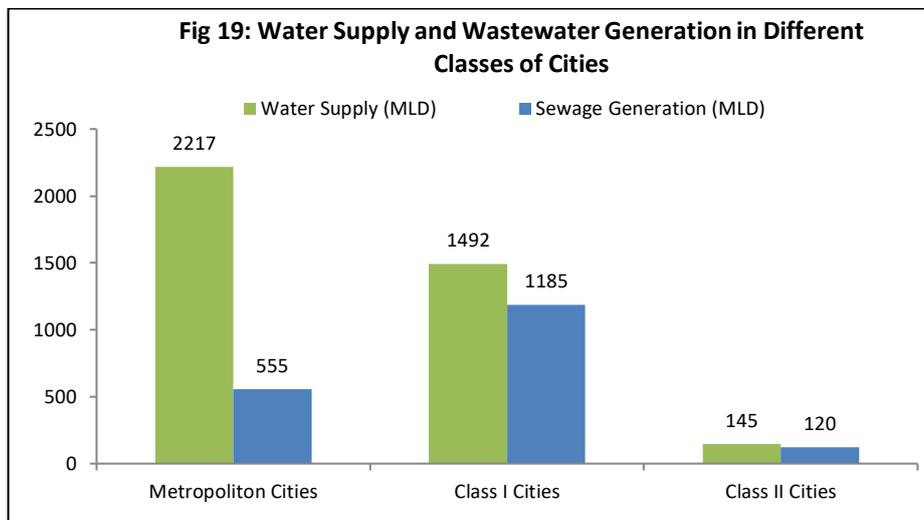
6. Ganga at Varanasi



3. Waste Water Generation and Treatment in Urban Areas

The Central Pollution Control Board in India has acknowledged that pollution caused by sewage discharged from cities and towns is the primary reason for the degradation of our water resources.

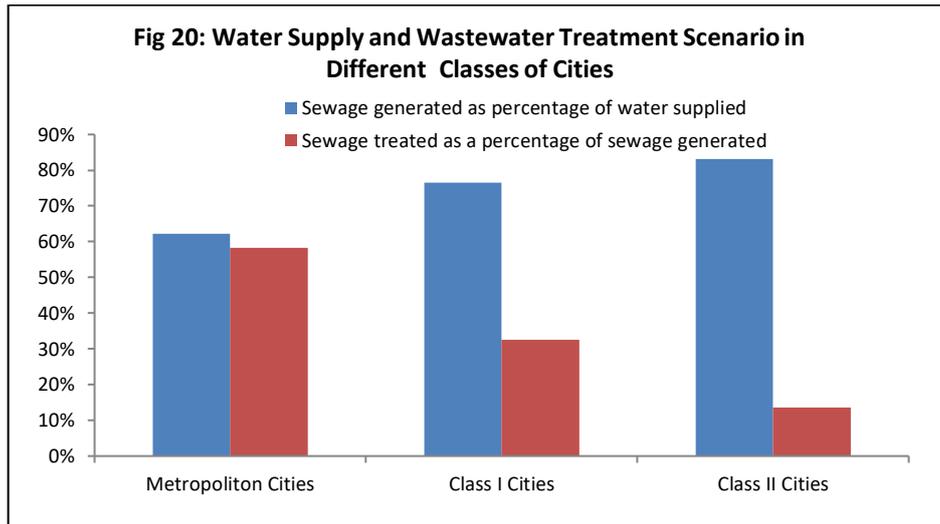
As per Census of India, 2011, more than 377 million people live in urban areas, which amount to 31.16% of the total population of India. A town or Urban Agglomeration (UA) with a population of 100,000 or above is categorised as a Class I UA/Town while Class II towns have a population between 50,000 and 99,999. 70% of India's urban population live in Class I UA/Towns. There are 468 UAs/Towns belonging to Class I category, 53 of which have a population of one million or above and house 42.6% of the urban population; Greater Mumbai UA (18.4 million), Delhi UA (16.3 million) and Kolkata UA (14.1million) with more than 10 million people are known as the mega cities. The urban population is expected to grow by 404 million by 2050 (World Urbanisation Prospects, 2014). While the population growth in the mega cities has slowed down considerably in the past decade, population is expected to rise in smaller towns and cities and new towns added.



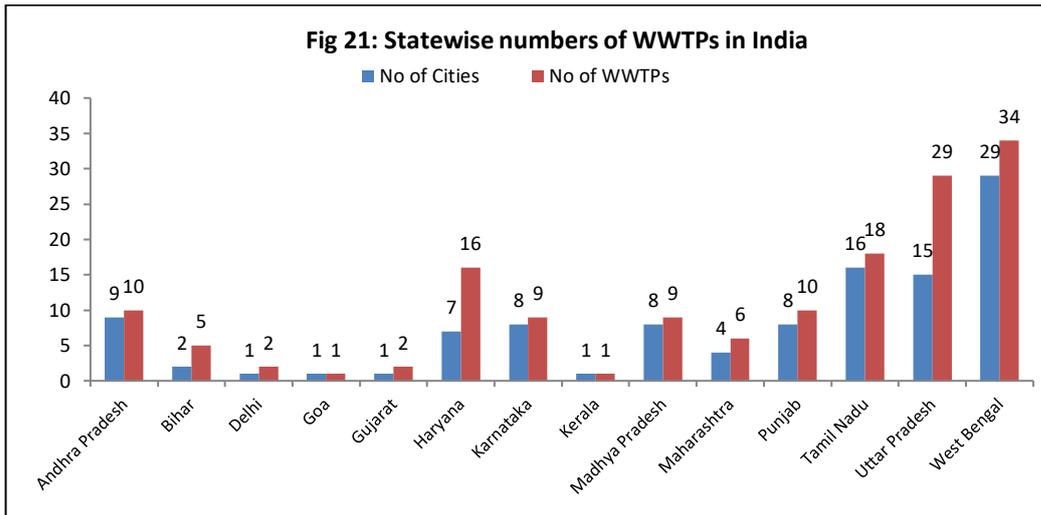
There is wide variation between states and between cities regarding availability of piped water supply as well as waste water treatment facilities and sewage networks. On an average, 80% of the fresh water supplied to a city or town gets converted into waste water. Figure 19 shows the water supply and waste water generation in different classes of cities.

