INTRODUCTION

India is rich in water resources, having a network of as many as 113 rivers (the figure does not include tributaries) and vast alluvial basins to hold plenty of groundwater. India is also blessed with snow-capped peaks in the Himalayan range, which 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, domestic and industrial consumption, the available water resources in many parts of the country are getting depleted and the water quality has deteriorated. In India, water pollution comes from three main sources: domestic sewage, industrial effluents and run-off from agriculture.

Urban environmental management is one of the most pressing issues as the urbanization trend continues globally. Among the challenges faced by urban planners is the need to ensure ongoing basic human services such as the provision of water and sanitation. The under-management of domestic wastewater in many southern urban areas presents a major challenge. The accumulation of human waste is constant and unmanaged wastewater directly contributes to the contamination of locally available freshwater supplies. Additionally, the cumulative results of unmanaged wastewater can have broad degenerative effects on both public and ecosystem health.

The most significant environmental problem and threat to public health in both rural and urban India is inadequate access to clean drinking water and sanitation facilities. Almost all the surface water sources are contaminated to some extent by organic pollutants and bacterial contamination and make them unfit for human consumption unless disinfected. The diseases commonly caused by contaminated water are typhoid, cholera, gastroenteritis, bacterial dysentery, hepatitis, poliomycitis, amoebic dysentery etc.

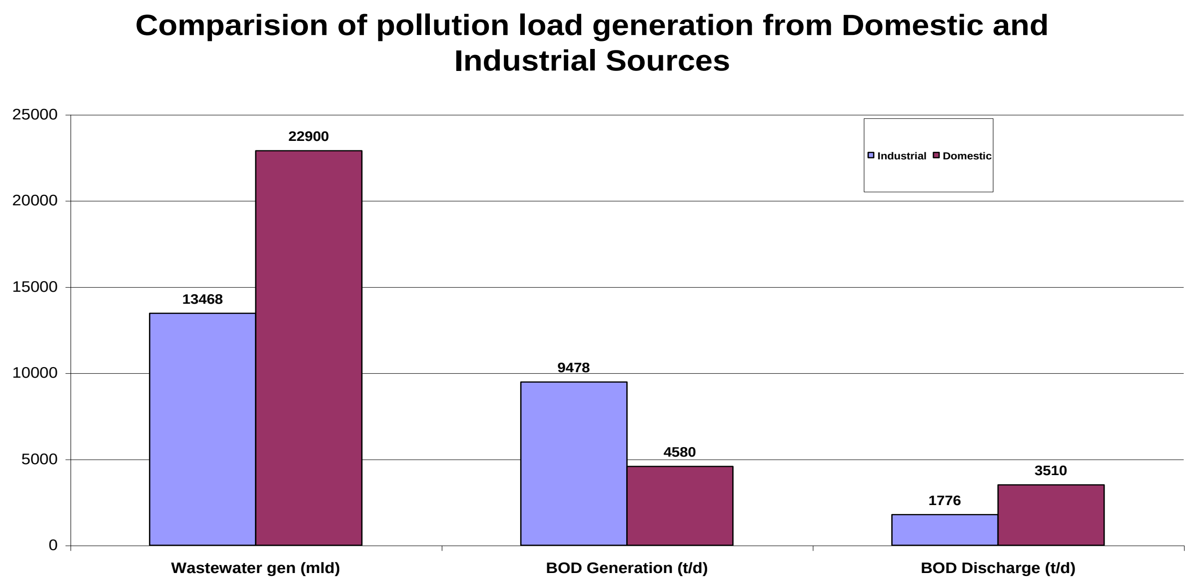
WASTEWATER GENERATION & TREATMENT: DOMESTIC SEWAGE VS INDUSTRIAL EFFLUENT

It is estimated that 22,900 million litres per day (MLD) of domestic wastewater is generated from urban centres against 13,500 MLD industrial wastewater. The treatment capacity available for domestic wastewater is only for 5,900 MLD, against 8,000 MLD of industrial wastewater. Thus, there is a big gap in treatment of domestic wastewater. Govt. of India is assisting the local bodies to establish sewage treatment plants under the Ganga Action Plan and subsequently under the National River Action Plan. Since the task is massive, it may take long time to tackle the treatment of entire wastewater. It is estimated that the total cost for establishing treatment system for the entire domestic wastewater would be around Rs. 7,560 crores. Operation & maintenance cost would be in addition to this cost. Similarly, there is a gap in treatment of about 5,500 MLD of industrial wastewater, mainly generated from small-scale industries. Establishing effluent treatment systems in small-scale industries is a problem, since a large number

Domestic human waste includes human excreta, urine and the associated sludge (collectively known as black water), and wastewater generated through bathing and kitchen (collectively known as grey water).

In 1950, the average daily output of human waste (i.e. excrement and urine) was estimated to be 3.2 million tonnes; in the year 2000, the estimated daily output was 8.5 million tonnes.

of them are located in residential areas, where space is a constraint. Moreover, the small-scale industries are not having adequate resources to establish treatment systems. Such industries need to establish common effluent treatment plants (CETPs). A number of such facilities have been established across the country. It is expected that establishment of CETPs would reduce the pollution load in the aquatic resources of the country to a large extent.



URBANISATION & WASTEWATER MANAGEMENT IN INDIA

The process of urbanisation in India since the beginning of last century reveals a steady increase in the size of its urban population, number of urban centres, and level of urbanisation since 1911 onwards and a rapid rise after 1951. From a modest base of 25.8 million persons in 1901, the number of urban dwellers has risen to 285 million, signalling a phenomenal eleven fold increase in urban population over the period 1901-2001.

The urban India has become a massive and perhaps a frightening reality as far as waste management is concerned. This country can no longer afford to allow urban areas constituting cities and towns of varying magnitude to take care of them; they need the full and undivided attention of our planners and decision makers for protection of environment, aquatic resources and ultimately for better management of health aspects.

The Central Pollution Control Board realised the gravity of water quality deterioration in water bodies and instituted studies on the wastewater management in India with changing urban pattern during last three decades and highlighted the need for urban wastewater management. The comparison of water supply, wastewater generation, collection and treatment during 1978-79, 1989-90 and 1994-95 indicates that the wastewater generation has increased from 7,007mld in 1978-79 to 16,622 mld in 1994-95 in class I cities (population one lakh or above). However, the treatment capacity has increased from 2755.94 mld in 1978-79 to 4037.20 mld in 1994-95, which was only 39% and 24% of the wastewater generated respectively.

