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Key Note Paper

Water Quality Management in Changing Environment

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Abstract : As we know water is the most essential natural resource for our life, economic growth and agriculture. In the recent past, it is becoming a critical scarce resource in many parts of the country. Fortunately, India is wettest country in the world with its annual average rainfall 1170 mm. However, the rainfall is highly erratic and variable spatially and temporarily, seriously affecting the water availability in different parts of the country. With population growth, fast urbanization, industrialization and advancement in agricultural activities, the demand of water has increased steeply, leading to over-exploitation of our water resources. Agriculture is predominant use of water and account for about 85% of water use. This has resulted in depleting the water table in many part of our country to a large extent and leading to shrinking or drying of many water bodies. This has led to a large number of water quality and environmental issues. Nearly 80% of water pollution is attributed to discharge of untreated domestic wastewater generated from the fast growing large urban centres. As per the estimates of Central Pollution Control Board, the Class-I cities (Population >1 lakh) and Class-II towns (population 50,000 – 1,00,000) in India generate about 38,000 million liter of wastewater every day, which is continuously increasing due to fast urbanization and treatment capacity exists for only about 7000 million liter of wastewater. In past 25 years, Govt of India has tried to assist the urban local bodies (ULBs), who are responsible for waste management, to create wastewater treatment facilities under Ganga Action Plan, Yamuna Action Plan and National River Action Plan and able to create treatment capacity of about 4000 million liter/day. However, these facilities are neither adequate nor effective to restore our rivers in terms of water quality. A massive effort is needed to manage our water resources judiciously through an integrated water resource management at basin level, proper allocation for different uses and regulation at Panchayat level, conservation of the surface runoff by different techniques for use in fair weather.

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 resources, 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 form 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 redressal 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 alongwith poverty , unemployment, diseases & 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.

WATER RESOURCES OF INDIA

The geographical area of India is 3,287,590 sq km. India's climate varies from tropical monsoon in south to temperate in north. Its terrain have upland plain (Deccan Plateau) in south, flat to rolling plain along the Ganges, deserts in west, Himalayas in north. India is rich with respect of water resources. The annual average rainfall over India based on the daily collected by Indian Meteorological Department data at 1476 rainfall-recording stations for a period of over 100 years (1901-2003) is computed as 1182.8 mm (IMD, 2006), which is largest anywhere in the world for a country of a comparable size. From precipitation alone India receives about 4000 billion cubic meter (BCM), including snowfall (Rakesh Kumar et al 2005). Of this 3/4 part occurs only during monsoon. A good part of it is lost through the process of evaporation and plant transpiration, leaving only half of it on the land for use. The rainfall, however, varies from 100 millimetre to 12000 millimetre within the country. During rainy season, availability of water from precipitation is far in excess of natural and man-made holding capacity which results in floods. During the non-rainy period, high evaporation rates coupled with high water demands cause drought conditions requiring import of water. Flood and drought thus constitute the extreme manifestations of hydrologic cycle. The situation is exacerbated due to depleting forest cover in the country. The National Commission for Integrated Water Resources Development (NCWRD 1999) has estimated the basin-wise average annual flow in Indian river systems as 1953 BCM. Due to topographical, hydrological and other constraints, it is assessed that only about 690 BCM of surface water can be put to beneficial use by conventional methods of development. The annual replenishable ground water resources are assessed to be about 433 BCM of which the annual usable resources are estimated at 399 BCM (http://mowr.gov.in). The Annual ground water draft is 231 BCM out of which 213 BCM is used for irrigation and 18 BCM is for domestic & industrial use. Since independence, the country has been planning to utilise this water by prolonging its stay on land by using engineering innovations such as dams and barrages.

There are 13 major (basin area e"20,000 Km^2), 45 medium (basin area 2000 to 20,000 Km^2) and 55 minor (bsin area <2000 Km^2) river basins in India as shown in Figure 1. All the major river basins are not perennial. Only four of the thirteen major basin posses areas of high rainfall, i.e. Brahmaputra, Ganga, Mahanadi and Brahmini having annual average discharge of a minimum of 0.47 million cubic meter per Km^2, and they are perennial. Six basins (Krishna, Indus, Godavari, Narmada, Tapi and Subernrekha) occupy the area of medium rainfall and have annual average discharge of a minimum of 0.26 million cubic meter per Km^2, and the remaining four (Cauvery, Mahi, Sabarmati and Pennar) occupy the area of low rainfall and have annual average discharge between of 0.06 and 0.24 million cubic meter per Km^2. Thus, many of the major river basins also goes dry during summer leaving no available water for dilution of waste water discharged in them.