3.1 Sewage Treatment Capacity

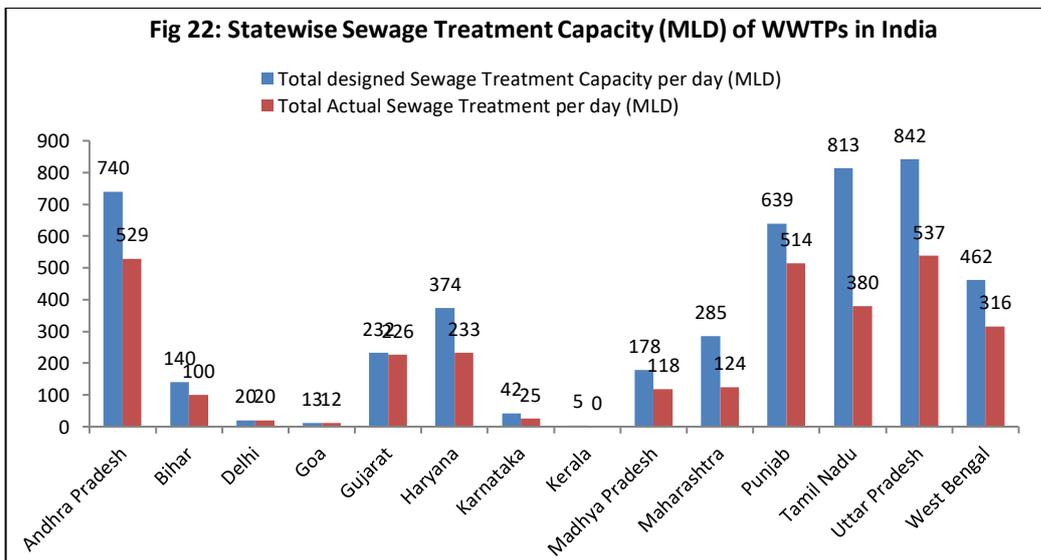
During 2015, the estimated sewage generation in the country was 61754 Million Litres per Day (MLD) as against the developed sewage treatment capacity of 22963 MLD (CPCB, 2016). The technology adopted by most Sewage Treatment Plants (STPs) are: 1) Primary settling followed by Activated Sludge Process (PST+ASP), 2) Up flow Anaerobic Sludge Blanket + Polishing Pond (UASB+PP) and 3) a series of Waste Stabilization Ponds (WSPs). There is a big gap between waste water generated and treatment capacity available, for domestic waste water and for industrial wastewater, mainly generated from small-scale industries.



CPCB had reported in 2005 that existing treatment capacity for domestic waste water was 18.6 % of sewage generated while the actual capacity utilization of STPs was only 72.2%, with the result that only 13.5 % of the sewage generated was being treated. To quote CPCB, “This clearly indicates dismal position of sewage treatment, which is the main cause of pollution of rivers and lakes. Operation and maintenance of existing plants and sewage pumping stations is also a very neglected field, as nearly 39% plants are not conforming to the general standards prescribed under the Environmental (Protection) Rules for discharge into streams” (CPCB, 2005). In 2009 the treatment capacity was reported to be 30% of the sewage generated. The installed capacity of sewage treatment plants in the country was 11800 MLD with a capacity utilization of only 65% the main reason for which being the lack of proper sewer networks for collection and transport of sewage to the treatment plants. This means that only 20% of a total quantity of 38000 MLD of sewage generated in Class I cities and Class II cities/towns was actually being treated, and that the “dismal position” regarding sewage treatment reported by CPCB in 2005 had not improved much. The treatment capacity in 2015 had increased to 22963 MLD. However, this has been offset by the increased rate of urbanisation with the result that the sewage treated as a percentage of sewage generated has not changed significantly. CPCB in its bulletin dated July 2016 said “Because of the hiatus (sic) in sewage treatment capacity, about 38791 MLD of untreated sewage (62% of the total sewage) is discharged directly into nearby water bodies”. Thus, it can be seen that there is not much improvement regarding the status of waste water treatment in the country in 2015, compared to 2005. Figure 20 gives an indication of the waste water treatment scenario in different classes of cities in India while Figures 21 & 22 give the state wise numbers of Waste Water Treatment Plants (WWTPs) and waste water treatment capacities.



All the metropolitan cities have a sewerage system but only a third of the Class I cities and less than one-fifth of the smaller sized urban centres do. The percentage of population covered by the sewerage system is partial in all urban centres. The system does not function properly in some cities or is defunct; others have a sewerage system but do not have sewage treatment plants to treat wastewater, resulting in untreated sewage being discharged into water bodies (CPHEEO, 2005). In 2012, only 13 out of 1000 households or 1.3% of the households in India had access to a toilet connected to a piped sewer system (National Sample Survey, 2014).



3.2 Sanitation Access in Urban India

While access to piped water supply in urban areas shows wide variation across states, ranging from 20% of the population in Bihar to 95.5% in Himachal Pradesh, there is not so much variation in the percentage of population having access to water for all household purposes. Access to water for use in toilet also does not show such a wide variation across states. While only 20% of the urban population in Bihar, 30.2% in Assam and 34.9% in Kerala get piped water supply as against 96.8 in Chandigarh, 82.6, 91.1 and 99.2 percentages of the urban households in these states have access to water for use in toilets from other sources.

The percentage of the urban population having sanitary toilets varies from 77.7% for Jharkhand to 100% for Uttarakhand and Arunachal Pradesh, with a national average of 88.8%. However, the number of administrative wards in the urban areas connected to the sewer network shows a much wider variation ranging from 0% in Meghalaya to 92.1% in Delhi and 93.2% in Gujarat (Swachhta Status Report, 2016). Wherever the toilets are not connected to a sewer network, various on-site sanitation systems are in use, mainly septic tanks. With more people migrating to cities and towns leading to increased population density in these urban centres, provision of on-site sanitation systems will become increasingly difficult. There will also be higher incidences of contamination of both surface and underground drinking water sources.

The situation being so, the Swachhta Report, 2016 only provides data on disposal of household waste water but not waste from toilets. The report says that in Census 2011, information was collected on the system of disposal of waste water which included kitchen waste water, bath and wash water but not the waste from latrines. The Swachh Survekshan, 2017 published by the Ministry of Urban Development, Government of India, evaluates cities on the basis of cleanliness, sanitation and municipal documentation. While freedom from open defecation and the availability of toilets are among the criteria based on which a city is evaluated, management of waste water from the toilets does not find mention in the report at all. There is no mention of wastewater treatment or availability of sewage network in the document.

3.3 Reuse of Wastewater

The water situation being so precarious there is increasing awareness on the need to treat and reuse waste water. Not only is it necessary in the context of increasing demand for water in the domestic, industrial and power sectors with an increasing urban population but also to protect the fresh water sources from pollution and prevent overdraft of ground water. Many city administrations have started moving in this direction.

The Haryana Urban Development Authority (HUDA) plans to reuse treated waste water on a large scale. It is proposed to use treated waste water for public parks and green belts as well as for activities like construction. In fact, part of the treated water from the Dhanwapur plant is being bought by builders for construction activities while a portion of the water that is allowed to flow into the Yamuna is used by farmers for irrigation.

