Water Quality Issues and Management in India

Dr. R. C. Trivedi
Ex-Addl. Director
Central Pollution Control Board
East Arjun Nagar, Delhi – 110 003
Email: dr_R_C_trivedi@rediffmail.com

Due to ever increasing water demand and uneven distribution of rainfall over time and space leading to severe water scarcity and water quality degradation in India. Discharge of untreated domestic wastewater is predominant source of pollution of aquatic resources. The estimated sewage generation from Class I cities and Class II towns (as per 2009) is 38200 million liter/day (MLD). Against this, sewage treatment capacity exists for only about 6190 MLD. The municipalities and such other civic authorities are not able to cope up with this massive task, which could be attributed to various reasons including lack of resources, erosion of authority, inability to raise revenues and inadequate managerial capabilities. The regular monitoring results indicate that organic and pathogenic pollution are the major water quality issues of India. That is why it became necessary to launch the Ganga Action Plan and subsequently the National River Action Plan, which are essentially addressed to the task of trapping, diversion and treatment of municipal wastewater. Similarly, out of about 17438 MLD of wastewater generated from all major industrial sources, the treatment capacity exists for about 9000 MLD wastewater. Thus there is a large gap between generation and treatment of wastewater from industrial sources also. Major part of untreated industrial wastewater is contributed from small scale industries, which could not treat the wastewater due to various reasons. It is also important to note that there is no adequate collection system for the wastewater. This is leading to accumulation of wastewater in urban/industrial areas. The accumulated wastewater percolates in the ground and pollutes the groundwater, which is the only source of drinking in many cities. Several efforts are made by Govt of India to restore water quality of the national aquatic resources like a series of legislations were enacted and a large number of institutions are established, several incentives and mutually agreed programmes are implemented. A brief overview of all these measures is provided here.

1. Introduction

Water is the most essential natural resource for life next to air and is likely to become a critical scarce resource in many region of the world in the coming decades. Preserving the quality and the availability of the freshwater resources is the most pressing of the many environmental challenges on the national horizon. Perhaps, because water is considered as a cheap resource, which is readily available, people fail to realize just how much stress human demands for water are placing on natural ecosystems. The stress on water resources is from multiple sources and the impacts can take diverse forms. The growth of urban megalopolises, increased industrial activity and dependence of the agricultural sector on chemicals and fertilizers has led to the overloading of the carrying capacity of our water bodies to assimilate and decompose wastes. This has led to deterioration of water quality and contamination of lakes, rivers and ground water aquifers. As we enter into the new millennium, there is a need to bring a perceivable shift in our philosophy and approach towards addressing water problems. However, water resource managers and professional are beginning to shift focus to use the existing infrastructure to meet the demands of growing population by virtue of efficiency improvements, reallocation of water for different uses and sectoral prioritization of water demand.

Geometric increase in population coupled with rapid urbanization, industrialization & agricultural development has resulted in critical shortages of water of suitable quality in several parts of our country to sustain future growth. The situation warrants immediate redress through radically improved water resource management strategies. The problem magnified due to conditions of poverty & underdevelopment as also the negative effects of development. The problem of water quality degradation resulted from discharge of untreated or partially treated domestic wastewater resulted from urban sprawl & city slums resulted from burgeoning population. However, protection of water courses from pollution present a most fundamental challenge to the nation's desire to industrialize faster to be self sufficient in food, & to be capable of fulfilling certain basic needs of the growing population. Consequently India's effort to protect water resources compounded to unmanageable proportion by poverty, squalor & ignorance, thus the strategy to tackle water quality problem along with poverty, unemployment, diseases and ignorance is unavoidable.

Water Quality' is a term used here to express the suitability of water to sustain various uses or processes. Any particular use will have certain requirements for the physical, chemical or biological charcteristics of water; for example limits on the concentrations of toxic substances for drinking water use or restriction on dissolved solids on irrigational use. Although many uses have common requirements for certain variables, each use will have its own demands & influences on water qulaity, quantity & quality demands of different users will not always be compatible & the activities of one user may restrict the activities of another, either by demanding water of a quality outside the range required by the other user or by lowering quality during use of the water.

2. Water Resources of India

The 14 major river basins in India, drains 85% of surface run-off, cover 83% of country's area supporting about 80% of the population. To feed the ever growing population of the country agricultural development is on top priority of the government. Although India is the wettest country in the world receiving average 1170 mm rainfall annually, the rainfall is not evenly distributed in time & space. Nearly 85% rain occurs only in three to four months period in a year.