Analysis of basin wise potential of ground water by the Ministry of Water Resources indicates that the Ganga Basin has the maximum potential which is 171 Km^3. Other basins are far behind the Ganga that accounts for more than 39 percent of total potential in the country. As a consequence of its prime place regarding availability, the quantities of ground water potential in the basin apportioned for different uses is very high vis-a vis other rivers. Net draft though highest in the Ganga, yet ground water development percentage is highest in the Indus basin, where it is 78.9 percent. The ground water development is the lowest in the Brahmaputra (3.37 percent), followed by Meghna (3.94 percent), Mahanadi (6.95 percent), Brahmani with Baitarni (8.45 percent), Subarnarekha (9.57 percent) North East Composite (17.20 percent) and Godavari (19.53 percent). Among the States, the highest potential of ground water is in Uttar Pradesh which mostly lies in the Ganga Basin. Development of ground water in Punjab in percentage is highest where about 94 percent of the resources appear to have been tapped. The neighbouring state of Haryana with 84 percent development occupies the second place. The other States where the percentage development is more than 50 percent are Tamil Nadu (60 percent) and Rajasthan (51 percent). Percentages of development in the states of Jammu and Kashmir, Assam, Goa and Orissa are very low.

WATER DEMAND

The demand for fresh water has been assessed by the Ministry of Water Resources (NCWRD 1999) as the quantity of water required to be supplied for specific use and includes consumptive as well s necessary non-consumptive water requirements for user sector. The total water withdrawal/ utilization for all uses in 1990 was about 518 BCM or 609 m^3/capita/year. Estimates for water requirements, through iterative and building lock approach, have been made for the years 2010, 2025 and 2050 for total national level requirements (Table 1) based on a 4.5% growth in expenditure and median variant population projections of United Nations. The country's total water requirement by the year-2050 would become 1447 BCM, which would be much in excess of total utilizable average water resources of 1086 BCM. At the national level, it would be a very difficult task to increase the availability of water for use from the 1990 level of approximately 520 BCM to be desired level of 1447 BCM by the year 2050 as most of the undeveloped utilizable water resources are concentrated in a few river basins, for example Brahmaputra, Ganga, Godavari, Mahanadi.

The over-exploitation of ground water resources is widespread across the country, and is projected to grow with time. The inappropriate land use practices prevalent in the country limit the groundwater recharge potential. Accordingly, the ground water levels are receding in some regions of the country at an alarming rate. On the other hand, due to excessive irrigation and large water storages, some regions have registered rise in ground water levels, at times leading to serious water logging problems.

The consumptive uses (e.g. irrigation) far outweigh the non-consumptive ones (e.g. industrial). However, the non-consumptive use is rising with increase in population coupled with rapid urbanisation and industrialisation. India's water use has significantly increased over the last five decades. Further increases envisaged up to 2025 AD are from the present level (Table 1). With higher rate of urbanisation and industrialisation, proportion of irrigation to total use is projected to fall. With given situation, future water demands can be met in absolute quantity and quality terms only through pragmatic planning that includes highest priority to water conservation, recycling-reuse of municipal and industrial wastewater, and inter-basin/inter-regional transfers of water.

WATER QUALITY MONITORING

The first step towards ensuring water quality is to generate reliable and accurate information about water quality. Several government institutions and departments are involved in water quality monitoring, leading to overlapping of functional areas and duplication of efforts. While the State Pollution Control Board laboratories and the Central Pollution Control Board (CPCB) regularly monitor surface water bodies, the Central Ground Water Board is primarily responsible for monitoring groundwater quality along with the State Drinking Water Mission under the respective public health engineering departments. In order to monitor the surface water quality, the CPCB started a national water quality monitoring programme in 1978 under the Global Environmental Monitoring System (GEMS). Parallel to GEMS, a National Programme on Monitoring of Indian National Aquatic Resources (MINARS) began in 1984. At present, a network comprising 1700 stations on rivers, lakes, ponds and groundwater (CPCB 2009) is in place. The Central Pollution Control has been monitoring water quality or national aquatic resources in collaboration with concerned state Pollution control Boards in India. Based on the monitoring results, the CPCB identifies polluted river stretches, which needs prioritization in pollution control efforts.