The New Delhi Municipal Council (NDMC) is constructing decentralised sewage treatment plants in NDMC area at 10 locations with different capacities, with plans to use the treated water for horticulture in the neighbourhood. NDMC has also identified 12 schools where decentralised sewage treatment plants of varying sizes, depending on available areas, will be set up. Delhi has set targets to treat and reuse 25% of total sewage produced, by 2017, increasing it to 50% by 2022 and to 80% by 2027 (PwC, 2006). The National Capital Region Planning Board in its proposal for 2021 says that all new development areas should have two distribution lines, one for drinking water and other for non-drinking water/recycled treated waste water for reuse and that all the water requirements for non-drinking purpose in big hotels, industrial units, central air-conditioning of large buildings/institutions, large installations, irrigation of parks/green areas and other non-potable demands should be met through treated recycled waste water.

The Chennai Metropolitan Water and Sewerage Board (CMWSB) sells secondary treated sewage to industries and the Chennai Municipal Corporation uses secondary treated sewage for watering plants and lawns in public parks and traffic islands. Part of the treated effluent is being auctioned off and used for the cultivation of Para grass for use as fodder, since the formation of

CMWSB in 1978. The Sewage Treatment Plants commissioned in 2005 and 2006 are self-supporting without any need for additional power from the electricity grid (UDRI, 2017). The present treatment capacity of the STPs under CMWSB is 486 MLD. Though the treatment capacity is sufficient to treat the waste water generated from the water supplied by the board, the actual water use in the city is much higher when you include supply from private sources, resulting in untreated sewage entering the storm water drains and water bodies.

The Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB) offers treated domestic waste water from its Sewage Treatment Plants (STPs) for non-potable uses as in construction. HMWSSB charges Rs 125 per 5,000 litres, with the tanker and transportation charges to be borne by consumers (Telangana Today, 2017). All the treated effluent was earlier diverted into the Musi River which farmers have been lifting for irrigation purposes.

In Bengaluru, the Bangalore Water Supply and Sewerage Board (BWSSB) supplies 40 MLD of tertiary treated water to the Kempegowda International Airport. BWSSB sells tertiary treated water at Rs 25 per Kilolitre. Surat, Nagpur and Vishakhapatnam are other cities where treated water is used by industries.

4. Institutional and Legal Regime for Control of Water Pollution

The Water (prevention and control of pollution) Act, 1974 (amended in 1988), aims to prevent and control water pollution and to maintain/restore wholesomeness of water by establishing central and state pollution control boards to monitor and enforce the regulations. The act defines the composition of the Central and State Pollution Control Boards as well as the terms and conditions of service of the members of the boards. The Water (Prevention and Control of Pollution) Cess Act, enacted in 1977 and amended in 2003, provides for the levy and collection of a cess on water consumed by persons operating and carrying on certain types of industrial activities to augment the resources of the Central Board and the State Boards for the prevention and control of water pollution. This act sets the standards and penalties for non-compliance for polluting bodies.

The Pollution Control Board advises the government on any matter concerning the prevention and control of water pollution, coordinates the pollution control activities, and provides technical assistance and guidance. The central and state pollution control boards collect, compile and publish technical and statistical data relating to water pollution and the measures devised for its effective prevention and control. They prepare manuals, codes and guidelines relating to the treatment and disposal of sewage and trade effluents and disseminate information related to the same. Water quality monitoring is therefore a prerequisite in order to assess the extent of pollution as well as the status regarding maintenance and restoration of water bodies.

Water quality monitoring is performed with the following objectives:

- Rational planning of pollution control strategies and their prioritisation
- Assessing the nature and extent of pollution control needed in different water bodies
- Evaluating the effectiveness of pollution control measures already in existence
- Evaluating water quality trend over a period of time
- Assessing the assimilative capacity of a water body thereby reducing cost on pollution control
- Understanding the environmental fate of different pollutants
- Assessing the fitness of water for different uses

As on 2012, the monitoring network comprised of 2500 stations in 28 States and 6 Union Territories spread over the country and covered 445 Rivers, 154 Lakes, 12 Tanks, 78 Ponds, 41 Creeks/Seawater, 25 Canals, 45 Drains, 10 Water Treatment Plants (Raw Water) and 807 Wells. Of the 2500 stations, 1275 were on rivers, 190 on lakes, 45 on drains, 41 on canals, 12 on tanks, 41 on creeks/seawater, 79 on ponds, 10 on Water Treatment Plants (Raw Water) and 807 were Ground water stations. The inland water quality-monitoring network is operated under a three-tier programme i.e. Global Environmental Monitoring System (GEMS), Monitoring of Indian National Aquatic Resources System (MINARS) and Yamuna Action Plan (YAP) (CPCB, 2012). In addition to general parameters, core parameters like pH, Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD), biological monitoring and monitoring the presence of trace metals and pesticides are undertaken.

The steps involved in the preparation of a water quality management plan by the Central Pollution Control Board (CPCB) are:

- Setting water quality goals
- Water quality monitoring
- Identification of the nature and magnitude of pollution
- Inventorying the sources of pollution
- Collation of water quantity information
- Selection of technologies for pollution control
- Financing waste management
- Maintenance of sewage treatment plants
- Control of industrial pollution including recycling and resource recovery, use of clean technologies, setting waste water discharge standards and charges on residual pollution (CPCB, 2008)

The Central Pollution Control Board has developed a concept of designated best use; according to this, out of the several uses of water of a particular body, the use which demands highest quality is termed its designated best use. This classification helps the water quality managers and planners to set water quality targets and design suitable restoration programmes for various water bodies.

The five designated best uses have been identified as given below:

- Drinking Water Source without conventional treatment but after disinfection
 - Outdoor bathing (Organised)
 - Drinking water source after conventional treatment and disinfection
 - Propagation of Wild life and Fisheries
 - Irrigation, Industrial Cooling, Controlled Waste disposal
- (http://www.cpcb.nic.in/Water_Quality_Criteria.php)

CPCB suggests that a major part of the cost on waste management should be borne by the urban population according to the 'polluter pays principle' which can be applied to domestic and industrial dischargers to induce waste reduction and treatment and can provide a source of revenue for financing wastewater treatment investments.

In order to protect the water quality of rivers, the National River Conservation Directorate (NRCD) was established by the Government of India under the Ministry of Environment, Forests and Climate Change (MoEF), to provide technical and financial support to State Governments for

the development of sewage treatment capacities of those municipalities which are discharging their wastewater into natural water bodies. The river cleaning programme in the country was initiated with the launch of the Ganga Action Plan (GAP) in 1985 and was expanded to cover other rivers under the National River Conservation Plan (NRCP) in the year 1995. The pollution abatement works are implemented on a cost sharing basis between the Centre and State Governments and include collection, transportation and treatment of municipal sewage, River Front Development (RFD), Low Cost Sanitation (LCS), Electric Crematoria, etc while prevention and control of industrial pollution is being addressed by the Central and State Pollution Control Boards/Pollution Control Committee.