Decadal Trend of water supply and sanitation status in Class I Cities and Class II towns

Parameters	**Class I cities**			**Class II Towns**		
	1978-79	**1989-90**	**1994-95**	**1978-79**	**1989-90**	**1994-95**
Number	142	212	299	190	241	345
Population (millions)	60	102	128	12.8	20.7	23.6
Water Supply (mld)	8,638	15,191	20,607	1533	1622	1936
Wastewater generated (mld)	7,007	12,145	16,662	1226	1280	1650
Wastewater treated (mld)	2,756 (39%)	2,485 (20.5%)	4,037 (24%)	67 (5.44%)	27 (2.12%)	62 (3.73%)
Wastewater untreated (mld)	4,251 (61%	9,660 (79.5%)	12,625 (76%)	1160 (94.56%)	1252 (97.88%)	1588 (96.27%)

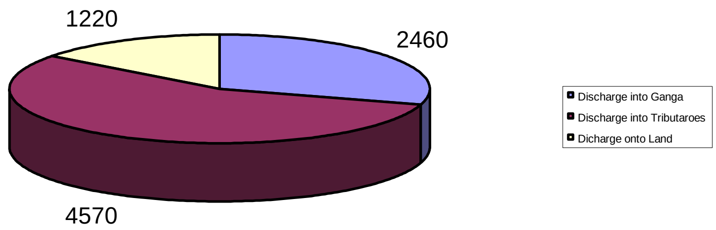
As per the updated status for the year 2003, out of 22,900 Mld of wastewater generated, only about 5,900 Mld (26%) is treated before letting out, the rest i.e., 17,100 Mld is disposed of untreated. Twenty-seven cities have only primary treatment facilities and forty-nine have primary and secondary treatment facilities. The level of treatment available in cities with existing treatment plant in terms of sewage being treated varies from 2.5% to 89% of the sewage generated. Treated or partly treated or untreated wastewater is disposed into natural drains joining rivers or lakes or used on land for irrigation/ fodder cultivation or disposed into the sea or a combination of them by the municipalities. The mode of disposal in 118 cities is indirectly but ultimately into the rivers/ lakes/ ponds/ creeks; in 63 cities to the agriculture land; in 41 cities directly into rivers and in 44 cities, it is discharged both into rivers and on agriculture land.

Status of Sewage Treatment in the Ganga Basin

The Ganga basin spreads over an area of 8,61,404 Km^2 covering the States of Uttaranchal, Uttar Pardesh, Haryana, Delhi, Madhya Pradesh, Rajasthan, Bihar, Jharkhand & West Bengal. There are 223 cities/towns (Municipalities/ Corporations) generating significant amount of sewage in the Ganga basin. These cities/towns generate about 8,250 MLD (million litre per day) of wastewater, out of which about 2,460 MLD is directly discharged into the Ganga river, about 4,570 MLD is discharged into its tributaries or sub- tributaries and about 1220 MLD is disposed on land or on low-lying areas.

Out of 8,250 MLD wastewater generated in the Ganga basin, the treatment facilities available for 3,500 MLD of wastewater. Out of 3,500 MLD treatment capacity, 882 MLD is created under the Ganga Action Plan, 720 MLD is created under the Yamuna Action Plan by NRCD/MoEF and about 1,927 MLD treatment capacity is created or under augmentation by the Govt. of Delhi for restoration of water quality in Yamuna river. The treatment facilities at 48 additional towns along the Ganga river and 23 towns on its tributaries/sub- tributaries are being created under GAP Phase-II and National River Action Plan. It is expected that after completion of these plans, an additional capacity of about 1,500 MLD will be created. However, still there will be a large gap between the wastewater generation and treatment capacity.

Disposal of Sewage generated in Ganga Basin in million litres per day



Sewage Generation, Treatment and Disposal in the Ganga Basin

Sewage Generation

1. Total number of towns generating significant amount of sewage (Class I cities and class II towns)	222
2. Sewage generating from these towns	8,250 MLD
3. Sewage directly disposed into the Ganga River	2,460 MLD
4. Sewage disposed into tributaries of the Ganga River	4,570 MLD
5. Sewage disposed on land or low lying areas	1,220 MLD

Sewage Treatment

1. Sewage Treatment capacity created under Ganga Action Plan Phase-I	882 MLD
2. Sewage Treatment capacity created along the Yamuna	2,647 MLD
3. Additional towns where sewage treatment capacity is being created under GAP Phase-II	48 (600 MLD)
4. Number of towns where sewage treatment capacity is being created on tributaries of the Ganga	23 (750 MLD)

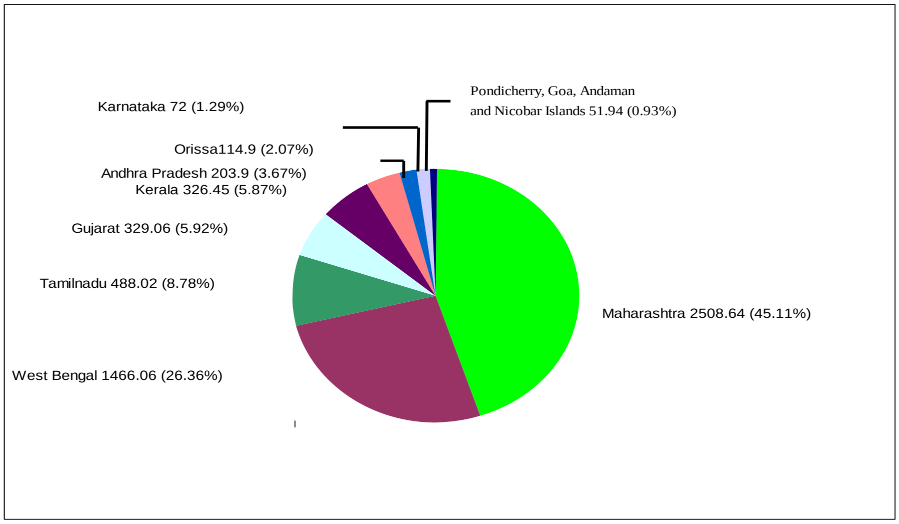
Sewage Management in Coastal Cities

About 60% of the world population live within 60 km of shoreline. India, by virtue of its geographical location, is having 8118 km long coastline. The coastal area accommodates about 25% of country's total population. The wastewater generated from the townships and cities finds its way into the coastal waters including estuaries, creeks, bays etc.

