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Water Quality Monitoring in India: A Review

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Abstract

India is rich in water resources, being endowed with a network of rivers and blessed with snow cover in the Himalayan range that can meet a variety of water requirements of the country. However, with the rapid increase in the population of the country and the need to meet the increasing demands of irrigation, human and industrial consumption, the available water resources in many parts of the country are getting depleted and the water quality has deteriorated. Indian rivers are polluted due to the discharge of untreated sewage and industrial effluents. The Central Pollution Control Board (CPCB) has established a network of monitoring stations on rivers across the country. The present network comprises of 870 stations in 26 States and 5 Union Territories spread over the country. The monitoring is done on monthly or quarterly basis in surface waters and on half yearly basis in case of ground water. The monitoring of water quality at 257 stations is being done on monthly basis, 393 stations on quarterly basis, 216 on half yearly basis and 4 stations on yearly basis. Presently the inland water quality-monitoring network is operated under a three-tier programme i.e. GEMS, Monitoring of Indian National Aquatic Resources System and Yamuna Action Plan. Water samples are being analysed for 28 parameters consisting of physico-chemical and bacteriological parameters for ambient water samples apart from the field observations. Besides this, 9 trace metals and 15 pesticides are analysed in selected samples. Bio-monitoring is also carried out on specific locations. In view of limited resources, limited numbers of organic pollution related parameters are chosen for frequent monitoring i.e. monthly or quarterly and major actions, other inorganic ions and micro pollutants are analysed once in a year to keep a track of water quality over large period of time. The water quality data are reported in Water Quality Statistics yearbooks. The grossly polluted

rivers on specific stretches are Sabarmati, Godavari, Satluj, Yamuna, Cauvery, Ganga, Krishna, Tapi, Mahanadi and Brahmani whereas relatively clean rivers are Mahi, Narmada, Brahmaputra and Beas with respect to organic and bacterial pollution.

Keywords: Floods, India, Types, Causes, Distribution, Impact, Management.

1. Water Resources in India at a Glance

The geographical area of India is 3,287,590 sq km. The length of its Coastline is about 7500 km. The climate of India 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 enviably endowed in respect of water resources. The country is literally criss-crossed with rivers and blessed with high precipitation mainly due to the southwest monsoon, which accounts for 75% of the an-nual rainfall. There are thirteen major river basins (area more than 20,000 square kilome-tre) in the country, which occupy 82.4% of total drainage basins, contribute eighty five percent of total surface flow and house eighty percent of the country's population. Major river basins are Brahmaputra, Ganga (including Yamuna Sub Basin), Indus (including Satluj and Beas Sub Basin), Godavari, Krishna, Mahanadi, Narmada, Cauvery, Brahmini (including Baitarni Sub Basin), Tapi, Mahi, Pennar and Sabarmati. The classification of river basin based on catchment area is given in Table 1. There are few desert rivers, which flow for some distance and get lost in deserts. There are complete arid areas where evaporation equals rainfall and hence no surface-flow. The medium and minor river ba-sins are mainly in coastal area. On the east coast and part of Kerala State, the width of land between mountain and sea is about 100 km, and hence the riverine length is also about 100 km. whereas, the rivers in the west coast are much shorter as the width of the land between sea and mountains is less than 10 to 40 km. Yet, in spite of the nature’s bounty, paucity of water is an issue of national concern resulting in deterioration of water quality in aquatic resources.

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 Brahamani having annual average discharge of a minimum of 0.47 million cubic meter per Km2, and they are perennial. Six basins (Krishna, Indus, Godavari, Narmada, Tapi and Subarnarekha) occupy the area of medium rainfall and have annual average discharge of a minimum of 0.26 million cubic meter per Km2, 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 Km2. Thus, many of the major river basins also go dry during summer leaving no available water for dilution of waste water discharged in them.

Replenishable ground water potential of the country, has been estimated by Ministry of Water Resources as 431 Km3 cubic kilometre per year. The potential available for irrigation is 360 Km3 per year and 16 percent is for drinking, industrial and other purpose.The figure for net draft of ground water considering the present utilisation indicates that substantial portion of total potential (about 68 percent) is still remaining untapped.