NRCD's National Lake Conservation Plan (NLCP) has a 70:30 funding pattern and includes the core components of interception, diversion and treatment of wastewaters before their entry into the lakes, catchment area treatment, shoreline protection, in-lake treatment etc while non-core activities include lake front eco-development and public participation. The National Wetlands Conservation Programme (NWCP) is for the conservation of wetlands including Ramsar sites in the country.

The National Urban Sanitation Policy's (2008) vision for urban sanitation in India is that 'All Indian cities and towns become totally sanitized, healthy and liveable and ensure and sustain good public health and environmental outcomes for all citizens with a special focus on hygienic and affordable sanitation facilities for the urban poor and women.'

The Municipal Solid Waste (Management and Handling) rules was notified in the year 2000 by the MoEF requiring Urban Local Bodies to collect waste in a segregated manner as well as transport, process and dispose it using safe and scientific methods. This was replaced in 2016 by the new Solid Waste Management Rules (SWM), 2016. The SWM rules is the sixth in the category of waste management rules notified by MoEF, the others being plastic, e-waste, biomedical, hazardous and construction and demolition waste management rules. In 2014, the Central Public Health and Environmental Engineering Organization (CPHEEO) in collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) had also published a Municipal Solid Waste Management (MSWM) Manual with an aim to guiding all urban areas in the country towards Sustainable Municipal Solid Waste Management, adopting the aspects of waste minimization at source with an emphasis on the 3R principles of reduce, reuse and recycle. The manual deals in detail with all aspects of Municipal Solid Waste Management including planning, institutional, financial and technical aspects with a step by step guide to MSWM.

The 2008 National Urban Sanitation Policy (NUSP) made local governments responsible for behavioural change, total sanitation and 100 per cent safe waste disposal. It envisages that cities will implement City Sanitation Plans prioritizing areas that need urgent attention, and implementing long-term plans in parallel, with emphasis on mobilizing all city stakeholders and raising the importance of behaviour change, practices and installations for safe and sanitary disposal of all wastes of the city on a sustainable basis. It is the responsibility of the state governments to draft state urban sanitation policies, which in turn require cities to develop their own sanitation strategies. The Swachh Bharat Mission (SBM) also recommends that the State-level High Powered Committee (HPC) shall prepare the State Sanitation Strategy and City Sanitation Plans as envisaged under NUSP, 2008 through the State Mission Directorate. While this is a step in the right direction which allows cities to develop their own strategies that best suit the local conditions, there has not been noticeable change on the ground.

The Swachh Survekshan Report published by the Ministry of Urban Development in 2017 presents the results of a massive sanitation survey undertaken across 500 cities in India and is expected to provide a comprehensive assessment of the sanitation status of cities and foster a spirit of competition among cities through publishing their scores and rankings. However, while progress in the construction of individual as well as community toilets and the presence of a processing plant for municipal solid waste are among the factors considered in the sanitation assessment, waste water treatment and septage/faecal sludge management do not feature among the list of parameters considered (Swachh Survekshan, 2017).

The draft National Urban Faecal Sludge and Septage Management (FSSM) Policy (Ministry of Urban Development, 2017) says that the problem of faecal sludge and septage / sewerage must be addressed in a holistic manner, with a strategy that provides for minimum needs and is appropriate and affordable for all areas and population considering the local situation. The policy calls for enabling provisions in the form of suitable regulation and institutional framework, capacity building and education and awareness among all stakeholders to be addressed. The policy also points to the need to ensure the efficiency of systems in place for onsite sanitation whereof the faecal sludge output needs to be managed in an environmentally safe manner including the proper engineering design, construction and maintenance of septic tank systems, pit latrines and such other systems generating faecal sludge. Table 1 lists the laws, rules, manuals, policies, guidelines and reports available in India to help analyse, monitor and combat water pollution and protect water resources.

Table 1: Laws, rules, manuals, policies, guidelines and reports on Sanitation, Waste Management and Pollution Control
1974 - <i>Water (Prevention and Control of Pollution) Act</i>
1988 - <i>Water (Prevention and Control of Pollution) Act, Amendment</i>
1977 - <i>The Water (Prevention and Control of Pollution) Cess Act</i>
2000 - Municipal Solid Waste (Management and Handling) rules, Ministry of Environment and Forest (MoEF), (Replaced in 2016 by the Solid Waste Management Rules)
2003 - <i>The Water (Prevention and Control of Pollution) Cess Act, Amendment</i>
2008 - <i>National Urban Sanitation Policy (NUSP)</i> , Ministry of Urban Development
2008 - <i>Guidelines for Water Quality Management</i> , Central Pollution Control Board
2011 - <i>Water Pollution in India</i> . Report No. 21 of 2011-12, Comptroller and Auditor General of India
2012 - <i>Status of Water Quality in India, Monitoring of Indian National Aquatic Resources Series: MINARS/36 /2013-14</i> , Central Pollution Control Board
2014 - <i>Municipal Solid Waste Management Manual</i> , Central Public Health and Environmental Engineering Organization & Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
2016 - <i>Plastic Waste Management Rules</i> , (MoEF)
2016 - <i>e-waste (Management) Rules</i> , (MoEF)
2016 - <i>Bio-Medical Waste Management Rules</i> , (MoEF)
2016 - <i>Construction and Demolition Waste Management Rules</i>
2016 - <i>Hazardous and Other Wastes (Management and Trans boundary Movement) Rules</i> , (MoEF)
2016 - <i>Solid Waste Management Rules</i> , (MoEF)
2016 - <i>Swachhta Status Report, 2016, Ministry of Statistics and Programme Implementation</i>
2017 - <i>Swachh Survekshan (Urban Sanitation Report)</i> , Ministry of Urban Development
2017 - <i>Draft Policy on National Urban Faecal Sludge and Septage Management (FSSM)</i>

However, it may be noted that in spite of all this institutional and legal support for the control of water pollution across the country, an audit by the Comptroller and Auditor General of India, 2012 found that there is no specific policy with regard to water pollution either at the

central or state level incorporating prevention of pollution, treatment of polluted water and ecological restoration of polluted water bodies and that without this, government efforts in these areas would not get the required emphasis and thrust. The Water (Prevention and Control of Pollution) Act, 1974 also does not address the issue of restoration of polluted water bodies. The CAG feels that “the low quantum of penalty and the failure of the State in enforcing the provisions of the Act strictly to secure prevention and control of water pollution have led to the situation where the cost of non-compliance became significantly lower than the cost of compliance...” The report says that “a highly tolerant inspection regime of the State Pollution Control Boards ensures that the cost of defiance, non-adherence and violations are lower than the cost of compliance”.