EXISTING WATER QUALITY STATUS

The CPCB water quality data revealed (cpcb.nic.in) that the major rivers of the country have retained pristine quality of water in their upper stretches, as they are least influenced by human interferences. As the rivers enter the plains, they gradually get polluted due to over-abstraction of their water and discharge of treated and untreated wastewaqter in course of flow. Thus, the middle stretches of the rivers are most affected due to increased water requirement for various consumptive and non-consumptive uses and input of pollution. In the lower stretches, the rivers are generally better due to more water available for dilution and assimilation of pollution. The water quality monitoring results indicate that organic and bacterial contamination is the main water quality issues with most of the rivers, lakes,

Table 1. Water requirement for different uses (BCM)

Use	2010	2025	2050
Irrigation	688	910	1072
Domestic	56	73	102
Industries	12	23	63
Energy	5	15	130
Others	52	72	80
Total	813	1093	1447

ponds and even the groundwater sources in the country. Apart from organic pollution originated from domestic sources, toxic pollutants (mostly organochlorine compounds and toxic metals) are also becoming increasingly important in many parts of the country due to industrial wastes and agricultural contribution. Increased salinity has also been observed in many parts of the country due to discharge of industrial wastewaters, and irrigation return flow and surface run-off from arid and semi-arid regions. It is estimated that the total riverine length is about 45,000 Km, out of which about 6000 Km is heavily polluted with biochemical oxygen demand (BOD) level always exceeding 6 mg/L, dissolved oxygen lower than 50% saturation and coliform count exceeding 5000 number/100 mL another 8,800 Km is moderately polluted with BOD between 3 to 6 mg/L, dissolved oxygen below 70% saturation and coliform count exceeding 5000 number/100 mL remaining 30,000 Km is relatively clean with BOD less than 3 mg/L and dissolved oxygen above 70% saturation. A major part of the cleaner category of riverine length is existing in hilly part of India, where the human influences are not so intensive.

GROUNDWATER QUALITY

Monitoring groundwater quality remains a prime concern and a major challenge in rural India since it is the predominant source of drinking water (World Bank 1999). It remains a major monitoring challenge considering the geographical spread of Indian villages and the fact that many of the remote villages are not accessible to regular monitoring by central agencies due to transportation and communication problems. Hence it is the rural population that suffers the most from problems related to fluoride, arsenic as well as microbial contamination (Water Aid, 2008). State Drinking Water Mission under the Rajiv Gandhi National Drinking Water Mission (RGNDWM, 2006) and sanitation department through the public health engineering division is mandated to undertake the assessment of all drinking water sources. The National Rural Drinking Water Quality Monitoring and Surveillance Programme was launched in February 2006, which is responsible for monitoring the drinking water quality. It has been provided with water testing kits. However, this program was not very effective in providing the water quality information to the users.

MAJOR CAUSE FOR WATER QUALITY DEGRADATION

India is urbanizing very fast. It is observed that from a modest base of 25.8 million urban population in 1901, the number of urban dwellers has raised to 377 million in 2011, signalling a phenomenal fourteen and half fold increase in urban population over the period of hundred and ten years. The growth rate has steeply increased in the recent past as clear from figure 1

Fast urbanizing led to steep increase in sewage generation. Discharge of untreated domestic sewage is predominant source of pollution of aquatic resources in India. Urban centres contribute most of the sewage in the country. The smaller towns and rural areas generally do not contribute significant amounts of sewage due to low water supply and predominant practice of open defecation. Whatever, little sewage generated in these human settlements normally percolates in the soil or evaporates. CPCB carries out regular inventory of water supply, sewage generation, collection, treatment and disposal in class-I (population >100,000) cities and class-II towns (population between 50,000-100,000) of the country. As per the latest inventory (CPCB 2009), total volume of sewage generated from class-I cities and class-II towns was 38,260 million liter per day (MLD), against which treatment capacity exists for only 11,780 MLD, and even this capacity is also not fully utilized. As per the CPCB's survey the sewage treatment plants are able to utilize only about 69% of their capacity and their performance was about 70% (CPCB 2006). Thus there is a large gap between generation and treatment. Figure 2 depicts