2. Approach to Monitoring

The monitoring activities under national network serve various assessment goals. These goals are determination of natural freshwater qualities in the absence of significant direct human impact, determination of long term trends in the levels of critical water quality indicators in freshwater resources and determination of the fluxes of organic matter, sus-pended solids, nutrients, toxic chemicals and other pollutants from major river basins to the seawater/coastal water interfaces. To meet the objectives and goals, highly selective network of strategically located monitoring stations is created and operated in the major, medium and minor watersheds of rivers, lakes, ponds, tanks, creeks, drains, canals and subsurface aquifers in the country. Three types of monitoring stations are set up for monitoring i.e. baseline, trend and impact or flux stations.

Table 1: Distribution of Monitoring Station in India.

River (main stream), Tributaries and Sub-Tributaries, Lake, Ponds, Tanks, Canals, Creeks and Groundwater Stations	Total Stations
Baitarni (5)	5
Brahmani (11) **Tributaries-Karo (1), Koel (2), Sankh (2)**	16
Brahmaputra (6) **Tributaries-Burhidihing (1), Dhansiri (6), Disang (1), Jhanji (1),Subansiri (1), Bhogdoi (1),Bharalu (1),Borak (1),Deepar Bill (1), Digboi (1),Mora Bharali(1),Teesta (4),Dickhu(1), Maney(2),Ranchu(2)**	31
Cauvery (20) **Tributaries-Arkavati (1), Amravati (1), Bhawani (5), Kabini (4), Laxmantirtha (1), Shimsa (2), Hemavati (1),Yagichi(1)**	36
Ganga (39) **Tributaries-Barakar (1),, Betwa (3), Chambal (7), Damodar (5), Gandak (1), Saryu-Ghaghra (3), Gomti (5), Hindon (3), Kali (West) (2), Kali Nadi (2), Khan (1), Kshipra (2), Mandakini (Madhya Pradesh) (1) , Parvati (3), Ramganga (1), Rapti (1), Rihand (2), Rupanarayan (1), Sai (1), Sone (5), Tons (Madhya Pradesh) (2), Yamuna (23),Sind (1), Johila (1),Sankh(1), Gohad (1), Kolar (1), Sai(1), Churni (1), Tons (Himachal Pradesh) (1),Sikrana (1),Daha (1), Sirsa (1), Dhous (1), Farmer (1)**	127
Godavari (11) **Tributaries- Manjira (2), Maner (2), Nira (I),), Wainganga (4), Wardha (1),Kolar (1), Kanhan(1), Purna(1),Karanja (1), Indravati (2), Shankhani (1)**	28
Indus **Tributaries-Beas (18), Chenab (1), Jhelum (3), Larji (1), Parvati (1), Ravi (3), Sutlej (21), Tawi (1), Gawkadal (1), Chuntkol (1), Sirsa (3), Swan (1)**	55
Krishna (19) **Tributaries- Bhadra (3), Bhima (10), (Ghataprabha (2), Malprabha (3), Muneru (1), Musi (2), Nira (1), Paleru (1), Tunga (1), Tungabhadra (6), Panchganga (3), Chandrabhaga (2)**	54
Mahi (9) (2G, 7) **Tributaries-Anas (1), Panam (1)**	11
Mahanadi (18) **Tributaries-Ib (4), Hasdeo (2), Kathajodi (1), Kharoon (4), Kuakhai (2), Sheonath (3), Birupa (1),Arpa (1), Kelo (2)**	38
Narmada (14) (3G,11) **Tributaries-Chhota Tawa (1)**	15
Pennar (1G, 4)	5
Sabarmati (2G, 4) **Tributaries-Shedhi (1), Khari (1)**	8
Subarnerekha (4G,2)	6
Tapi (11) (3G, 8) **Tributaries-Girna (2M), Rangavali (1)**	14

Source: CPCB, Delhi.

Groundwater quality problems have reached to a cause of concern throughout the country. Salinisation and use of agrochemicals mandate the monitoring of trends in important aquifers, particularly of the arid and semi-arid climate belt. Trace contaminants, Fluoride and Nitrates, by levels and trends, are the primary monitoring concerns for aquifers in agriculture, industrialized and grossly polluted areas. Monitoring of groundwater quality needs to be strengthened for parameters from pollution point of view.