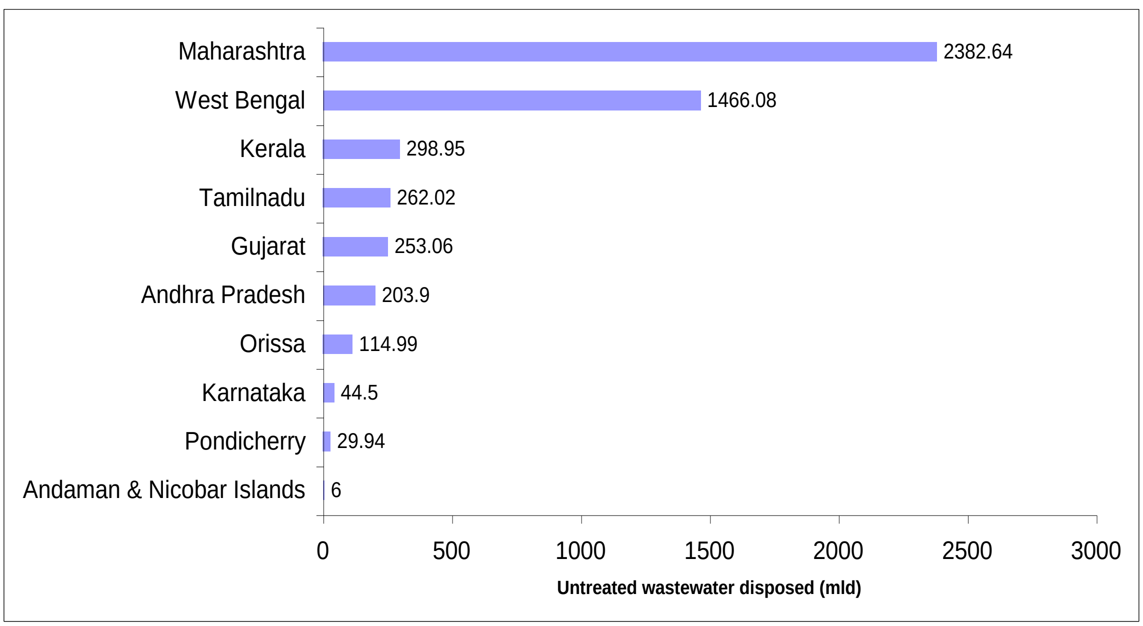
The municipal wastewater constitutes the largest single source of coastal marine pollution. 87 cities and towns located in the coastal areas of the country generate 5560.99 mld of wastewater, which is almost 80% of their total water supply. This quantity is almost 33.37 % of the total quantity of the wastewater generated by 644 class I cities and class II towns in the entire country. The volume of wastewater has increased over two and a half times than the quantity generated two decades ago. Out of this only 78% is collected, while during 1978 the collection was only 46%. About 58.50% of this is generated from the west coast. The State of Maharashtra contributes about 45% of the total wastewater generated by the coastal cities and towns, while the state of West Bengal comes second, contributing about 26%. Thus Maharashtra, West

Bengal and Tamil Nadu generate almost 80% of the wastewater among the coastal states and union territories. Out of 5560.99 mld of wastewater generated only 521.51 mld receives various levels of treatment before letting out to the coastal waters.

Out of the total wastewater generated, 90.62% find its destination into the coastal waters without any treatment. The coastal waters of Maharashtra state receive maximum quantity of untreated municipal wastewater, to the tune of 2382.64 mld followed by the coastal waters of West Bengal, 1466.08 mld from their respective cities and towns.



State and Union Territory wise generation of municipal wastewater (mld) in coastal cities



State and Union Territory wise contribution of untreated municipal wastewater disposed into the coastal waters

Regarding untreated wastewater disposal, there is a four-fold increase in quantity in a span of two decades. In 1999 the quantity of untreated wastewater disposed to the coastal waters was 5039.48 mld, on the other hand it was only 1264.03 mld in 1978. These problems stem from over population, poor planning and uncontrolled development in the nearby coastal watersheds.

Sewage Management in Delhi

It is estimated that out of 3267 mld of sewage generated in Delhi, the treatment capacity is existing for 2330 MLD of sewage (71% of total sewage generation). However, actual treatment is received to only about 1478 mld (63%) of sewage in terms of BOD load. Out of 480 tonnes/day of BOD load generated in Delhi, 264 tonnes/day (or 55%) is reduced due to treatment.

There are 30 STPs located at 17 locations in Delhi. The total combined treatment capacity of all the STPs is 2,330 mld. The actual treatment of sewage during November-December 2003 was observed only 1478 mld, about 63% of the installed treatment capacity.

Out of total STPs, 20 STPs were running under capacity, 5 STPs were running over capacity, 3 STPs were non functional while only 2 STPs are running to their capacity. An attempt was made to evaluate the performance of the STPs in terms of percent reduction in pollution load. Average reduction in BOD, COD and TSS load computed based on the study was 87%, 81% and 92% respectively.

Status of Sewage Treatment Plants in Delhi during Nov – Dec, 2004

Sl. No.	STP's Capacity (MGD)	Design capacity (MLD)	Actual flow (MLD)	Type of STP	Present Status
1	Coronation Pillar STP's (10) (10+20)	 45.46 45.46 90.92	 40.87 63.46 56.55	Activated sludge process (ASP), Trickling filter & ASP	Over the Designed Capacity Under Utilized
2.	Delhi Gate (2.2)	10.00	10.00	High rate biofilters (Densadeg technology	Running on designed capacity
3.	Ghitorni (5)	22.73	Nil	-	Not in operation
4.	Keshopur STPs (12) (20) (40)	 54.55 90.92 181.84	 46.55 95.10 106.46	All three plants designed on activated sludge process	12 MGD not running properly sewage passes through PST. Not running Over the Designed Capacity Under- utilized
5.	Kondli STP's (10-Phase-I) (25 -Phase-II) iii. (10-Phase-III)	 45.46 113.65 45.46	 56.55 57.96 28.36	All three activated sludge process	Over the capacity Under- utilized Under- utilized
6.	Mehrauli STP (5)	22.73	4.95	Activated Sludge Process (ASP)	Under-utilized
7.	Najafgarh STP (5)	22.73	2.27	Activated Sludge Process (ASP)	Under- utilized
8.	Nilothi STP (40)	181.84	15.0	Activated Sludge Process (ASP)	Under- utilized
9.	Narela STP (10)	45.46	2.50	Activated Sludge	Under- utilized