4.1 Water Pollution Control in Other Parts of the World

Most developing countries have an aging, inadequate or even non-existent sewage infrastructure, unable to keep up with rising populations (UNEP, 2010). An estimated 90 percent of all wastewater in developing countries is discharged untreated directly into rivers, lakes or the oceans. The proportion of untreated sewage or industrial wastewater entering water bodies in developed countries is very low in comparison. Enforcement of environmental laws is also stricter in these countries. Another important factor is the active involvement of the general population which is not bogged down by poverty or the struggle to survive unlike in many parts of the developing world. The following image (Figure 23) from UN Water shows the ratio of treated to un-treated waste water reaching water bodies in ten regions of the world.

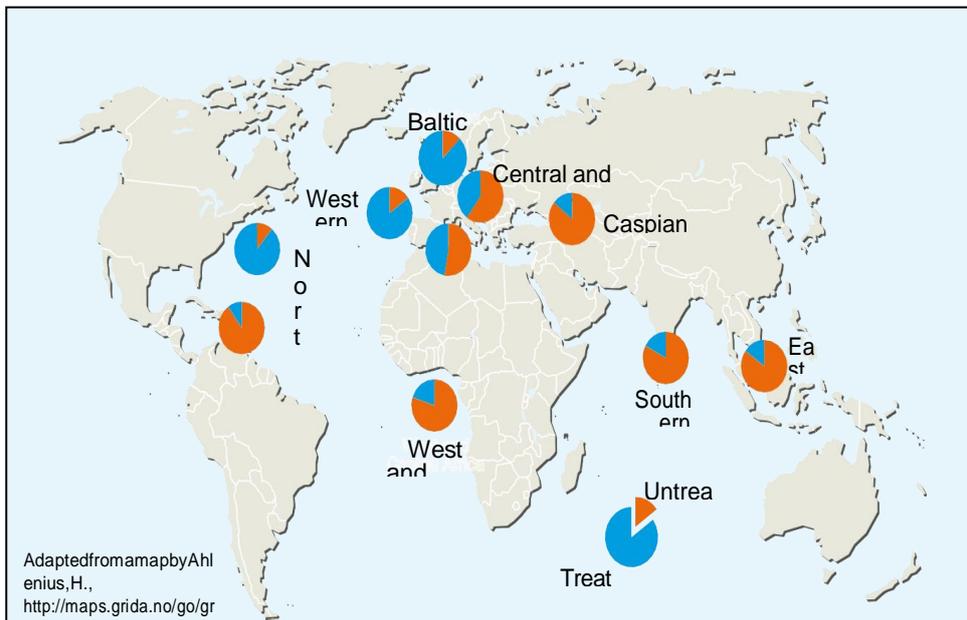


Fig 23: The ratio of treated to untreated wastewater reaching water-bodies for 10 regions (UN Water, 2008)

In the United States of America, public awakening to the need for better pollution control came through the 1967 publication of Rachel Carson's ground-breaking 'Silent Spring' and environmental disasters that happened in the country. The earliest environmental laws were the result of demands from citizens for comprehensive environmental protection laws. These early environmental laws are the broad framework on which the present national pollution control laws in the USA are based. U.S. pollution control laws are very broad and complex and are implemented in an organized system that focuses on the most effective strategies for

approaching problems and bringing about compliance with the law's stated goals. Because of its long history of environmental regulation, it is ahead of most countries in pollution control (www.pollutionissues.com)

In Singapore, the Deep Tunnel Sewerage System or DTSS uses deep tunnel sewers to convey used water by gravity to centralised water reclamation plants (WRPs) located at the coastal areas. The treated used water is further purified into ultra-clean, high-grade reclaimed water called NEWater or discharged to the sea through outfalls. By 2060, NEWater is expected to meet up to 55% of Singapore's future water demand (PUB, 2017).

The main water treatment plant in Vienna which treats approximately 90% of Vienna's sewage adopts a number of renewable energy technologies to minimize the use of resources and is expected to be energy self-sufficient by 2020. Energy consumption is also reduced through process optimisation and infrastructural measures. The plant uses a two-stage activated sludge process which combines the advantages of a two-stage process with optimal use of the volume for denitrification in both stages (ebswien hauptkläranlage, 2017).

5. Technologies for Wastewater Treatment

Centralised treatment of wastewater is normally used for urban areas where water supply is normally adequate to generate sufficient waste water for its flow in the sewer system. As seen in section 3, there is a big gap in treatment capacity for domestic wastewater. There is also a gap in treatment of industrial wastewater, mainly generated from small-scale industries. Wastewater treatment systems can be classified as conventional or centralized wastewater treatment systems and decentralised systems of wastewater treatment.

Open defecation is highly prevalent in rural areas in India. Given the dispersed and unplanned development in rural areas and the technical expertise required to operate them, it is not practical to provide centralized sewage treatment systems in rural areas. Various types of decentralized systems are in use in rural areas chief among them being pit latrines and septic tanks.

5.1 Conventional or Centralised Wastewater Treatment

The Sewage Treatment Plants (STPs) are based on different technologies to treat waste water. However, only a few sewage treatment plants in India are functioning satisfactorily. Many STPs in urban areas are non-functional due to various problems associated with the centralised treatment system. Due to lack of required operational and maintenance facilities, untreated and semi-treated waste water flows into rivers causing severe health and environmental problems. STPs are also used for decentralized waste water treatment in urban areas for small townships, apartment complexes and even individual apartment blocks.

Centralised waste water treatment entails high operation and maintenance costs. Experienced technical personnel are required to implement and operate the system. Due to high electrical energy requirement, the system does not work where electricity is not available on a continuous basis. On an average, the Operation & Maintenance cost for per MLD treatment of sewage is estimated at Rs 30,000 per month with advanced treatment technologies incurring higher expenses. The activated sludge treatment process requires 2.6 Kilo Watt of electricity per MLD sewage (CPCB, 2013).

'Conventional' wastewater treatment separates solids from liquids by physical processes and then purifies the liquid using biological and chemical processes. The process is divided in three phases (mechanical, biological and chemical), which are referred to as primary, secondary and tertiary treatment. The purpose of primary treatment is to separate solids from liquids as much as possible, producing a homogeneous liquid that can be treated biologically, and a sludge that can be disposed or treated separately.

Primary treatment removes large objects and reduces oils, grease, sand, grit and coarse solids. This is usually done using large sedimentation tanks and rotating screens to remove floating and larger materials.

Secondary treatment is intended to degrade organic compounds that consume oxygen when degraded and therefore increase the BOD and COD of the water. To do this, most treatment plants in developed countries use a process known as activated sludge process in which the liquid is heavily oxygenated and substrate is provided so that naturally occurring bacteria and protozoans consume the biodegradable soluble organic compounds. These microorganisms also bind less soluble fractions into floc particles that tend to settle to the bottom of the tanks. Eventually the microorganisms also flocculate and settle so that the supernatant liquid can be discharged.

Tertiary treatment is the final stage to raise the effluent quality to the standard required before being discharged. This phase usually includes different types of filtration, nutrient removal and chemical disinfection treatments.