3. Major Water Quality Issues

For India's large & growing population, water courses must satisfy various domestic demands besides those for agriculture, industry, fisheries, navigation & power generation as well as be a receptacle for community, industrial & agricultural wastes. There are variety of efffects on water quality of different water bodies in the country. These range from the transmittal of waterborne diseases like cholera, joundice, typhoid & dysentary to fish kills, excessive growth of aquatic plants & loss of agricultural production through the use of polluted water. The effects can be summarised as:

- Bacterial
- Oxygen depletion
- Eutrophication
- Increase in salinity
- Toxicity

Although about 84% of the urban population ha been provided with safe drinking water supply facilities and about 46% with adequate sanitation facilities, the situation in most of the cities and towns is not satisfactory. Water supply ranges from as low as 12 litres/capita/day to as high as 460 litres/capita/day in Class I cities. However, the national average for Class-I cities is 147 litres/capita/day. In the case of Class II towns, the water supply ranges from as low as 7 litres/capita/day to as high as 500 litres/ capita/day with a national average of 78 litres/capita/day. Thus there exists a wide gap in the per capita water supply in different urban areas of the country. Even in a given city equitable distribution of water to all citizens is not abailable.

4. Approach to Water Quality Management

The water quality management in India is performed under the provision of Water (Prevention and Control of Pollution) Act, 1974. The basic objective of this Act is to maintain and restore the wholesomeness of national aquatic resources by prevention and control of pollution. The Act does not define the level of wholesomeness to be maintained or restored in different water bodies of the country. The Central Pollution Control Board (CPCB) has tried to define the wholesomeness in terms of protection of human uses, and thus, taken human uses of water as base f or identification of water quality objectives for different water bodies in the country.

It was considered ambitious to maintain or restore all natural water body at pristine level. Planning pollution control activities to attain such a goal is bound to be deterrent to developmental activities and cost prohibitive. Since the natural water bodies have got to be used for various competing as well as conflicting demands, the objective is aimed at restoring and/or maintaing natural water bodies or their parts to such a quality as needed for their best uses.

Thus, a concept of “designated best use” (DBU) was developed. According to this concept, out of several uses a water body is put to, the use which demands highest quality of water, is termed as “designated best use”, and accordingly the water body is designated. Primary water quality criteria for different uses have been identified. A summary of the use based classification system is presented in Table 1.

Table 1. Use Based Classification of Surface Waters in India

Designated Best Use	Quality Class	Primary Quality Criteria
Drinking water source without conventional treatment, but with chlorination	A	6.5 to 8.5 (1); 6 or more (2); 2 or less (3); 50, not >5% 200. and not >20%-50 (4); NIL (5 - 8)
Outdoor bathing (organised)	B	6.5 to 8.5 (1); 5 or more(2); 3 or less (3); 500, not >5%-2000, and not >20%-500(4); NA (5- 8)
Drinking water source with conventional treatment	C	6.5 to 8.5 (1); 4 or more (2); 3 or less (3); 5000, not >5%-20000, and not >20%-5000 (4); NA (5 – 8)
Propagation of wildlife and fisheries	D	6.5 to 8.5 (1); 4 or more (2); NA (3 - 4); 1.2 (5); NA (6 - 8)
Irrigation, industrial cooling, and controlled waste disposal	E	6.0 to 8.5 (1); NA (2 - 5); 2250 (6); 26 (7); 2 (8)

(1) pH, (2) dissolved oxygen, mg/l (3) BOD, (20^oC) mg/l (4) total coliform (MPN/100ml) (5) free ammonia mg/l, (6) electrical conductivity in μMHO/cm, (7) sodium adsorption ratio, and (8) boron mg/l, NA = Not applicable

The entire water resources of the country were classified according to their designated best uses and a "Water Use Map" was prepared. For identification of the water bodies or their parts where water quality is at variance with water quality criteria, it was felt important to measure water quality of that water body or its part. It would help in preparation of "Water Quality Map" of India. The idea was to superimpose "Water Quality Map" on "Water Use Map" to identify the water bodies or their parts which are in need of improvement (restoration). Subsequently through a wide network of water quality monitoring, water quality data are acquired. A large number of water bodies were identified as polluted stretches for taking appropriate measures to restore their water quality. Today almost all policies and programmes on water quality management are based on this concept including the Ganga Action Plan and National River Action Plans.

5. Water Quality Monitoring

The Central Pollution Control has been monitoring water quality or national aquatic resources in collaboration with concerned state Pollution control Boards at 784 locations. Out of which 707 stations are under MINARS (Monitoring of Indian National Aquatic Resources), 50 stations are under GEMS (Global Environmental Monitoring

Systems) and 27 stations under the YAP (Yamuna Action Plan). The polluted stretches identified in some of the major rivers (Table 3) are based on regular monitoring. The water quality and desired water quality have been classified in classes A,B,C,D and E, which reflect the best use of the water. Class A stands for drinking water without conventional treatment but after disinfection, Class B water is suitable for outdoor bathing, while Class C stands for water suitable for drinking after conventional treatment. Class D water is suitable for propagation of wildlife and fisheries. Class E water can be used for irrigation, industrial cooling and controlled waste disposal.