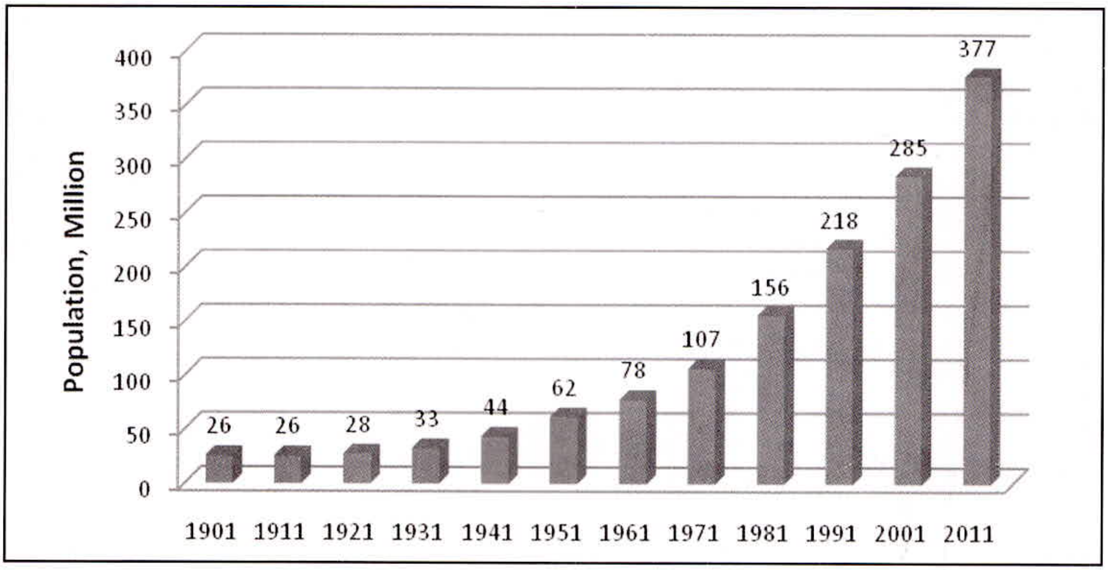

Fig. 1. Trend in Urban Population Growth in India

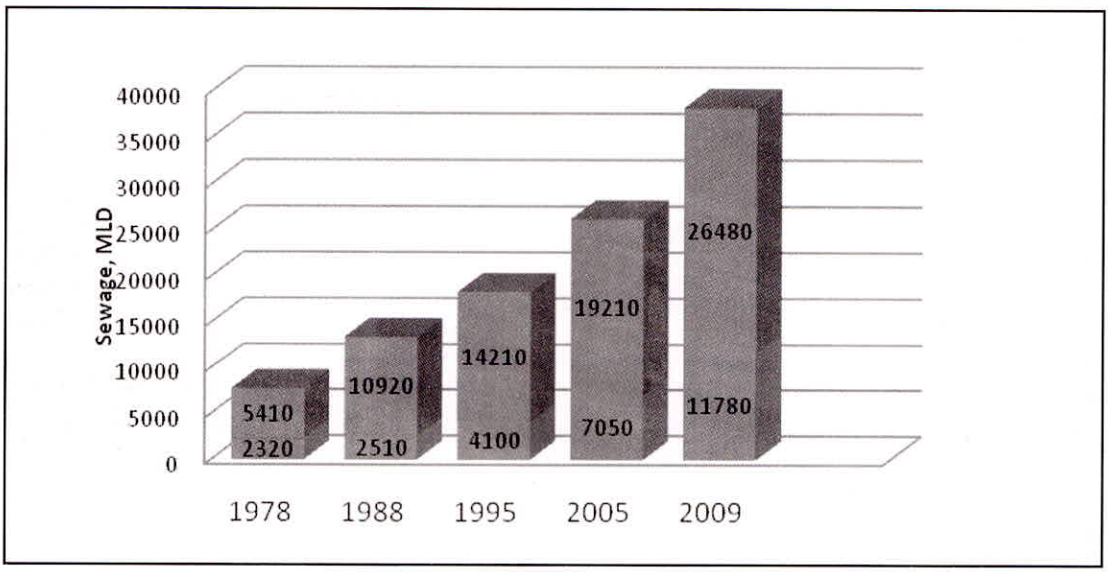

Fig. 2. Growth in Sewage Generation and Treatment in India

the growth of sewage generation and its treatment. It is observed that although the sewage treatment capacity is continuously being augmented in the country, the growth of sewage generation is much faster and thus the gap is continuously widening.

It is also observed that there is no proper collection system for sewage and thus, a large part of the sewage is flowing in storm water drains. These drains many times also receive garbage, solid wastes including plastic wastes, which result in their chocking. This leads to retention of large amount of sewage in the city premises, forming cess pools, which are good breeding grounds for mosquitoes and leading to groundwater pollution. Since these storm water drains are ultimately leading to rivers, lakes or sea, the treated, partially treated or untreated sewage is disposed into natural rivers or lakes or used on land for irrigation/ fodder cultivation or to the sea.

APPROACH TO WATER QUALITY MANAGEMENT

The government explicitly 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 lay down and maintain 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. The basic objective of Water 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), which was created under the provision of Water Act, 1974 has taken human uses of water as a base to identify the level of water quality to be maintained. 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 maintain 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 2.

All major rivers in 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.