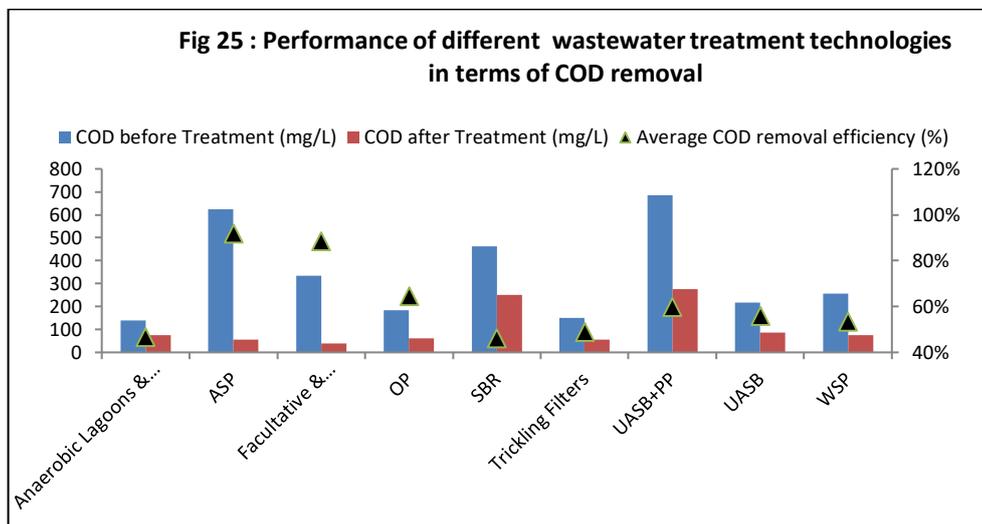
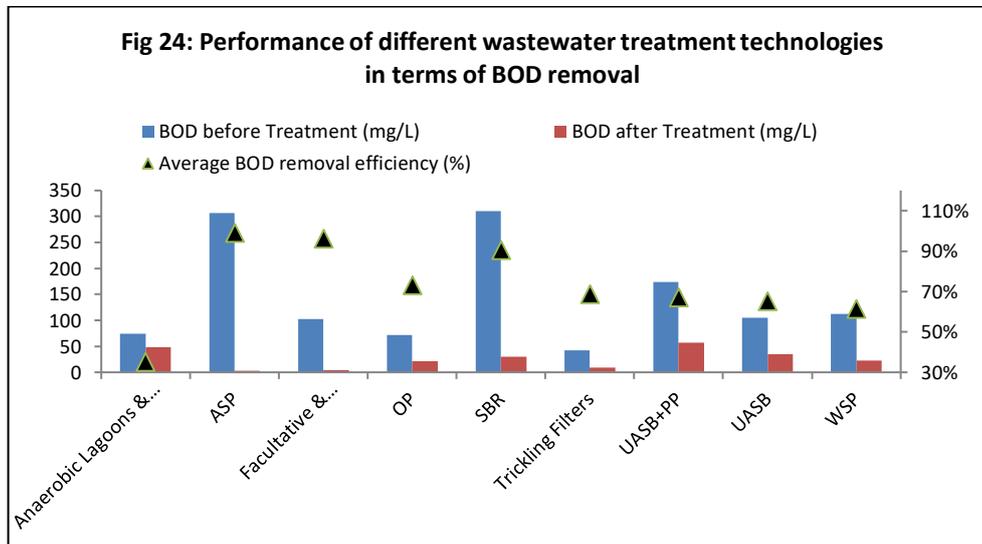
5.3 Treatment Technologies used in Sewage Treatment Plants in India

In Class I cities, the Activated Sludge Process (ASP) is the most commonly employed technology, covering 59.5% of total installed capacity followed by Up-flow Anaerobic Sludge Blanket(UASB) technology, covering 26% of total installed capacity, these two technologies being mostly used as the main treatment unit of a scheme including other primary or tertiary treatment units. A series of Waste Stabilization Ponds (WSP) is employed in 28% of the plants even though their combined capacity is only 5.6%. Activated Sludge Process (ASP) technology is the most suitable one for large cities because it requires less space as compared to the other two technologies, namely, UASB technology and WSP technology both of which are land intensive.

In Class II towns, a series of Waste Stabilization Ponds (WSP) is the most commonly employed technology, covering 71.9% of total installed capacity and 72.4% of STPs, followed by Up- flow Anaerobic Sludge Blanket (UASB) technology, covering 10.6% of total installed capacity and 10.3% of STPs. UASB technology is mostly used as the main treatment unit of a scheme including other primary and tertiary polishing units (CPCB, 2013).

In terms of BOD and COD removal using different technologies, the efficiency varies based on the climate of the region. It also depends on how the STPs are operated and maintained. It is observed that the ASP, facultative and maturation pond and SBR technologies have the highest BOD removal efficiency of about 99%, 96% and 90% respectively. The BOD removal efficiency of other technologies like OP, SBR, Trickling Filters, UASB and WSP vary between 60 and 75%. The Anaerobic lagoons and stabilization ponds have the lowest BOD removal efficiency of around 35%. In terms of COD removal efficiency, it is observed that the ASP and facultative maturation pond have the highest removal efficiency i.e. 92% and 88% whereas for the other technologies the COD removal efficiency varies from 45 to 65%. For SBR the COD

removal efficiency is very low at 46%. It can be concluded that the SBR is efficient for the removal of biological matter but not suited for removal of inorganic matter from the wastewater. The anaerobic lagoons and stabilization ponds are inefficient for removal of biological and inorganic matters. Figure 24 and Figure 25 compare the performance of various wastewater technologies in terms of BOD and COD removal.



Treatment technologies adopted under NRCD funded schemes included the Natural system, Conventional technology and Advanced Technology. Table 2 summarizes the treatment technologies adopted in the NRCD schemes (CPCB, 2013).

Table 2: Different Conventional technologies used for STP in India

Oxidation Pond	34
Waste Stabilization Pond	31
Anaerobic Lagoons	3
Activated Sludge Process	19
Extended Aeration	2
Trickling Filters	7
Cyclic Activated Sludge Process	2
UASB	37

Karnal Technology	4
Sequential Batch Reactor	3
Fluidises aerobic bio reactor	2
Biofar	2
Others	6

A comparison of the cost and area required for the various technologies used in sewage treatment is given in Table 3.