6. Existing Water Quality Status

The major rivers of the country have retained pristine quality of water in their upper stretches where there are least affected by man's interference. As the rivers enters the plains, these start getting exploited for irrigation use and receiving pollution discharges due to various human activities like intensive agriculture, use of fertilizers and insecticides, industrial effluents, domestic sewage etc. Thus in the middle stretches, the rivers are most affected due to increased water requirement for various consumptive and non-consumptive uses. The increased wastes find their way into the river and tend to deteriorate the water quality, especially during the lean flow season.

The water quality monitoring results obtained during last 10 years indicate that organic and bacterial contamination still continues to be critical sources of pollution in Indian aquatic resources. The analysis results indicated that nearly 6000 Km riverine length in the country is highly polluted, another 8700 Km riverine length is moderately polluted and remaining riverine length is relatively clean. The cleaner stretches are mostly located in Himalayan part of India. CPCB has identified about 150 polluted stretches of the rivers based on the data obtained for BOD as an indicator of pollution.

7. Major Cause for Water Quality Degradation

7.1 Domestic Wastewater

India is urbanizing very fast as evident from Fig. 1. With increasing urban population water supply and wastewater generation is also increasing steeply. However, the treatment facilities are lagging behind due to paucity of resources with the urban local bodies, who are responsible for sewage management. Discharge of untreated domestic wastewater is predominant source of pollution of aquatic resources in India. Urban centers contribute most of the sewage generation in the country. The smaller towns and rural areas do not contribute significant amounts of sewage due to low per capita water supply. The wastewater generated in these areas normally percolates in the soil or evaporates. CPCB carry out regular inventory of water supply, wastewater generation, collection and disposal in class-I cities and class-II towns of the country. As per the latest estimate, 423 class I cities and 498 class II towns of the country harbouring population of 20 crore generate about 26250 million litre per day (mld) of wastewater. It was observed that most of the cities do not have adequate organized water supply, as well as wastewater collection and treatment facilities. Out of which about 7000 mld of wastewater gets some kind of treatment. It was also observed that Maharashtra, Delhi, Uttar Pradesh, West Bengal and Gujarat are the major contributors of wastewater (63%). The facilities constructed to treat wastewater do not function properly and remain closed most of the time due to improper design and poor maintenance, together with a non-technical and unskilled approach. As per the latest information about 38300 MLD of wastewater generated from urban centres out of which treatment capacity exists for only about 11000 MLD. Thus, a large part of the untreated sewage is discharged into water bodies causing pollution. In many cases, there is no dilution water available resulting in severe pollution in the receiving water body. Growth of water supply and wastewater generation in last 4 decades are presented in Fig. 2 and 3.

Figure 2: Water supply and sewage disposal status in class I cities (MLD)

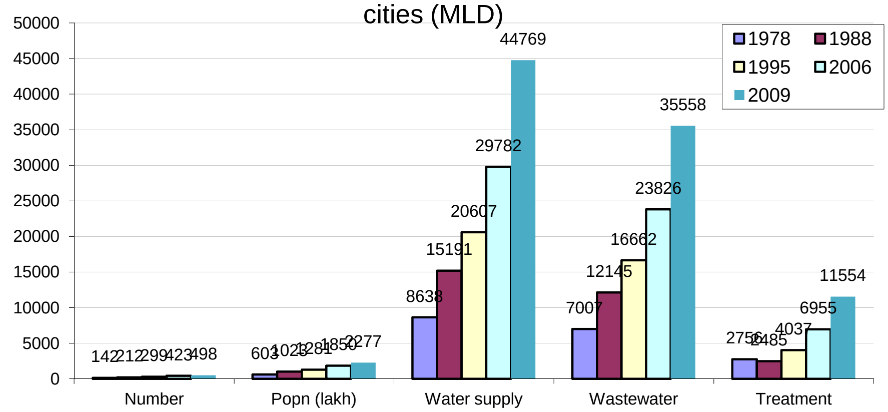
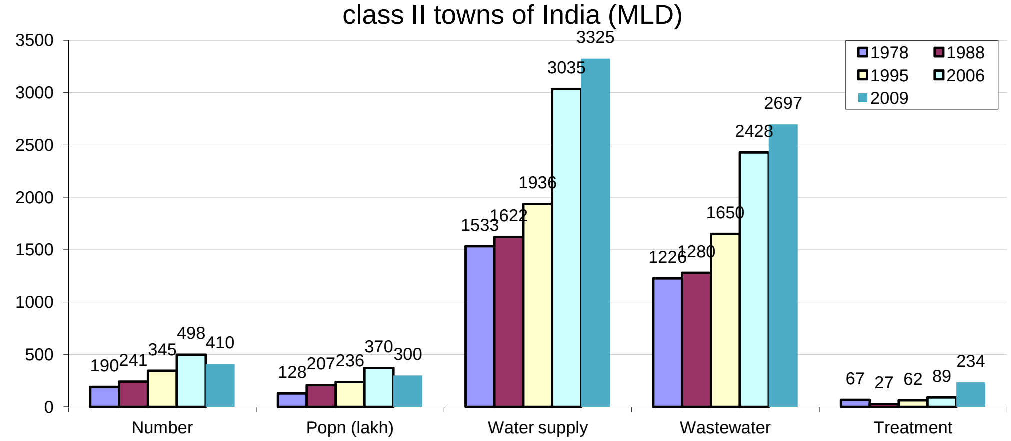