Table 2. Use Based Classification of Surface Waters In India

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

Source. (Govt of India, 2006)

DEVELOPMENT AND IMPLEMENTATION OF EFFLUENT STANDARDS

The simplest administrative approach to regulate industrial pollution would be to promulgate permissible limits for various pollutional parameters on a general basis, make them binding on all discharges and prosecute and punish any offenders. Control of pollution at sources is the immediate short term objective adopted by all the state pollution control boards in India. To control pollution at source the industries must know the extent up to which their effluent or emission must be treated/controlled so that they can discharge the treated effluent to receiving environment without significant effect. The cost of treatment should be such that the industry is able to take the burden (economically feasible). The Central Pollution Control Board has initiated evolving industry specific Minimum National Standards

(MINAS) as early as in 1977-78. At present it has evolved effluent standards and emission standards for almost all major polluting industries. These standards have been notified under Environmental (Protection) Act, 1986, by the Government of India. The MINAS is binding on all the State Boards. No state board is permitted to relax the MINAS, if situation so demand, the state boards may make them more stringent.

MAJOR WATER QUALITY THREATS

Water Scarcity

The rainfall, which is the only source of freshwater, is highly un-even in distribution in time and space in India. The rainfall in some area of Rajasthan is as low as about 100 mm to some areas in North-East as high as 12000 mm. The rainfall is also not evenly distributed throughout the year. It is concentrated to only 3-4 months. The average number of rainy days in a year is about 40 and in terms of hours it is less than 100 hours in a year. Which means the rainfall is concentrated to a very short duration in a year resulting in a major part of it is flowing back to sea. It gets little opportunity to percolate and recharge groundwater. A major part of the flow (about 69% to 96%) in majority of rivers occurs in a short duration of monsoon period (mowr.nic.in). In the remaining dry period all uses of water are being sustained by the water retained by land in form of surface water in lakes, ponds, rivers (dry weather flow) and in form of groundwater. The ever-increasing demand of water for agricultural, industrial and domestic activities, the water resources are over-exploited. This is resulting in shrinking or even drying up of many water bodies for considerable period in a year. Many rivers which used to have considerable flow throughout the year now flow for 3 to 4 months in a year. The over-drafting of groundwater resulted in lowering the water table below the river bed resulting in low-flow or no-flow conditions in many rivers in the country. For example River Yamuna has practically very little or no freshwater release from Tajewala to Wazirabad barrage (about 250 Km stretch) after October every year. Similarly, many of its tributaries like Chambal, Parbati, Sindh, Kshipra, which used to flow for whole year just 25 years ago, remain dry for almost 200 to 250 days in a year. Majority of the rivers in Central and Southern India has similar story. This results in loss of aquatic flora and fauna, leading to loss of livelihoods for river fisher folk, significant impacts on human health from polluted water, increased drudgery for poor, rural women in collecting drinking water from distant water bodies, loss of habitat for many bird species, and loss of inland navigation potential. Apart from these, many rivers are inextricably linked with the history and religious beliefs of peoples of India, and the degradation of such river systems accordingly offends their spiritual, aesthetic, and cultural sensibilities. The direct causes of river degradation are, in turn, linked to several policies and regulatory regimes. While setting Minimal National Standards (MINAS), which are implemented all over the country for regulation of pollution, it was envisaged that at least 10 times dilution was available in the receiving water bodies. Unfortunately, in majority of the cases such dilution is not available for considerable time in a year in the recent past leading to water quality degradation. Discharging wastewaters even after treatment in such water rivers results in serious water quality problems and maintaining targeted water quality is very difficult. If objectives of Water Act, 1974 or Environment (Protection) Act, 1986 are to be met, minimum level of water needs to be maintained in the water bodies in order to assimilate the residual pollution.

Over-Drafting of Groundwater

India is now the biggest user of groundwater for agriculture in the world (Shah 2009). Groundwater irrigation has been expanding at a very rapid pace in India since the 1970s.There is no appropriate policy for groundwater use in agriculture. In order to pursue green revolution, to feed the growing population of the country, and make it self sufficient in food grain, irrigation is promoted all over the country. This has led to steep increase in abstraction of groundwater. The number of groundwater structures in the country has steeply increased in last 4-5 decades. The number was about 3.8 million in 1951 have grown to about 19 million and about 7900 cubic meter/year water is extracted per structure. This is a phenomenal growth. The farmers do not pay for the amount of groundwater pumped for irrigation. In addition, electricity costs for pumping are very heavily subsidised by many governments. Accordingly, farmers mostly pump more groundwater than is needed for optimising crop production. In turn, this over-pumping is resulting in a steady decline of groundwater levels in many important aquifers all over the country. As the groundwater levels decline, more energy is needed to pump the same quantity of water, which requires additional subsidising of electricity costs. This has contributed to a vicious cycle of overuse of groundwater, declining aquifer levels, increasing losses to the electricity boards and increasing adverse environmental impacts (like land subsidence), none of which are sustainable on a long-term basis. Thus, major policy changes in the water and energy sectors will be needed in the future to balance water and energy uses, stabilise the levels of declining groundwater tables and reduce electricity subsidies to the farmers. Matthew Rodell et al (2009) used terrestrial water storage-change observations from the NASA Gravity Recovery and Climate Experiment satellites and simulated soil-water variations from a data-integrating hydrological modelling system to show that groundwater is being depleted at a mean rate of 4.0 ± 1.0 centimeter/year equivalent height of water (17.7 ± 4.5 cubic kilometre/year) over the Indian states of Rajasthan, Punjab and Haryana (including Delhi). During the study period of August 2002 to October 2008, groundwater depletion was equivalent to a net loss of 109 cubic kilometer of water, which is double the capacity of India's largest surface-water reservoir. The annual average rainfall was close to normal during this period. Punjab State Farmers Commission in its report has shown alarming picture of the state. It has shown that the area under rice has increased to unsustainable level of 2.6 million hectare (mha) against 1.6 to 1.8 mha can be sustained (based on annual average recharge) and the water table is receding at alarming rate of 60 to 75 centimeter/year, 30% of tubewells are converted to submersible pumps. They predicted that in next 10 years all the tubewells in the state have to be converted to submersible pumps (MoWR 2006). Similar alarming situations are prevailing in many other parts of the country.