Sl. No.	STP's Capacity (MGD)	Design capacity (MLD)	Actual flow (MLD)	Type of STP	Present Status
				Process (ASP)	
10.	Okhla STP's (12) (16)) (30) (37) (45)	 54.55 72.73 136.38 168.20 204.57	 39.09 40.91 136.98 159.11 181.84	All the plants designed on Activated Sludge Process (ASP)	 Under- utilized Under- utilized Running in capacity Under-utilized Under-utilized
11.	Papankalan STP (20)	90.92	37.73	Activated sludge proc.	Under-utilized
12	Rithala STP's (40) Old (40) New	 181.84 181.84	 46.28 185.07	 ASP UASB	 Under-utilized Over the designed capacity
13.	Rohini STP (15)	68.19	Nil	Activated sludge process (ASP)	Not in operation
14.	Dr. Sen N.H. STP (2.2)	10.0	10.0	High rate Bio filter	Running on designed capacity.
15.	Timarpur O.P. (6)	27.27	4.79	Oxidation ponds	Under-utilized
16.	Yamuna Vihar STP's Ph-I(10) Ph-II(10)	 45.46 45.46	 27.27 14.77	 Activated sludge process	 Under-utilized Under-utilized
17.	Vasant Kunj STP's (2.2) (3.0)	 10.00 13.63	 3.18 4.36	 Extended aeration ASP	 Under-utilized Under-utilized
	Total	**2330**	**1478**	**-----**	**-----**

SOURCE-RELATED CHARACTERISTICS OF DIFFUSE WATER POLLUTION

Pollution From Small Rural Hamlets/Villages: Almost as a rule these would neither have running water supply nor sewered sanitation. In many developing countries (as is the case of India) most people would use open fields 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. 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 and as washings in the storm run-offs. On the basis of various experiences, the Central Pollution Control Board estimated an average 15g BOD 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.

Wastewaters and Pollutants from Unsewered Towns: For improving standards of life, running water- supply has been established in most of the towns 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 does not bring the same political dividends in developing countries as running water-supply does. Hence sewerage has lagged far behind the 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 bulk of pollution shall get retained on land to percolate, leach or get washed-off to streams or groundwater.

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.

Future Scenario of Sewage Management

The Population of India is likely to be stabilized by 2050 at the level of 1700 million people. As per the census of 2001 the urban population is 285 million and keeping in view of population projection for the year 2051 is likely to be of the magnitude of 1093 million. The per capita wastewater generation is around 121 litre/capita/day based on the average wastewater generation observed during the three studies carried out by CPCB. Based on the projected population for the year 2051 the wastewater generation is going to be around 132000 mld. As minimum dry weather flow of rivers is going to reduce due to increase in population and as a result increase in water requirements for various purposes, the wastewater generation in any urban centre is going to adversely affect water supply of d/s located urban centres. In view of such situation there is a need to attain 100% wastewater treatment in each city with more stringent standard.

Projected population and respectively wastewater generation

Year	Urban Population	Litres/Capita/Day (lpcd)	Gross Wastewater Generation (mld)
77-78	60	116	7007
89-90	102	119	12145
94-95	128	130	16662
2001	285	-	-
2011	373	-	-
2021	488	121 (Assumed)	59048 (Projected)
2031	638	121 (Assumed)	77198 (Projected)
2041	835	121 (Assumed)	101035 (Projected)
2051	1093	121 (Assumed)	132253 (Projected)

CHARACTERISTICS OF DOMESTIC SEWAGE

The design of a sewage treatment works will be dependent on the quality and quantity of the waste to be treated. The following are some of the important characteristics of domestic sewage:

Organic Matter : Organic matter is the most important polluting constituent of sewage in respect of its effects on receiving water bodies. It is mainly composed of proteins, carbohydrates and fats. Organic matter is commonly measured in terms of BOD and COD. If untreated sewage is discharged into natural water bodies, biological stabilization of organic matter leads to depletion of oxygen in water bodies.

Nitrogen & Phosphorus : Nitrogen and phosphorus are also very important polluting constituents of sewage because of their role in algal growth and eutrophication of water bodies. Nitrogen is present in fresh domestic sewage in the form of proteinaceous matter urea (i.e. organic nitrogen). Its decomposition by bacteria readily changes it into ammonia. In aerobic environments ammonia nitrogen is oxidized into nitrites and nitrates. Nitrates can be used by algae to form plant proteins. Nitrogen is commonly measured as TKN (organic + ammonical) as sewage characteristics. Nitrate and nitrite forms of nitrogen are also measured when quality of receiving/affected water (streams, underground water) is monitored.

Phosphorus is usually present in orthophosphate, polyphosphate and organic phosphate forms. Organically bound phosphorus is of little importance in domestic sewage whereas polyphosphate forms undergo hydrolysis to revert into the orthophosphate forms, although this conversion is quite slow.

Suspended Solids : Suspended solids represent that fraction of total solids in any wastewater that can be settled gravitationally. Suspended solids can further be classified into organic (volatile) and inorganic (fixed) fractions. Organic matter is present in the form of either settleable form or non-settleable (dissolved or colloidal) form. If the organic fraction of suspended solids present in sewage is discharged untreated into streams, it leads to sludge deposits and subsequently to anaerobic conditions.

Dissolved Oxygen : Dissolved oxygen, as such, does not have any significance as a sewage characteristics. However, it is the most important pollution assessment parameter of the receiving water bodies. Stabilization of organic matter, when discharged untreated or partially treated in receiving waters, leads to depletion of their dissolved oxygen. Nutrients (nitrogen and phosphorus) addition due to discharge of untreated or treated sewage may lead to algal growth in streams. During day time, algae undergo photosynthesis process and the oxygen released by this process is much more than their respiration requirements resulting in a net addition of dissolved oxygen to water. However, during night time photosynthesis process is stopped whereas respiration requirement continues. This leads to depletion of dissolved oxygen in waters. Thus, it is observed that all the polluting constituents of sewage explained above have their direct or indirect effect on dissolved oxygen of receiving waters.