Table 3: Comparison of various technologies used in sewage treatment plants

Technology	Average Capital Cost (Secondary Treatment), Lac Rs/MLD	Average Capital Cost (Tertiary Treatment), Lac Rs/MLD	Total Capital Cost (Secondary + Tertiary), ` Lac Rs/MLD	Total Area, m ² /MLD Secondary + Tertiary treatment	Total daily Power requirement (avg.), kWh/d/MLD	Total Annual O & M Costs, ` Lac Rs/MLD up to secondary Treatment
Activated Sludge Process	68	40	108	1000	185.7	353.02
Moving Bed Biological Reactor	68	40	108	550	223.7	372.11
Sequential Batch Reactor	75	40	115	550	153.7	288.15
Upflow Anaerobic Sludge Blanket + Extended Aeration	68	40	108	1100	125.7	290.72
Membrane Bio Reactor	300		300	450	302.5	-
Waste Stabilization Pond	23	40	63	6100	5.7	116.09

Source: CPCB, 2013

5.2 Decentralised systems for wastewater treatment

Decentralised waste water treatment systems can be built to suit site conditions and varying inflows. The length of the sewer networks required are smaller and a variety of simple and natural treatment methods can be used which need no mechanisation. As a result, it is possible to achieve cost effective sanitation in addition to reusing the water and nutrients near the source of waste generation.

The houses in rural areas are not built in a planned manner and are not close to one another like in urban areas. Houses may be in the middle of large farms so that they are isolated. Hence in rural areas decentralised waste water treatment systems are more suitable. Currently, even in urban areas about 70% of the population is served by on site sanitation systems. The advantages of decentralised waste water treatment systems are low operational and maintenance costs, nil or very low energy consumption depending upon the technology chosen, easy operation by semi-skilled persons and economic returns depending upon the technology

used. There is safe reuse of treated effluent as well as of sludge. A decentralised system is suitable for all site conditions including an undulating topography where conventional sewage treatment cannot be implemented.

The performance of the various treatment systems depends on the influent characteristics and temperature. The performance can be defined by the approximate BOD removal rates, as follows:

25 to 50% removal rates for Septic and Imhoff tanks

70 to 90% removal for anaerobic filters and baffled septic tanks

70 to 95% removal for constructed wetland and pond systems (Kumar, 2014)

Decentralised systems for wastewater treatment can be divided into three broad categories:

1. Soil-based systems, which include subsurface infiltration, rapid infiltration/soil aquifer treatment, overland flow, and slow rate systems
2. Aquatic systems, which include waste stabilization ponds and floating aquatic plant systems
3. Wetland systems, which include free water surface and subsurface flow systems

Septic tanks are the most favoured type of onsite sanitation system in India while pit latrines are also largely used in rural areas. Septic tanks are watertight, multi-chambered receptacles that receive black and/or grey water and separate the liquid from the solid waste, which it stores and partially digests; black water is wastewater generated from toilets and grey water is wastewater generated from bathing, kitchen and other household activities excluding waste from toilets. A septic tank is a combined sedimentation and digestion tank. The settleable solids in the sewage settle down to the bottom in one or two days accompanied by anaerobic digestion of settled solids (sludge) and liquid, resulting in reasonable reduction in the volume of sludge, reduction in biodegradable organic matter and release of gases like carbon dioxide, methane and hydrogen sulphide. The effluent although clarified to a large extent, will still contain appreciable amounts of dissolved and suspended putrescible organic solids and pathogens, as the efficiency is only 30-50 % for BOD and 60-70 % for TSS removal. This effluent can contaminate ground water. Septic tanks also need to be de-sludged for their effective functioning.

Most cities and towns in India do not have effective septage or faecal sludge management mechanisms. Faecal sludge is the settled contents of pit latrines and septic tanks while septage is the liquid and solid material that is pumped from a septic tank, cesspool, or onsite treatment facility after it has accumulated over a period of time. A pit latrine or septic tank system to be environmentally safe there should be a proper system for faecal sludge management. Table 4 lists the treatment methods and costs involved in selected emerging decentralized waste water treatment technologies where the treated water can be used for horticultural or other purposes.

Table 4: Comparison of different Decentralized STP technologies

Method	Description	Capital Cost	O & M Costs	Remarks
Bioremediation	Using biological products to decompose organic matter	Rs 20,000 to 30,000/MLD for flowing water, Rs 400 to 5000/ML	Rs 1.9 Lac/MLD for flowing water and Rs 2.8 Lac/Acre for still water	Suitable for in-situ treatment of lakes and ponds

		for still water		
DEWATS	Sedimentation, anaerobic treatment, plant root zone treatment, oxidation process	Rs 35000 to 70000/KLD	Rs 1000 to 2000/KLD/Year	Selection of modules is based on the quality of waste water to be treated; no electro-mechanical equipment used
Fixed Film Biofilter Technology	Settling and flow equalization followed by biochemical process	Rs 25,000 to 30,000/KLD	1000 to 2000/KLD/Year	Use of micro culture reduces the area required for due to enhanced natural degradation of contaminants
Phytoid	Settling followed by plant root zone treatment involving both aerobic and anaerobic treatment in specially engineered baffle treatment cells	14000 to 35000/KLD	Rs 100 to 2000/KLD/Year	Locally available wetland plants are used in the process

Source: Centre for Science and Environment

5.4 Faecal Sludge Management

About seventy per cent of the urban population in India is dependent on Onsite Sanitation Systems (OSS) while all sanitation systems in rural areas are in-situ systems. While open defecation has decreased and the number of toilets keeps increasing, it is not ensured that the waste from the toilets is disposed-off in a manner that does not harm the environment; a large part of it ends up polluting our rivers, lakes and the soil. As such without proper management of faecal sludge and septage, waste water treatment cannot be complete and the ideal of Swachh Bharath cannot be achieved.

The draft National Urban Faecal Sludge and Septage Management (FSSM) Policy published by the Ministry of Urban Development in February 2017 aims to address the problem of faecal sludge and septage / sewage in a holistic manner with a focus on environmental safety.

6. Socio-Economic Factors

Poor water quality spreads disease and hampers socio-economic progress. E Coli, Shigella and V cholera bacteria, Hepatitis A, Polio and Rota Viruses and parasites like E histolytica, Giardia and Hook worm are the pathogenic organisms mainly responsible for water borne diseases in India. About 1, 95,813 habitations are affected by poor water quality in the country. About 37.7 million Indians are affected by waterborne diseases annually and 1.5 million children are estimated to die of diarrhoea each year. The annual economic loss due to waterborne diseases is estimated to be Rs.112 crores. Water-related diseases cause economic burden on both households and the nation. At household levels, the economic loss includes cost of treatment, while the government spends a lot of money and time on treatment of the sick and providing other supportive services. Statistics show that rural people in India spend at least Rs.100 each

year for the treatment of water/sanitation-related diseases. According to the Government of India, this adds up to Rs.6700 crore annually, which is just Rs.52 crore less than the annual budget of the Union Health Ministry and more than the allocation for education.