Figure 3: Water supply and wastewater generation and treatment in class II towns of India (MLD)



7.2 Industrial Wastewater

The total wastewater generated from all major industrial sources is 83,048 mld that includes 66,700 mld of cooling water generated from thermal power plants. Out of remaining 16,348 mld of wastewater, thermal power plants generate another 7,275 mld as boiler blow down water and overflow from ash ponds. The second largest contributors of wastewater in terms of volume are engineering industries. A major part of the industries in this category is in small-scale sector. Under this category the major polluting industries are electroplating units. The electroplating units are mostly in small-scale sector and control of pollution from this category is not very effective as many of these industries are located in congested residential areas, where land is not available for treatment of wastewater. The other significant contributors of wastewater are paper mills, steel plants, textile industries and sugar industries.

The major contributors of pollution in terms of organic load are distilleries followed by paper mills. Since the distilleries generate very concentrated wastewater, it is hard to treat it. Despite the efforts on treatment of distillery waste, the targeted effluent quality is hard to achieve. The paper and board mills also generate heavy organic pollution load. A large number of paper mills are in small-scale sector. These industries do not have adequate arrangement for treatment of wastewater. Thus, create heavy pollution in many areas. The other significant contributors of organic load are sugar and engineering industries. Considering that treatment plants in all the industries are working efficiently, the major contributors of organic load in the treated effluent are paper mills followed by distilleries and tanneries.

The industries generating chemical pollution can be divided in two categories i.e. i) those which generate high TDS bearing wastes like pharmaceuticals, rayon plants, chemicals, caustic soda, soap and detergents, smelters etc. (ii) those which generates toxic wastes e.g. pesticides, smelter, inorganic chemicals, organic chemicals, steel plants, pharmaceuticals and tanneries etc. Major contributors of TDS load are distilleries followed by pharmaceuticals, textile industries and rayon plants. Major contributors of suspended solid load are thermal power plants that generate a significant quantity of cooling water followed by paper mills and tanneries. Considering that treatment plants in all the industries are working efficiently, the major contributors of suspended solids load in treated effluent are paper mills follow by tanneries. Toxic waste such as cyanide and arsenic are generated by fertilizer plants (nitrogenous) and steel plants.

Steel plants and oil refineries are major contributors of phenol. Engineering industries contribute maximum amount of oil and grease followed by oil refineries and edible oil vanaspati industry. Major pollution in terms of ammonia load is contributed by fertilizer plants (nitrogen) followed by steel plants. Pollutants such as chloride are generated by tanneries while fluorides are generated by fertilizer plants (phosphate) and sulphide by oil refineries. Waste such as mercury is generated by caustic soda industries employing mercury cell process. Total Wastewater generation from the industries is about 17,000 mld.

7.3 Source-Related Characteristics of Diffuse Water-Pollution

For a proper understanding of the nature and the magnitude of diffuse water-pollution under different circumstances, it would be necessary to consider some source-related characteristics, briefly discussed below for diffuse pollution from some more common sources.

Pollution from Small Rural Hamlets/Villages: Almost as a rule these would not have running water supply nor sewered sanitation. In many developing countries (as is the case of India) most people would use open field for defecation, with a few using pit-latrines or septic-tanks. Much of the bathing and washing (clothes, utensils etc.) shall be in or near the water-body reducing abstraction and transport of water but causing in-situ diffuse pollution. Generation of liquid effluents would be minimal and all wastewater generated shall soak into the nearby land. One would be tempted to say that such habitats would cause no water pollution. And yet a careful materials-balance as also field experience would show significant quantities of various types of pollutants including salts, nutrients, organics and micro-organisms from such hamlets and rural areas reaching ground or surface water bodies through leachate see pages and as washings in the storm run-offs. On the basis of varies experience, the Indian Central Pollution Control Board estimated an average 15g BOD_{5-20} per capita per day of the rural population reaching the major river draining that particular basin and used this as a basis of computations in its "Basin Sub-Basin Inventory of Water Pollution" series (CPCB 1982-1995). Corresponding loads of salts, nutrients, micro-organic and other pollutants would also be reaching streams and rivers, while the amounts of pollutants percolating to ground waters may be much larger.