Table 2: Water Quality of Major Indian Rivers of India.

River Name	Length (km)	No. of Monitoring locations	Observed Range of Water Quality Parameters							
			Temperature °C	pH	Conductivity (µmhos/cm)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Total Coliform (MPN/100 ml)	Faecal Coliform (MPN/100 ml)
Ganga	2525	34	3-34	6.4-9.0	19-2220	2.7-11.5	0.5 – 10.8	1-30	800-25x10^5	20-11x10^5
Yamuna	1376	23	3-34	6.7-9.8	56-1959	0.1-22.7	1.0 – 36	1-112	27-26.3x10^5	11-17.2x10^5
Sabarmati	371	8	12-32	2.9-8.6	269-13530	0.6-7.9	0.8 – 475	4-1794	210-28x10^5	28-28x10^5
Mahi	583	7	19-34	7.1-9.2	175-5720	0.2-8.5	0.1 – 3.0	9-163	3-2400	3-75
Tapi	724	10	20 40	7.4 9.0	76 700	4.8 8.8	0.6 10.0	8 40	40 2100	2 210
Narmada	1312	14		6.9-9.3	102-1341	5.8-9.8	0.1 – 3.8	6-47	9-2400	2-64
Godavari	1465	11	22-35	7.0-9.0	118-1400	3.1-10.9	0.5 – 78.0	3-96	8-5260	2-3640
Krishna	1401	17	18-33	6.8-9.5	28-11050	2.9-10.9	0.2 – 10.0	3-88	17-33300	3-10000
Cauvery	800	20	21-37	2.0-9.2	31-53100	0.1-12.6	0.1 – 26.6	30	39-160000	2-28000
Mahanadi	851	16	18-38	7.3-8.9	114-15940	1.3-10.4	1.0 – 7.6	7-39	15-30000	50-17000
Brahmani	799	11	20-38	7.0-8.4	81-376	5.2-9.8	1.5 – 6.0	8-13	80-90000	40-60000
Baitarni		5	24-36	7.3-8.3	54-78400	6.8-9.3	2.0 – 6.8	7	900-22000	700-11000
Subarnrekha	395	6	18-36	6.5-8.0	113-355	5.2-8.5	0.2 – 12.0	4-96	150-1800	70-540
Brahmaputra	916	6	15-32	6.5-9.0	104-684	1.1-10.5	0.1 – 3.9	6-11	360-240000	300-24000
Pennar	597	4		7.5 8.7	361 978	6.0 9.3	1.0 2.9	14 16		
Sathj	1078	20	9-32	6.8-8.8	131-819	3.8-11.4	0.1 – 45.0	1-80	8-35000	2-3500
Beas	460	19	3-32	7.1-8.7	53-517	5.2-11.5	0.3 – 5.0	1-13	2-2400	2-1600

3. Monitoring Result

The monitoring results obtained under the programme indicate that organic pollution con-tinues to be the predominant pollution of aquatic resources. The organic pollution meas-ured in terms of bio-chemical oxygen demand (BOD) & coliform count gives the indica-tion of extent of water quality degradation in different parts of India. It is observed that nearly 66% of the observations recorded during 2004 are having BOD less than 3 mg/l, 19% between 3-6 mg/l & 15% above 6 mg/l. Similarly, Total & Faecal coliform, which indicate presence of pathogens in water are also a major concern. About 44% observa-tions are having Total Coliforms and 59% observations are having Faecal Coliform less than MPN 500/100 ml.

4. River Specific Findings

The water quality data of rivers Ganga, Yamuna, Sabarmati, Mahi, Tapi, Narmada, Goda-vari, Krishna, Cauvery, Mahanadi, Brahmani, Baitarni, Subarnrekha, Brahmaputra, Satluj and Beas is computed statistically to obtain information on polluted stretches. The water quality of major rivers varied widely with respect to DO,BOD,TC and FC. The level of DO is observed more than 4 mg/l in river Tapi, Narmada, Brahmini, Brahmapu-tra, Subarnrekha and Beas throughout the year, whereas the lowest values (0.1 mg/l) are observed in river Yamuna at downstream of National Capital city of Delhi , Krishna at Vijaywada and Cauvery at Mohanur respectively; Sabarmati (0.8 mg/l) at downstream of Ahmedabad city, Mahanadi (1.4 mg/l) at Sheorinarayan due to discharge of untreated municipal wastewater that is responsible for high oxygen demand.