6.1 Rapid Urbanization and Deterioration of Water Quality

World over, population growth and the associated increase in sewage generation have proved to be a challenge. There is a need to improve water quality management measures including introduction of new wastewater treatment technologies for increasing the treatment capacity. Also, an integrated approach needs to be taken up between infrastructure and socio-economic measures for water quality management (Kannel et al, 2007; Groppo et al, 2008; Su et al., 2011). It is observed that during the last few decades, surface and ground water quality has deteriorated due to rapid economic growth, failure to implement wastewater technologies, inadequate infrastructure as well as social, economic and political issues arising from rapid urbanization.

Presently, the rate of urbanization in India has crossed 30%, leading to increased demand for common resources including water, leading to more sewage generation. The treated or untreated wastewater is mainly disposed into natural drains joining rivers or lakes or used on land for irrigation/ fodder cultivation or disposed into the sea or a combination of them by the municipalities. There are 152 waste water treatment plants in India in 110 cities of which 111 are operational and 34 are non-operational, the remaining 6 numbers being under proposal or construction. Most of the operational plants are in the metropolitan cities. The mode of disposal in 118 cities is indirectly but ultimately into the rivers/ lakes/ ponds/ creeks; in 63 cities onto agriculture land; in 41 cities directly into rivers and in 44 cities, it is discharged both into rivers and on agriculture land. There is thus a need for greater focus on urban and industrial water management in India.

6.2 Wastewater Infrastructure with focus on economic viability and environmental sustainability

In the urban areas there is considerable gap between the population and economic growth during rapid urbanization of an area, and water infrastructure construction. Wastewater treatment infrastructure available is highest in the metropolitan cities; even there the gap between wastewater generated and treated is considerable with the population and wastewater generated increasing day by day. The existing treatment capacity is not fully utilized in most cities because of lack of sewage pipe lines bringing sewage to the treatment plants. 34 out of the 152 sewage treatment plants across various cities in India are non-operational. Many a time, enough money is not set aside for Operation and Maintenance even when huge amounts of money are spent on new infrastructure. This leads to poor maintenance of STPs with discharge from them not conforming to environmental protection standards. While there is a big focus on the construction of toilets under the Swachh Bharat Mission, not enough focus is given to the treatment of the waste water produced and faecal sludge management. Apartment complexes in cities are beginning to have their own Sewage Treatment Plants, but the cost involved makes it impossible for it to be implemented in all housing developments especially in those owned by poorer sections of the society. Users must also be aware of the interrelationship between hygiene and health and on how their actions can lead to pollution of land and water bodies.

Thus, there is a need for new wastewater infrastructure construction and improvement of the existing wastewater treatment systems. Upgrading of the wastewater treatment technologies

also needs to be undertaken, for better treatment of the sewage. There is also a need for renovation of the sewer system from time to time. New wastewater treatment systems need to be constructed with more focus on economic viability and environmental sustainability. Importance should also be given to create awareness on sanitation and pollution issues among users so that their cooperation in maintaining their own environments can be assured.

Unlike in urban areas, the waste water generated in rural areas is relatively free from inorganic components. As such the reuse after treatment of waste water as well as the solid residue for agriculture is possible. Scientific design of rural sanitation systems by technically qualified personnel taking into consideration local geological, hydrological, social and economic conditions is necessary. Continued use of the toilets in a proper way and proper handling and reuse of waste water and septage with timely de-sludging of pits/septic tanks are needed for a sanitation system to be a success. The local government should also ensure that enough funds are allocated and officials appointed for the successful operation and maintenance of the sanitation system.

7. Key Findings

- Discharge of sewage into surface water bodies which is widely prevalent in India is a major threat to fresh water availability and water security; according to CPCB, 62% of the total sewage generated in India is discharged directly into nearby water bodies.
- The BOD, faecal coliform and DO of river water do not conform to norms downstream of the cities at Hyderabad, Delhi, Agra, Mathura and Varanasi. Of particular significance is the fact that there has been no improvement in these values over the period from 2007 to 2013 in spite of the many programmes for the rejuvenation of rivers. This is true even for river Ganga with a national mission for cleaning the river.
- For the projects undertaken under NLCP for restoration and conservation of lakes, only in very few lakes the water quality has improved after completion of the conservation programmes.
- There is not much improvement in the status of waste water treatment in the cities and towns between 2005 and 2015. Any increase in treatment capacity has been offset by the increased rate of urbanisation.
- Capacity utilization for the STPs of metropolitan cities and Class I and Class II cities is only about 65% of the treatment capacity. The main reason for this in addition to problems with operation and maintenance is the absence of sewage networks. Steps have to be taken to increase capacity utilization.
- Treated waste water is used for horticultural purposes and by industries in cities viz., Chennai, New Delhi, Bengaluru and Hyderabad. However, the water thus used is only a very small fraction of the waste water that is being generated. There has to be greater reuse of treated waste water.
- The Ministry of Urban Development, Government of India, evaluates cities on the basis of cleanliness, sanitation and municipal documentation (Swachh Survekshan). While freedom from open defecation and the availability of toilets are among the criteria based

on which a city is evaluated, management of waste water from the toilets including sewage collection and treatment and the presence of sewage networks are not considered.

- While there is a strong institutional and legal regime for control of water pollution in India, there is no single policy either at the central level or at the state level that encompasses aspects of pollution prevention and treatment of polluted water for ecological restoration. Also, enforcement of the rules and regulations and the penalties for defiance, non-adherence and violations are not sufficient enough to ensure compliance.

8. Conclusion

The urban population in India, which stood at 377 million in 2011, is expected to grow by 404 million to become 781 million by 2050 (World Urbanisation Prospects, 2014). Many Indian cities get their water supply from sources far away at high costs including for energy used for pumping water to these cities. Cities with larger populations generally rely more on surface water than ground water. In cities where ground water is the source of water supply, aquifers are getting depleted due to over extraction. At the same time, sanitation has not kept pace with water supply in the country. Human health and economic prosperity are very much dependant on clean water supply and good sanitation as on other factors. Hence it is important to look at how pollution of water sources, especially from sewage, affects water quality and water security.

In this paper we have studied the quality of water in surface water bodies across India. We used information from government agencies, particularly reports from the Central Pollution Control Board and the CAG, to analyse the quality of surface water. The data on quality of water in rivers upstream and downstream of selected cities over a period of time were analyzed to understand the changes in water quality parameters over time. We have also studied the status of sewage treatment across states in the country to understand the gaps in waste water treatment. The institutional and legal measures available for the control of water pollution were also looked into.

An integrated approach needs to be evolved balancing infrastructural and socio-economic measures for water quality management. Construction of new wastewater treatment systems, improvement of the existing wastewater treatment systems, upgrading of wastewater treatment technologies and renovation of the sewer system, all with greater accent on economy viability and environmental sustainability is the need of the hour. Importance should also be given to creating awareness on sanitation and pollution issues among users to ensure their cooperation in maintaining their own environments. The “Clean India” or “Swachh Bharat” campaign will be successful only if water is available in the toilets constructed and if the wastewater generated is also treated and the treated water reused or disposed-off in a sustainable manner.

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