Populations Food Grain Requirement

Kalipada Chatterjee (2008), an expert from Climate Change Centre estimated the food grain availability at present in India is around 525 gms per capita per day. With growing economy and prosperity in the country this may grow. If small raise is made in per capita consumption to 650 gms the food grain requirement will be about 390 MT of food grain. Taking the projections of about 1800 million populations by 2050 AD Kalipada Chatterjee estimated food grain requirement of about 430 MT annually at the present level of consumption, which may need much greater use of available inputs including water and fertilizers. Which may need to increase area under irrigation from present 28% to roughly 40% by the year 2050 and adopting drip and sprinkler irrigation in India?

Drinking Water Quality and Health Impacts

ACCESS to safe drinking water remains an urgent necessity, as 30% of urban and 90% of rural households still depend completely on untreated surface or groundwater (Rakesh et al, 2005). More than 300 million episodes of acute diarrhoea occur every year in India in children below 5 years of age (Annual Report, Ministry of Health 2010) .

While access to drinking water in India has increased over the past decade, the tremendous adverse impact of unsafe water on health continues (WHO/UNISEF 2004). It is estimated that about 21% of communicable diseases in India is water related (Brandon and Homman,1995). The highest mortality from diarrhoea is said to be among children under the age of five, highlighting an urgent need for focused interventions to prevent diarrhoeal disease in this age group (Gadgil 1998). Despite investments in water and sanitation infrastructure, many low-income communities in India continue to be bereft of safe drinking water (World Bank, 2007). Regardless of the initial water quality, widespread unhygienic practices during water collection, storage and consumption, overcrowded living conditions and limited access to sanitation facilities perpetuate the transmission of diarrhoea-causing germs through the faecal–oral route (Montgomery and Elimelech, 2007). A majority of inland rivers which are the sources of drinking water in urban India are also contaminated (CPCB, 2009). While the shift in usage from surface water to groundwater has undoubtedly controlled microbiological problems in rural India (Shah 2005), the same has however, led to newer problems of fluorosis and arsenicosis (Rao and and Mamatha 2004, Chakraborty and Saha 1987). Excess iron is an endemic water quality problem in many parts of eastern India (Smedley, 1991). In 2002, 17 states were affected by severe fluorosis (Choubisa, 2001) and now the problem exists in 20 states, indicating that endemic fluorosis has emerged as one of the most alarming public health problems of the country (Teotia and Teotia 1984). About 62 million people are suffering from various levels of fluorosis, of which 6 million are children below the age of 14 years; they suffer from dental, skeletal and/or non-skeletal fluorosis (Susheela and Majumdar 1992). High rates of mortality and morbidity due to water-borne diseases are well known in India. Serious degradation of water quality in urban India has often been attributed to indiscriminate disposal of sewage and industrial effluents into surface water bodies. Although some degree of intervention in terms of chlorination and monitoring of water quality exists in major cities and towns, rural India, which constitutes the bulk (70%) of the population, is usually deprived of such interventions.

It has been estimated that around 37.7 million Indians are affected by water-borne diseases annually, 1.5 million children are estimated to die of diarrhoea alone and 73 million working days are lost due to water-borne diseases each year (Divakar and Nagaraj, 2003). The resulting economic burden is estimated at US$ 600 million a year (Murthy et al, 1999). Clearly, the health benefits in terms of reduction in water-borne diseases have not been commensurate with the investments made (Hughues et al, 2001). Another estimation by Water and Sanitation Program of World Bank along with Asian Development Bank, Australian Government (AusAID) and UKAID the total economic impacts of inadequate sanitation at Rupees 2.44 trillion (US $ 53.8 billion) a year, which is equivalent of 6.4% of India's GDP in 2006 or Rs. 2,180 (US $ 48) per person per year.