7.4 Wastewaters and Pollutants from Unsewered Towns

For improving standards of life, running water- supply has been established in most of the towns and even in some villages over the past three decades, even in developing countries. This has, in turn, led to flush- latrines and much large use of water in homes for bathing, washing of clothes utensils etc, generating significant amounts of wastewaters. Use of soaps and detergents and amounts of various food materials going to the sink have also grown with improved life standards. Unfortunately, sewerage or improved sanitation does not bring the same political dividends in developing countries as running water-supply does. Hence sewerage has lagged far behind water supply. A large number of the cities/towns either do not have any sewerage system or the sewerage system is overloaded or defunct. All this resulted in large amount of wastewater uncollected. The only differences in case of this category of habitations from that of category (i) above would be: (a) much larger pollution loads of salts, nutrients, organics, micro-organisms, soaps, detergents and other chemicals per capita per day will be generated, and (b) part of the pollution generated shall flow as sullage to streams and other water-bodies through storm-drains or other channels. The bulk of pollution shall get retained on land to percolate, leach or get washed-off to streams or groundwater as in the case of pollutants from habitations of category (i) and (ii).

7.5 Sewage, Sullage and Pollutants from Urban Areas with Inadequate or Faulty Sewerage and/or Sewage Treatment System

With exponential growth in urbanisation through migration of the poorest section of populations to cities in search of livelihood, it would be difficult to name many cities or urban areas in developing countries that have adequate and effective sewerage. According to CPCB (1995) only about 40-50% of the populations of the major Indian metro-cities of Delhi, Bombay Calcutta, Madras and Bangalore are served by sewer systems. Even where sewers exist, they often leak or overflow, releasing their contents to storm-water or other surface drains or to percolate in to soil to reach ground-water or streams as in case of pollutants from habitations of category (i) and (ii).

7.6 Industrial Pollutants from Cottage / Small Scale Industries

Encouragement of cottage and small-scale industries through subsidies, market-preferences or other benefits has been an important component of economic development programmes of many developing countries. There were about one lakh such units in the Union territory of Delhi alone in 1995 according to Delhi State Industrial Development Corporation (1998), and the number in the entire country might have run into about 3 millions. These units, in general, neither have nor can afford appropriate sanitation and/ or pollutant disposal systems, and yet have not been hesitant in adopting highly polluting production technologies such as chrome-tanning of leather, use of azo-dyes in fabrics, use of cadmium in ornaments and silver-ware, electroplating with cyanide baths, production of dye-intermediates and other refractory and toxic chemicals etc. Their solid wastes and sludge's get scattered-around or dumped in unlined pits and effluents flow to streams through storm-drains or stagnate in depressions to percolate, leach or get washed-off during next rainy season. This is the story of many industrial areas & urban centres in the country of industrial Pali, Balotra, Patancheru, Jajmau, and many such recently emerged industrial congregations in India and other developing countries resulting in significant diffuse water pollution.

7.7 Industrial Pollutants from Large Industries

While they might claim to have installed costly treatment and disposal, these are also often causing leachates and wash-over from storage yards, waste dumping, ash-ponds, sludge-pits etc. And treated effluents, having at least some pollutants, are getting leached or washed to streams as diffuse pollution. While any number of examples could be cited, oily wastes present in the storm-water channel along Haldia Refinery and ammonia pollution in ground water around a urea factory at Kanpur and of a natural spring close to Zuari Agro urea plant in Goa, should suffice.

7.8 Pollutants in Agricultural Drainage Waters

Drainage waters from irrigated agricultural land are always high in salts, since they also have to carry the salts originally contained in the trans- evaporated fraction of the irrigation water. In economically developed areas such as State of California, USA, this had been appreciated fifty years back and arrangements made to drain away such saline waters without causing undue damage to fresh- water bodies. In developing countries, while irrigation has been expanding exponentially, little is done to tackle the problem of the high salinity return-waters. This would be the situation in Punjab and Haryana States of India. In Haryana the 40 Kms long drain No.8 pours 250,000 kg/day (2147 mg/l in a steady flow of 1.5 m^3/s) of chlorides into River Yamuna to raise the chloride concentration in the river from 32 mg/l just upstream of the drain- confluence to

150 mg/l just downstream of it. And most of these chlorides are from agricultural return flows, some of the seepage into the drain being monitored to contain over 15,000 mg/l of chlorides (CPCB's unpublished report-1993). Intensive and ever- increasing usage of chemical fertilizers, pesticides, weedicides and other chemicals is adding a new facet to such pollution, though the problem in this respect may yet be at a lower stage than in developed countries

7.9 Deposition of Air - Pollutants

Atmospheric pollutants may deposit directly on surface waters. Also the pollutants depositing on vegetation and soils may get leached or washed - over to water bodies. Acid rains causing water-pollution has been well-known and heavy metal deposition from air-emissions on-to-water has been causing concern.

8. Effect of Water Pollution

8.1 Effect of Organic Pollution on Water Quality

All organic materials or wastes can be broken down or decomposed by microbial and other biological activity (biodegradation). Although some inorganic substances are included in this category, most are organic compounds that can exhibit a biochemical oxygen demand (BOD) because oxygen is used in the degradation process. Oxygen is a basic requirement of almost all aquatic life except anaerobic microbes. If sufficient oxygen is not available to the aquatic life, the ecosystem will be adversely affected. Typical sources of organic pollution include sewage from domestic and animal sources; industrial wastes from food processing, paper mills, tanneries, distilleries, sugar and other agro-based industries.