Bacterial Parameter (Fecal Coliform) : Although organic matter, in dissolved as well as suspended form, is the most important parameter of sewage as far as ecology of receiving water bodies is concerned, Bacterial parameters, such as Fecal Coliform (FC), which serve as indicators of fecal pollution are also very important when human health is the prime concern.

Sewage from large and small towns is discharged either into a water body, which is used for various purposes such as source of drinking water supply and bathing or discharged on land for irrigation, where human beings come in contact with it. Population consuming water from such sources which receive sewage discharges and persons involved in agricultural activities where sewage is applied become vulnerable to infection from pathogenic organisms (mainly bacteria and viruses) which are discharged by human beings who are infected with disease or who are carriers of a particular disease. Thus, to check quality of receiving waters for various uses and to assess acceptability of degree of treatment given to sewage, assessment of bacterial quality also becomes important. Because specific identification of pathogenic bacteria is extremely difficult, the coliform group of organisms is used as an indicator of the presence in wastewater of pathogenic organisms. Coliform bacteria are found in intestinal tract of human beings. Each person discharges about 100 to 400 billion coliform bacteria per day. Presence of coliform organisms is taken as an indication of presence of pathogenic organisms and absence of coliform organism is taken as an indication that water is free from disease producing organisms.

Coliform group of bacteria include genera Escherichia and Aerobacter. Aerobacter and certain Escherichia can also grow in soil and, therefore, use of coliform group of bacteria as indicator of human waste becomes complicated. Difficulty in determining E.coli. to the exclusion of the soil coliform led to use of entire group of coliform as indicator of fecal pollution. Separate determination of Total Coliform (TC), Fecal Coliform (FC) and Fecal Streptococci (FS) is now possible. Presence of FC and pathogenic organism together is well established and FC is the widely used bacterial parameter as indicator of fecal pollution. Determination of FS in waters and wastewaters is also in practice because FC/FS ratio further helps in identification of source. FC/FS ratio for human beings is more than 4, whereas FC/FS ratio for domestic animals is less than 1. Thus FC/FS ratio can be used to find whether suspected contamination of water is derived from human or animal waste. When FC/FS ratio is obtained between 1 to 2 interpretations become difficult. Incidentally, the rate of removal or death of coliform bacteria in waters and wastewaters is parallel to the respective rates for pathogenic intestinal bacteria which makes the use of coliform organisms as indicator of fecal pollution very important. FC is therefore a very important parameter in determing bacterial quality of waters and wastewaters.

A detailed study of all the sewage treatment plants located in Delhi was carried our during November – December, 2003. The analysis of raw sewage (influent to Sewage Treatment Plant) presents a systematic view of its chemical characteristics.

Characteristics of Sewage in Delhi
(As on November-December, 2003)

Treatment Plants	Influent Quality				
	PH	TSS	COD	BOD	Cond.
Cor. Pillar(10)	7.2	179	317	112	908
(20+10)	6.44	342	172	48	1700
Keshopur(12*)	Not operational				
(20)	7.3	404	560	282	1390
(40)	7.3	404	560	282	1390
Okhla(12)	7.3	498	517	204	1440
(16)	7.4	291	486	207	1510
(30)	7.4	647	551	222	1480
(37)	7.3	480	515	249	1590
(45)	7.3	480	515	249	1590
Narela (10)	7.4	426	447	100	1720
Y. Vihar (Ph.-I 10,	7.1	391	505	174	1110
Ph.-II 10)	7.2	405	538	199	1020
Timarpur O.P -(6)	6.7	412	272	106	1650
Najafgarh (5)	7.4	165	205	54	810
Nilothi (40)	7.7	432	328	90	2340
Dr. Sen N.H.(2.2)	7.5	370	585	236	1680
Delhi Gate (2.2)	7.5	263	605	147	1020
Papankalan (20)	7.6	142	275	103	2190
Kondli Ph.-I (10)	7.3	363	507	241	1390
Ph.-II (25)	7.3	604	588	261	1550
Ph.-III (10)	7.3	519	615	237	1530
Mehrauli(5)	7.8	251	326	126	1090
Rithala {(40 Old)	7.2	330	399	205	1260
(40 New)}	7.2	330	399	205	1260
Vasant Kunj (2.2)	7.5	379	460	323	1710
(3)	7.4	479	565	306	1400

EFFECT OF SEWAGE POLLUTION ON SURFACE WATER BODIES

Organic Pollution

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 biodegradation by employing re-oxygenation processes. However, in many situations the anthropogenic pollution overwhelms the given system.

Effect of Nutrients

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.

Effect of High Dissolved Solids (TDS)

As water is best solvent known on the earth, it can dissolve variety of substances to which it come in contact 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 impairment in physiological processes in the human body. For irrigation water dissolved solid are 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 corrosion, and interfere with the colour and tastes of many finished products.

Effect of Toxic Pollutants on Water Quality

The toxic Pollutants are mainly heavy metals, pesticides & 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 occurred in Japan in fifties due to consumption of fish contaminated by methyl mercury. Metals in natural water can exist 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.

Ecological Health

A large number of areas in our aquatic environment support rare species and ecologically very sensitive. They need special protection. Since, the Water Act, 1974 provides for maintenance and restoration of “wholesomeness” of aquatic resources, which is directly related to ecological health of the water bodies, it is important that ecological health of the water bodies is given first priority in the water quality goal.

HEALTH DIMENSION OF SEWAGE (POLLUTED WATER)

Water-related diseases are a human tragedy, killing millions of people each year, preventing millions more from leading healthy lives, and undermining development efforts. About 2.3 billion people in the world suffer from diseases that are linked to water.

Some 60% of all infant mortality is linked to infectious and parasitic diseases, most of them water-related. In some countries water-related diseases make up a high proportion of all illnesses among both adults and children. In Bangladesh, for example, estimated three-quarters of all diseases are related to unsafe water and inadequate sanitation facilities. In Pakistan one-quarter of all people attending hospitals are ill from water-related diseases.

Providing clean supplies of water and ensuring proper sanitation facilities would save millions of lives by reducing the prevalence of water-related diseases. Thus, finding solutions to these problems should become a high priority for developing countries and assistance agencies.

While water-related diseases vary substantially in their nature, transmission, effects, and management, adverse health effects related to water can be organized into three categories: water-borne diseases, including those caused by both fecal-oral organisms and those caused by toxic substances; water-based diseases; and water-related vector diseases. Another category—water-scarce (also called water-washed)—diseases consist of diseases that develop where clean freshwater is scarce.