Sanitation v/s Water Quality

Although the burden of diarrhoeal disease resulting from inadequate water quality, sanitation practice and hygiene remains high, there is little understanding of the integration of these environmental control strategies (Eisenberg et al 2007). Sanitation and hygiene are often perceived as social and behavioural issues, and water quality as a technical issue requiring technical intervention. In the absence of common verifiable indicators for both water quality, and hygiene and sanitation at the community level, the outcomes of various interventions are seldom quantifiable. Moreover, sanitation is often perceived by both the government agencies as toilet coverage at household level, but seldom emphasis is laid on treating the water emanating from these facilities leading to gross contamination of water sources. Although open defecation remains a major problem in rural India and responsible for contamination of surface water, animal wastes (cattle excreta) also play a significant role in groundwater contamination in rural India in the absence of effective animal waste management (Water Aid 2008).

Inadequate Volumes in Receiving Waters

Although the MINAS is mainly technology based, some consideration is given to the receiving water body based on the assumption that in the receiving water body at least 10 times dilution is available to achieve the ambient water quality objective in the immediate vicinity of the downstream. In the recent past due to over use of surface and ground waters to fulfil the ever increasing demand of agriculture, industrial and domestic uses, the water level in our aquatic resources is gradually decreasing. As a result, the assumption of 10 times dilution is no more valid in many parts of our country. This poses great difficulties to achieve the ambient water quality objective (wholesomeness) even after implementing MINAS. This is a challenge before the Pollution Control Boards and the polluters. Thus, it has become necessary to achieve progressive reduction or elimination of effluent discharges. It implies adoption of no waste or low waste technologies through new treatment methods which can fulfil the above objective.

Multiplicity of Organizations

There are a large number of organizations working on different aspects of water resources. They have their own agenda and their own targets to be achieved. Little cooperation exists between these agencies responsible for the use and management of water resources in different sectors such as environment, public health and agriculture. The result is a planning process which does not take into account the needs of these different interest groups and lacks accountability on the part of any given agency. The major bottleneck in an effective policy formulation and implementation is the current institutional set-up involving various government agencies. Further, there is a separation of responsibilities on the basis of water quality and quantity. As many as eighteen agencies are involved in water use and its management. Such a fragmentary approach, both at the central and state levels, results in duplication and ambiguity of functions and discourages unitary analysis of this scarce resource.

Standards and Compliance

Complying with the Minimum National Standards (MINAS) set by the CPCB requires that near-the-maximum effluent reduction technically achievable must be done. It has been found that a significant proportion of small scale industries discharging trade effluents to water stream do not have treatment plants especially those located in residential areas. It has also been observed that a significant proportion of polluting units, which have some treatment mechanism, do not comply with standards. The punitive action by the State Pollution Control Boards (SPCBs) is more or less tied up with litigation and considerable proportion of cases is pending for several years. The SPCBs are, sometimes, not able to exercise the powers to force compliance by stopping electricity supply or water because of interference by powerful pressure groups. Credible action requires formation of sufficiently empowered legal bodies to decide these cases expeditiously.

Environment Impact Assessment (EIA)

Although EIA processes consider water as component of environment, the impact of a proposed activity is evaluated only on quality. Whereas many developmental activities cause serious impacts on quantity and ultimately on the quality of water, this is not evaluated in integrated and holistic manner, which results in a large number of developmental activities e.g. industries, housing complexes, etc., coming up in an area consuming large quantities of ground and surface water causing their depletion in the area. There is a need for evaluation of impact on quantity and quality in cumulative way of all the activities in an area and its impact zone should be demarcated so that any new proposed developmental activity takes care of already existing impacts

Ecology and Environmental Flows

The basic objective of Water Act, 1974 and Environemnt (Protection) Act, 1986 is conservation of rivers by way of restoring their ecosystems to their natural ecosystem structures and functions. Initially it was thought that the pollution of rivers was the main cause for disturbing the ecosystem and that major pollution is coming from the urban centres located along the rivers. The National River Conservation Directorate (NRCD) under Ministry of Environment and Forests, Government of India with the help of concerned State agencies established sewage treatment plants to achieve a reduction in pollution from urban centres. However, at a later stage of implementation it was realized that sewage treatment alone might not be sufficient to restore the river's ecological integrity because it was seriously affected by low-flow or no-flow conditions prevailing over a considerable segments of many rivers.