This category of pollution becomes a problem when the oxygen required for biodegradation due to organic pollution is greater than the available oxygen in the water body. Natural systems do have a limited capacity to accommodate self-purification through biodegradationby employing re-oxygenation processes. However, in many situations the anthropogenic pollution overwhelms the given system.

8.2 Effect of Nutrients on Water Quality

The nutrients are always present in water and thus it supports aquatic life. Here the primary focus is on fertilizing chemicals such as nitrates and phosphates. While important for plant growth, too much of nutrients encourage the overabundance of plant life and can result in environmental damage called “eutrophication”. This can occur at both microscopic level in form of algae or macroscopic level in form of larger aquatic weeds. The diurnal change in dissolved oxygen is of serious concern. During day time oxygen remain supersaturated due to photosynthetic contribution of oxygen. But during night the oxygen is depleted as the algal mass consumes significant amount of oxygen. Nitrates and phosphates contributed through anthropogenic sources such as sewage, agricultural run-off and run-off from un-sewered residential areas.

8.3 Effect of High Dissolved Solids (TDS) on Water Quality

As water is best solvent known on the earth, it can dissolve variety of substances to which it come incontact during hydrological cycle. In natural waters, the dissolved solids mainly consist of bicarbonates, carbonates, sulphates, chlorides, nitrates and phosphates of calcium, magnesium, sodium, potassium with traces of iron, manganese and other minerals. The amount of dissolved solid is important consideration in determining its suitability for irrigation, drinking and industrial uses. In general, waters with a total dissolved solids <500 mg/l are most suitable for drinking. Higher dissolved solids may leads to impairement in physiological processes in the human body. For irrigation water dissolved solid is very important criteria due their gradual accumulation resulting in salinization of soil, thus, rendering the agriculture land non-productive.

Dissolved solids are undesirable in industrial water due to many reasons. They form scales, cause foaming in boilers, accelerate corrossion, and interfer with the colour and tastes of many finished products.

8.4 Effect of Toxic Pollutants on Water Quality

The toxic Pollutants are mainly heavy metals, pesticides and other industrial xenobiotic pollutants. The ability of a water body to support aquatic life, as well as its suitability for other uses depends on many trace elements.Some metals e.g. Mn, Zn and Cu present in trace quantity are important for the life as it helps and regulates many physiological functions of the body. The same metals, however, causes severe toxicological effects on human health and the aquatic ecosystem. Water pollution by heavy metals resulting from anthropogenic impact is causing serious ecological problems in many parts of the world. This situation is aggravated by the lack of natural elimination processes for metals. Thus, metals shift from one compartment of environment to another, including the biota, often with detrimental effects. Where sufficient accumulation of the metals in biota occurs through food chain transfer, there is also an increasing toxicological risk for man. As a result of absorption and accumulation, the concentration of metals in bottom sediments is much higher than in the water above, which may cause secondary pollution problem. The toxicity of metals in water depends on the degree of oxidation of a given metal ion together with the forms in which it occurs. As a rule, the ionic form of a metal is the most toxic form. However the toxicity is reduced if the ions are bound into complexes with, for example, natural organic matter. Under certain conditions, metallo-organic, low-molecular compounds formed in natural waters exhibit toxicities greater than the uncombined forms. An example is the highly toxic alkyl-derivatives of mercury (methylmercury) from inorganic mercury by aquatic microorganisms. A famous episode of Minamata disease occured in Japan in fifties due to consumption of fish contaminated by methyl mercury. Metals in natural water can exists in truly dissolved, colloidal and suspended forms. The proportion of these forms varies for different metals and for different water bodies.

Many thousands of organic compounds enter water bodies as a result of human activities. Monitoring every individual compound is not feasible. However, it is possible to select priority organic pollutants based on their prevalence, toxicity and other properties. Mineral oils, petroleum products, phenols, pesticides, polychlorinated biphenyls (PCBs) and surfactants are examples of such compounds. However, these compounds are not universally monitored because their determination requires sophisticated instrumentation and highly trained personnel. Therefore, they are evaluated in terms of toxicity as a summary parameter. Many of these compounds are highly toxic and sometimes are carcenogenic and mutagenic in nature. Some selected compounds are measured by gas chromatography method.