Water-Borne Diseases

Water-borne diseases are "dirty-water" diseases—those caused by water that has been contaminated by human, animal, or chemical wastes. Worldwide, the lack of sanitary waste disposal and of clean water for drinking, cooking, and washing is to blame for over 12 million deaths a year.

Water-borne diseases include cholera, typhoid, shigella, polio, meningitis, and hepatitis A and E. Human beings and animals can act as hosts to the bacterial, viral, or protozoal organisms that cause these diseases. Millions of people have little access to sanitary waste disposal or to clean water for personal hygiene. An estimated 3 billion people lack a sanitary toilet, for example. Over 1.2 billion people are at risk because they lack access to safe freshwater.

Where proper sanitation facilities are lacking, water-borne diseases can spread rapidly. Untreated excreta carrying disease organisms wash or leach into freshwater sources, contaminating drinking water and food. The extent to which disease organisms occur in specific freshwater sources depends on the amount of human and animal excreta that they contain.

Diarrheal disease, the major water-borne disease, is prevalent in many countries where sewage treatment is inadequate. Instead, human wastes are disposed of in open latrines, ditches, canals, and water courses, or they are spread on cropland. An estimated 4 billion cases of diarrheal disease occur every year, causing 3 million to 4 million deaths, mostly among children.

Using contaminated sewage for fertilizer can result in epidemics of such diseases as cholera. These diseases can even become chronic where clean water supplies are lacking. In the early 1990s, for example, raw sewage water that was used to fertilize vegetable fields caused outbreaks of cholera in Chile and Peru. In Buenos Aires, Argentina, a slum neighbourhood faced continual outbreaks of cholera, hepatitis, and meningitis because only 4% of homes had either water mains or proper toilets, while poor diets and little access to medical services aggravated the health problems.

Toxic substances that find their way into freshwater are another cause of water-borne diseases. Increasingly, agricultural chemicals, fertilizers, pesticides, and industrial wastes are being found in freshwater supplies. Such chemicals, even in low concentrations, can build up over time and, eventually, can cause chronic diseases such as cancers among people who use the water.

Health problems from nitrates in water sources are becoming a serious problem almost everywhere. In over 150 countries nitrates from fertilizers have seeped into water wells, fouling the drinking water. Excessive concentrations of nitrates cause blood disorders. Also, high levels of nitrates and phosphates in water encourage growth of blue-green algae, leading to deoxygenation (eutrophication). Oxygen is required for metabolism by the organisms that serve as purifiers, breaking down organic matter, such as human wastes, that pollute the water. Therefore the amount of oxygen contained in water is a key indicator of water quality.

Pesticides such as DDT and heptachlor, which are used in agriculture, often wash off in irrigation water. Their presence in water and food products has alarming implications for human health because they are known to cause cancer and also may cause low sperm counts and neurological disease. In Dhaka, Bangladesh, heptachlor residues in water sources have reached levels as high as 0.789 micrograms per litre—more than 25 times the WHO-recommended maximum of 0.03 micrograms per litre. Also, in Venezuela a study of irrigation water collected during the rainy season found that the water was contaminated with a number of pesticides. Examination of pregnant women in the area found that they all had breast milk containing DDT residues—toxins that can be passed to an infant.

The seepage of toxic pollutants into ground and surface water reservoirs used for drinking and household use causes health problems in industrialized countries as well. In Europe and Russia the health of some 500 million people is at risk from water pollution. For example, in northern Russia half a million people on the Kola Peninsula drink water contaminated with heavy metals, a practice that helps to explain high infant mortality rates and endemic diarrhoeal and intestinal diseases reported there.

Improving public sanitation and providing a clean water supply are the two steps needed to prevent most water-borne diseases and deaths. In particular, constructing sanitary latrines and treating wastewater to allow for biodegradation of human wastes will help curb diseases caused by pollution. At the least, solids should be settled out of wastewater so that it is less contaminated. It is important that a clean water supply and the construction of proper sanitary facilities be provided together because they reinforce each other to limit the spread of infection.

Many studies link improvements in sanitation and provision of potable water with dramatic reductions in water-related morbidity and mortality. A review in 1991 of over 100 studies of the effects of clean water and sanitation on human health found that the median reduction in deaths from water-related diseases was 69% among people with access to potable water and proper sanitation.

Providing clean water and sanitation greatly reduces child mortality. According to a review of 144 studies from the 1980s, infant and child deaths fell by an average of 55% as a result of providing clean water and sanitation. In a study of countries where infant mortality rates dropped dramatically—as in Costa Rica, where the decline was from 68 deaths per 1,000 live births in the 1970s to just 20 per 1,000 in the 1980s—researchers attributed three-quarters of the mortality decline to water and sanitation projects provided as part of rural community health programs.

While the cost of building freshwater supply systems and sanitation facilities is high, the costs of not doing so can become staggering. In Karachi, Pakistan, for example, a study found that poor people living in areas without any sanitation or hygiene education spent six times more on medical care than people who lived in areas with access to sanitation and who had a basic knowledge of household hygiene.

Water-Based Diseases

Aquatic organisms that spend part of their life cycle in the water and another part as parasites of animals cause water-based diseases. These organisms can thrive in either polluted or unpolluted water. As parasites, they usually take the form of worms, using intermediate animal vectors such as snails to thrive, and then directly infecting humans either by boring through the skin or by being swallowed.

Water-based diseases include guinea worm (dracunculiasis), paragonimiasis, clonorchiasis, and schistosomiasis (bilharzia). These diseases are caused by a variety of flukes, tapeworms, roundworms and tissue nematodes, often collectively referred to as helminths, that infect humans. Although these diseases usually are not fatal, they can be extremely painful, preventing people from working and sometimes even making movement impossible. The prevalence of water-based diseases often increases when dams are constructed, because the stagnant water behind dams is ideal for snails, the intermediary host for many types of worms. For example, the Akosombo Dam, on the Volta Lake in Ghana, and the Aswan High Dam, on the Nile in Egypt, have resulted in huge increases of schistosomiasis in these areas. Also, in Mali a survey conducted in 225 villages in different ecological settings found that the prevalence of urinary schistosomiasis was five times greater in villages with small dams (67%) than in the drier savanna villages (13%).