Many living creatures need perennial flow in the river because they complete their lifecycle in more than a year. They also need a natural flow regime, which means floods and lean flow conditions for different stages of their life cycle. Until this complexity is understood properly, any change in flow regime will cause many vital living creatures to vanish and cause serious ecological damage in the river, thus violating the principal objective of NRCD.

The flow is also needed to continuously transport the wastes and to maintain a reasonable capacity in the rivers to assimilate the residual pollution that needs to be discharged even after proper treatment. As no technology, which is presently economically viable in the Indian context, can remove all pollution from wastewater, some residual pollution will be found in the treated effluent, which needs to be assimilated by the river ecosystem. Due to heavy abstraction of surface and groundwater in the catchment area of the rivers, they remain dry for a considerable period in a year. In order to maintain the environmental flows in these rivers, it is important that water resources are first optimally utilised with water conservation as the goal and then augmented water resources in the entire basin in a very large way ensuring that the water table never falls below the river bed in any reach of the rivers. This needs a massive effort in groundwater recharge, revival of the village ponds, watershed development, micro-catchment treatment, optimising cropping patterns and irrigation demands, water conservation integrated in urban planning, recycling of wastewater and overall economy in water use. This would further need significant institutional strengthening to manage and operate all water related activities with full cost recovery.

Pollution Control in Industries

Although, the enforcement framework for industrial pollution control could brought a large change in the behavior of the industries and was successful in reducing industrial pollution in the country in almost all the large and medium industries. However, in case of small scale industries the enforcement is still weak due to various reasons. The most important one is related to their locations, insufficient resources, skilled manpower and space. Moreover, nearly 80% of the water pollution is caused by discharge of untreated domestic wastewater, which is very often from the Government supported urban local bodies due to lack of technical, managerial and financial capacities leading to such unhealthy practices. Thus even if the all industrial effluents are fully treated to the stipulated levels, the water quality objectives cannot be achieved without similar surveillance and strict adherence to water quality protocol

Operation and Maintenance of sewage treatment plants (STPs)

Operation and maintenance of existing plants and sewage pumping stations is a neglected field, as nearly 39% plants are not conforming to the general standards prescribed under the Environmental (Protection) Rules for discharge into streams as per the CPCB's survey report (CPCB 2006). STPs are usually run by personals that do not have adequate knowledge of running the STPs and know only operation of pumps and motors. The operational parameters are not regularly analyzed hence the day-to-day variation in performance is not evaluated at most of the STPs. Thus, there is a need that persons having adequate knowledge and trained to operate the STPs be engaged to manage STPs and an expert be engaged to visit the STPs at least once a month and advice for improvement of its performance. In a number of cities, the existing treatment capacity remains underutilized while a lot of sewage is discharged without treatment in the same city. Auxiliary power back-up facility is required at all the intermediate pumping station (IPS) & main pumping stations (MPS) of all the STPs. It is very essential that they be efficiently maintained by the State Governments whose properties and charge they are. Inter-agency feuds and inadequate consideration of which agency would be responsible for what has led to inadequate maintenance of various STPs and other facilities created under various Central or State funded schemes. The maintenance of the sewage system, namely, sewers, rising mains, intermediate pumping stations, etc. should also be entrusted to the nodal agencies identified for the maintenance of the sewage treatment plants and sufficient funds and staff provided to them. Facilities like community toilets, electric crematoria, etc. should be maintained by the local bodies. Also the aspect of resource recovery by way of raising the revenue through sale of treated effluent for irrigation, of sludge as a manure and biogas utilization for power generation wherever provision exist needs to be addressed. Biogas generation, pisciculture from sewage as envisaged in the Ganga Action Plan is still not adequately addressed.

Diffuse Water-Pollution

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. 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 was not adequately addressed. 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 partially functioning, overloaded or defunct. Thus, the uncollected sewage flows in storm water drains or retained on land to percolate, leach or get washed-off to streams or groundwater. Similarly, industrial areas are being developed and large number of industries are coming up. Due to alck of proper conveyance system for the wastewater, a large part of it is retained in the industrial area with same fate as explained above.

CONCLUSIONS

Recent data on the status of water resources management in India reveal several alarming trends. The country is urbanizing very fast leading to steep increase in waste generation. Due to paucity of resources the urban local bodies, which are responsible for waste management are not able to cope with the ever increasing problem. In order to achieve higher economic growth, fast industrialization is also leading to put higher demand on water and generating wastes, which are let out into the water bodies causing water quality degradation. The groundwater, which is main source of drinking for nearly 85% population is also depleting at alarming rate and its quality is deteriorated due to geogenic and man-made pollution, thus threatened the drinking water security. The situation has dramatically worsened within a short span of last few years. Until a massive efforts are put on water conservation, rainwater harvesting and augmenting effective sewage treatment, the situation would be un-manageable in few years from now.

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