1. Water-borne diseases **Bacterial** • Typhoid • Cholera • Paratyphoid • Gastroenteritis • Bacterial dysentery **Viral** • Infectious hepatitis • Poliomycetis • Diarrhoeal diseases • Other symptoms of enteric diseases **Protozoan** • Amoebic dysentery	 Salmonella typhi Vibrio cholerae Slmonella parayphi Enterotoxigenic Escherichia coli Variety of Escherichia coli Hepatitis-A virus Polio-virus Rota-virus, Norwalk agent, other virus Echono-virus, Coxsackie-viru Entamoeba hystolitica
2 Water-washed diseases • Scabies • Trachoma • Bacillary dysentery	 Various skin fungus species Trachoma infecting eyes E. coli
3 Water-based diseases • Schistosomiasis • Guinea worm	 Schistosoma sp. Guinea worm
4 Infection through water related insect vectors • Sleeping sickness • Malaria	 Trapanosoma through tsetse fly Plasmodium through Anaphelis
5 Infections primarily due to defective sanitation • Hookworm	 Hook worm, Ascaris

Testing pathogens in water in a water quality monitoring laboratory on routine basis is a difficult task. This is mainly due to sophisticated methodology involved in testing pathogens, their smaller number in water and thus, their absence in test sample does not always ensure their absence in the water being monitored. For ensuring Examinations for faecal indicator organisms remain the most sensitive and specific way of assessing the hygenic quality of water. Faecal indicator bacteria should fulfil certain criteria to give meaningful results. They should be universally present in high numbers in the faeces of humans and warm blooded animals, and readily detectable by simple methods, and they should not grow and multiply in natural water. For an indicator species it is essential that their persistence in water and their degree of removal in treatment of water are similar to those of waterborne pathogens. The major indicators of faecal pollution are *Escherichia coli*, the thermotolerant and other coliform bacteria, the faecal streptococci, and the spores of sulfite-reducing clostridia. While the criteria described above for an ideal faecal indicator are not all met by any one organism, many of them are fulfilled by *E. coli* and, to a lesser extent, by the thermotolerant coliform group of bacteria. The faecal streptococci satisfy some of the criteria, although not to the same extent as *E. coli*, and they can be used as supplementary indicators. It is recommended that *E. coli* is the indicator of first choice when resources for microbiological examination are limited. Recently, However, it has been suggested that *E. coli* may be found and even multiply in tropical waters that are not subject to human faecal pollution. Spores of sulfite reducing bacteria can also be used as an additional indicator.

There are various types of pathogenic microbes that pass through their host species and may enter the aquatic ecosystem by way of contamination from human or animal wastes. Through drinking water consumption or through various water contact activities, the spread of diseases such as typhoid, cholera, hepatities, dysentery etc. may occur. Pathogens may spread to water only sporadically, and once there, do not survive long, but still may cause health related problems. In this category, we may also want to consider man's activities resulting in the creation of an environment that fosters diseases. Disease-vector like mosquitoes, flies breeding environments can be created, for example, by certain construction activities that may create stagnant water.

9. Initiatives for Control of Pollution

9.1 Legal and Institutional Provision

As demand for freshwater is increasing and the availability is gradually reducing due to erratic monsoons, it is essential to make judicious allocation of the available water resources. The National Water Policy formulated by the Government of India in 1987 accords top priority to drinking water supply in the allocation of water resources for various beneficial uses. After drinking water, the list includes irrigation, hydropower, navigation and industrial and other uses. These priorities, however, might be modified if necessary, particularly with reference to area-specific considerations.

The government explicity enacted the Water (Prevention and Control of Pollution) Act, 1974 with the primary objective of prevention and control of water pollution. The Water Act established the Central Pollution Control Board and the State Pollution Control Boards for its implementation. The Water Act empowers the pollution control boards to laydown and maintains water standards, the actual provisions for enforcement such as penalties, imprisonment etc. are largely confined to source-specific standards for individual polluters. The Environment Protection Act, 1986 is an umbrella act providing for the protection and improvement of environment and for matters connected therewith. It authorizes the central government to intervene. The nature of penalties allowed under this act are similar to those authorized under the Water Act.

Owing to the indiscriminate discharge of untreated sewage and industrial effluents into natural water bodies, the quality of surface water as well as ground water is deteriorating. A result of this is that the principal drinking water supply sources of cities and towns are becoming polluted. Which is resulting in damaging the aquatic ecosystems, increaded incidences of water borne diseases, increased cost on health and of drinking water treatment. Under the National River Action Plan, certain stretches of major rivers with high or intermediate levels of pollution were identified by the CPCB. Sewage collection and treatment works are being created to reduce the pollution load to these rivers. In the first phase , as the GAP (Ganga Action Plan), 29 towns were selected along the river. At present 156 towns are being considered NRAP, out of which about 74 towns are located on river Ganga, 21 on river Yamuna, 12 on Damodar, 6 on Godavari, 9 on Cauvery, 4 each on Tungbhadra and Satlej, 3 each on Subarnrekha, Betwa, Wainganga, Brahmini, Chambal, Gomti, 2 on Krishma and one each on Sabarmati, Khan, Kshipra, Narmada and Mahanadi. During later stages of implementation of GAP, it was realized that the local authorities are not able to operate and maintain these assets due to inadequate resources with them. The level of commitment required from the state agencies was also missing. The pollution was also from a number of diffused sources either urban or rural. In order to regulate pollution, changes in government policies are required and the community participation is also necessary to ensure the success of NRAP. In order to enhance waste water treatment capacity, there is a need to introduce low-cost and effective waste treatment facilities. Many new technologies for waste water treatment, eg.. UASB, duckweed ponds, and horizontal filters have been developed in other parts of the world and applied to a limited extent in India. They offer numerous advantages in terms of the negligible amount of energy required, beneficial uses by - products (sludge as manure and biogas), lower operation and maintenance costs, etc. Another area of concern in India is the large number of scattered sources of pollution from high-density low-income communities. Adequate provision for sewerage and sanitation facilities requires concentrated point-sources, which are easier to monitor and the waste they discharge can be intercepted easily for further treatment.