The very high values of Biochemical Oxygen Demand (BOD) are observed in river(s) Sabarmati (475 mg/l) downstream of Ahmedabad followed by Godavari (78mg/l) down-stream of Nanded city, Satluj (45mg/l) downstream of Ludhiana city, Yamuna (36 mg/l) downstream of Delhi, Cauvery (27mg/l) downstream of Tiruchirapalli, Ganga (17mg/l) downstream of Varanasi, Krishna and Tapi (10 mg/l each) downstream of Sangli and Uphad respectively, Mahanadi (8mg/l) and Brahmani (6mg/l) after meeting river Mand and Panposh downstream respectively. The relatively low values of BOD (less than 6 mg/l) are measured in river(s) Mahi, Narmada, Brahmaputra and Beas throughout the length of the river.

In respect of Total Coliform Numbers and Faecal Coliform Numbers, river Yamuna is leading with highest count of 2.6 billion MPN/100 ml and 1.7 million MPN/100 ml re-spectively, which is followed by Sabarmati (2.8 million), Ganga (2.5 million and 1.1 mil-lion), Brahmaputra (240,000 and 24,000), Cauvery (160,000 and 28,000), Brah-mani(90,000 and 60,000),Satluj (35,000 and 3500),Krishna (33,300 and 10,000), Mahanadi (30,000 and 17,000),Baitarni (22,000 and 11,000) and Godavari (5260 and 3640).The river Mahi, Tapi, Narmada, Subernrekha and Beas are relatively clean rivers as the number of Total Coliform and Faecal Coliform count are quite less as compared to other rivers and are meeting the criteria.

5. Water Quality Status – Creeks/ Canals/ Lakes/Tanks

- The creeks in Gujarat and (Mumbai) Maharashtra and sea water in the vicinity of Mumbai are having high concentration of BOD due to discharge of waste water from metropolitan region and high conductivity due to effect of sea water.
- The Western Yamuna Canal downstream of Yamuna Nagar at 100 m D/s and at Damla is grossly polluted due to municipal and industrial waste water disposal. Similarly Pragati Vidhya Bhawan Canal in Agartala, Gurgaon Canal and Narmada.
- Main Canal in District Gandhinagar is also not meeting the criteria limits with respect to BOD.

- Lakes and Tanks having high concentration of organic matter and not complying to the standard limits for BOD are Kistrapetrareddy Tank, Sai Chevuru, Asani Kunta, Kajipally Tank, Noor Md. Kunta, Pedda Chevuru, Durgam Chevuru, Gandigudem Tank, Mallapur Tank, Saroornagar lake, Premajipet Tank, Nalla Chevuru, Hussain Sagar lake, Miralam Lake, Dharmasagar Tank, Laxminarayana Chevuru,
- The water quality monitoring results were analysed with respect to indicator of oxygen consuming substances (Bio-chemical Oxygen Demand) and indicator of pathogenic bacteria (Total coliform and Faecal coliform). The result of such analysis shows that there is gradual degradation in water quality. The number of observations having BOD and Coliform density has increased during 1995 to 2009.
- The monitoring results obtained during 2009 under National Water Quality Monitoring Programme reflect that organic matter & bacterial population of faecal origin continue to dominate the water pollution problem in India. The major water quality concerns as revealed from the monitoring results are pathogenic pollution as reflected through indicators i.e. Total Coliforms (TC) & Faecal Coliform (FC), organic matter as reflected through Biochemical Oxygen Demand (BOD) and salinity as reflected through conductivity.

6. Constrains

- Sustainability of infrastructure
- The resources in terms of financial as well as manpower are inadequate
- Travel to long distance for monitoring and preservation of samples in warm weather condition adversely affects the result.
- Lack of training for data management and statistical tools
- Lack of software to analyse the data for trend analysis and data variation.

The monitoring of water resource in India need to be focused with well technical support and trained staff and researchers.