Individuals can prevent infection from water-based diseases by washing vegetables in clean water and thoroughly cooking food. They can refrain from entering infected rivers, because many parasites bore through the feet and legs. In areas where guinea worm is endemic, people can use a piece of cloth or nylon gauze to filter out guinea worm larvae, if clean water is unavailable. As with water-washed diseases, providing hygienic disposal of human wastes helps control water-based diseases. Also, for irrigation channels and other constructed waterways, building fast-flowing streams makes it more difficult for snails to survive, thus eliminating the intermediary host.

Some water-development schemes have started disease control programs along with construction of facilities. In the Philippines, for example, where the development of water resources is a high priority, the National Irrigation System Improvement Project in Layte, begun in 1979, included specific provisions and funding to control schistosomiasis. As a result of these measures, the prevalence of water-based diseases fell from 24% in 1979 to 9% in 1985. Because fewer people fell ill, the average increase in productivity was an estimated 19 days of work per person per year, worth an additional US$1 million in wages.

Water-Related Vector Diseases

Millions of people suffer from infections that are transmitted by vectors—insects or other animals capable of transmitting an infection, such as mosquitoes and tsetse flies—that breed and live in or near both polluted and unpolluted water. Such vectors infect humans with malaria, yellow fever, dengue fever, sleeping sickness, and filariasis. Malaria, the most widespread, is endemic in about 100 developing countries, putting some 2 billion people at risk. In sub-Saharan Africa malaria costs an estimated US$1.7 billion annually in treatment and lost productivity.

The incidence of water-related vector diseases appears to be increasing. There are many reasons: people are developing resistance to antimalarial drugs; mosquitoes are developing resistance to DDT, the major insecticide used; environmental changes are creating new breeding sites; migration, climate change, and creation of new habitats mean that fewer people build up natural immunity to the disease; and many malaria control programs have slowed or been abandoned.

Lack of appropriate water management, along with failure to take preventive measures, contributes to the rising incidence of malaria, filariasis, and onchocerciasis. Construction projects often increase the mosquito population, as pools of stagnant water, even if they exist only briefly, become breeding grounds. For example, in West Africa an epidemic of Rift Valley fever in 1987 has been linked to the Senegal River Project. The project, which flooded the lower Senegal River area, enabled the type of mosquito that carries the virus to expand so much that the virus was transmitted to humans rather than remaining in the usual animal hosts.

The solution to water-related vector diseases would appear to be clear—eliminate the insects that transmit the diseases. This is easier said than done, however, as pesticides themselves may be harmful to health if they get into drinking water or irrigation water. Also, many insects develop resistance to pesticides, and diseases can emerge again in new forms.

Alternative techniques to control these diseases include the use of bednets and introducing natural predators and sterile insects. In Gujarat, India, for example, an important part of an integrated project to control disease vectors was breeding guppies—fish that eat mosquito larvae—in bodies of water, while eliminating the use of insecticides altogether. An inexpensive approach to controlling insect vectors involves the use of polystyrene spheres floating on the top of bodies of static water. Because the spheres cover the surface of the water, the mosquito larvae die from lack of air.

Water related diseases and Causative factors

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

Another way to control the vectors is species sanitation—using biological methods and habitat management to reduce or eliminate the natural breeding grounds of the disease vectors. Such methods can include: filling and draining unneeded bodies of stagnant water; covering water storage containers; eliminating mosquito breeding sites by periodically clearing canals, reservoirs, and fish ponds of weeds; installing sprinkler and trickle irrigation instead of canals; and lining canals to prevent silt deposits from forming and impeding the flow of water. Also, integrating education about disease prevention into health services and encouraging community discussion of prevention would help people to control vectors and to identify and eliminate inconspicuous breeding sites.

Water-Scarce Diseases

Many other diseases—including trachoma, leprosy, tuberculosis, whooping cough, tetanus, and diphtheria—are considered water-scarce (also known as water-washed) in that they thrive in conditions where freshwater is scarce and sanitation is poor. Infections are transmitted when too little fresh water is available for washing hands. These diseases, which are rampant throughout most of the world, can be effectively controlled with better hygiene, for which adequate freshwater is necessary.

Some parasitic diseases not usually considered water-related and previously limited in their reach have been rapidly expanding as populations grow and water supplies become more polluted. For example, cysticercosis, a disease usually produced by tapeworms found in undercooked pork and limited to rural areas, expanded rapidly in Mexico City in the early 1980s. As the city's population soared, the parasite multiplied in the highly polluted water of the Tula River, which supplies much of the drinking water for the makeshift settlements on the city's outskirts. Tens of thousands of people downstream from the city sewage system were infected.