Besides the ‘command and control’ regulatory mechanism the government has also introduced major economic incentives for pollution abatement in India, not as alternative to regulation but only as a supplementary measure. The Water Cess Act was introduced in 1977, empowering the state pollution control boards to levy a cess on local authorities supplying water to consumers and on consumption of water for certain specified activities. The Act also provides for a rebate on the cess payable if the person or local authority concerned installs a plant to treat sewage or trade effluent. The cess rates were increased three fold in February 1992. A rebate of 25% on the cess payable has been provided to those industries that do not exceed the quantity described by them and that also comply with the effluent standards prescribed under the Water Act and the Environment Protection Act. The cess is potentially an effective instrument for inducing abatement. However, the rates are so low, varying between 1.5 to 5 paise per kilolitre to raw water, that the rebate has not served as much of an incentive so far. It is important to assess the effectiveness of this Act and work out measures, which would improve the applicability and outcomes of the Act. Incentives have to be made more attractive to make the industries undertake pollution control measures. Besides the Water Cess Act, efforts have to be made to introduce and implement the Zero discharge concepts, which would enhance recycle and reuse of effluent discharge.

If water is available in abundance, there is a usually tendency to use it carelessly. Along with the measures towards pollution abatement it is imperative to further intensify our efforts for conservation of water to prevent ground water depletion. The consumer has little incentive to conserve water, as water tariffs are very low. In addition to appropriate pricing of water to reduce water demand in the household sector, there is a need to develop and implement such cost-effective water appliances as low-flow cisterns and faucets and formulate citizen forum groups to encourage and raise awareness on water conservation. The need is to develop surface irrigation sources and take measures for rainwater harvesting and preventing water run-offs. The amount unit area run-off from various basins of India very widely reflects the spatial distribution of annual rainfall. Moreover, the rivers of the country carry about 80% during the monsoon months of June-September and generally in excess of 90% during the period of June-November. Hence, the run-off can be tapped by building appropriate water harvesting structures in the lower reaches to trap the water. However, there are certain constraints associated with rainwater harvesting in terms of the capacity of soil to absorb large quantities of water in a shorter time frame, quality of the harvested water for drinking water purpose, and the cost involved with building such harvesting structures. There is no doubt that water harvesting is a highly desirable solution but it is an iota solution to a holistic problem of water scarcity.

The concept of watershed development has also to be adopted more rigorously, which effectively contributes to the revival of local level traditional water control works. Micro-watershed development provides a medium for revival and integration of traditional water control measures. This type of integrated planning helps to make investments far more effective, functionally and economically. But is also more demanding on both the government and the affected people. Obviously a major effort in public education and training of local people to impart the basic understanding and skills necessary for eliciting such participation.

Community management is the key to successful overall performance of the water sector. One of the major reasons the International Drinking Water Supply and Sanitation Decade did not have as much impact as it could have had was its emphasis on health improvement. The planners failed to take into account the perceptions and concerns of the user community at large while implementing water supply and sanitation projects. It has been amply demonstrated that projects with community input are more successful in terms of reaching the greatest number of affected people with long lasting services. Other benefits include lower costs, greater acceptance of the technology, and better maintenance of the facilities by the users. However one needs to maintain some degree of caution while adopting either 'community participation' or 'community management' approaches. Community-based management goes one step beyond just simple involvement of the people in the process - it empowers the community to control its systems. This would require a number of committed volunteers and trained staff to carry out the tasks. At the micro-level, the delegation of integrated water resources development and management procedures to the lowest appropriate levels would lead to redressal of the problems of the affected people within their own social and regional domains. The NGOs can provide a very important link between the community and government institutions. The NGOs can offer their services in capacity-building of the relevant stakeholders, R&D for low-cost and effective water supply and sanitation facilities, and timely enforcement of policies.

10. Conclusion

India is endowed with opulent water resource. However, it is slowly becoming a water-stressed country. Availability of water is highly uneven both in space and time. The increasing levels of pollution also threaten the ever-reducing quantum of water. Scarcity of water, its qualitative deterioration together with inefficient water use practices has serious implications on the water resources of the country reaching an alarming state. The present approach for water quality management is not sufficient to achieve the targeted goal on water quality. Massive efforts are needed to to augment the treatment capacity for ever increasing sewage, industrial effluents and use them for irrigation and water conservation.