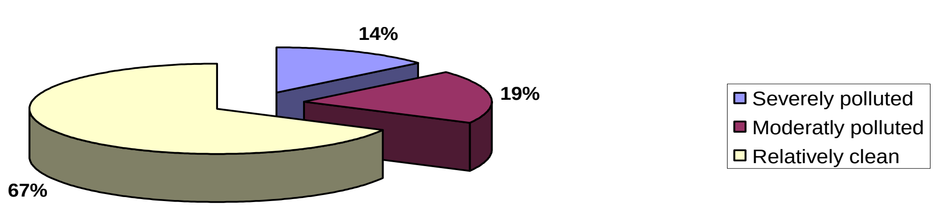
WATER QUALITY MONITORING

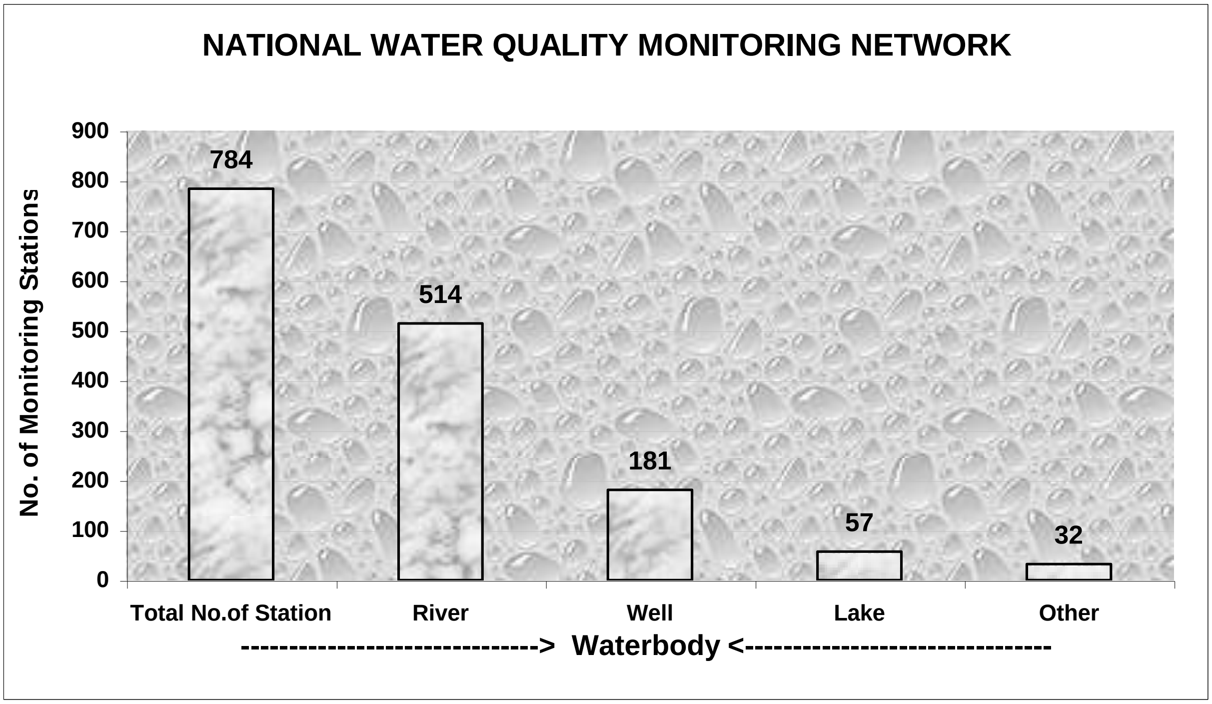
The Central Pollution Control Board in collaboration with State Pollution Control Boards has established a network comprising of 784 stations in 26 States and 5 Union Territories spread over the country for water quality monitoring of aquatic resources. The monitoring is done on monthly or quarterly basis in surface waters and on half yearly basis in case of groundwater. The monitoring network covers 168 Rivers, 53 Lakes, 5 Tanks, 2 Ponds, 3 Creeks, 3 Canals, 12 Drains and 181 groundwater Wells.

The monitoring results obtained during year 2003 indicate that organic pollution continues to be the predominant pollution of aquatic resources. The organic pollution measured in terms of bio-chemical oxygen demand (BOD) and bacterial contamination measured in terms of coliform count give the indication of extent of water quality degradation in different parts of our country. It is observed 67% of the observations, out of nearly 3000 observations are having BOD less than 3 mg/l, 18% between 3-6 mg/l & 15% above 6 mg/l. Similarly Total & Faecal coliform, which indicate presence of pathogens in water, are also of major concern. About 45% observations are having Total coliform and 58% observations show Faecal Coliform less than 500 MPN /100 ml.

The trends of % of observations obtained during year 1994 to 2003 in different levels of pollution with respect to BOD & Total coliform and Faecal Coliform are presented ahead, indicating different ranges of BOD and Coliform organisms. It is clear from the data that there is a increasing trend in percentage of observations having BOD below 3 mg/l. This indicates that there is a gradual improvement in water quality with respect to organic pollution.

Total riverine length under different levels of pollution in India





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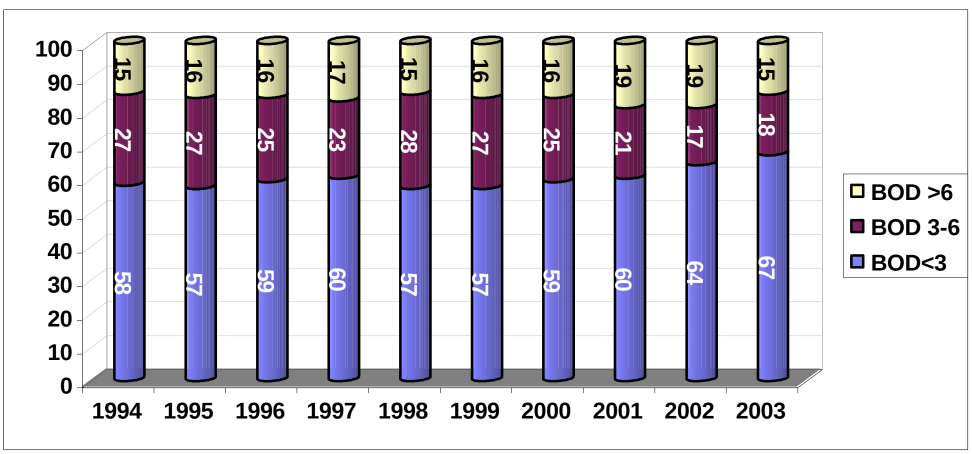
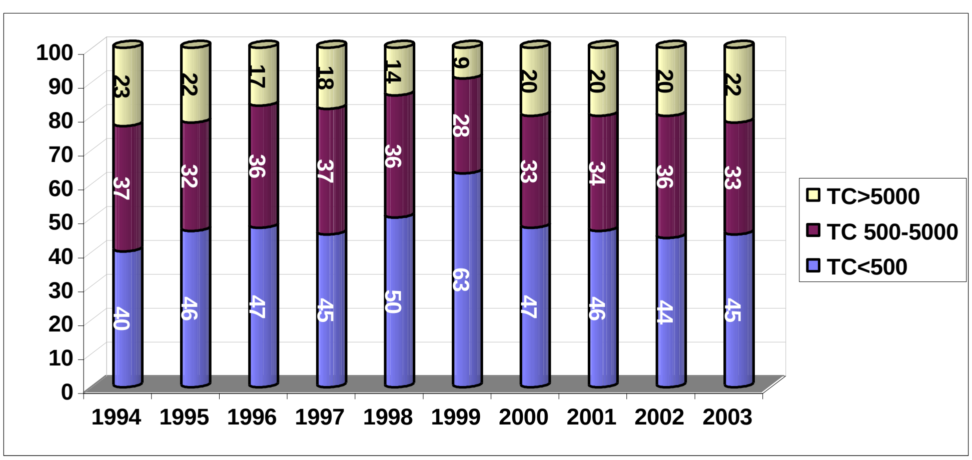
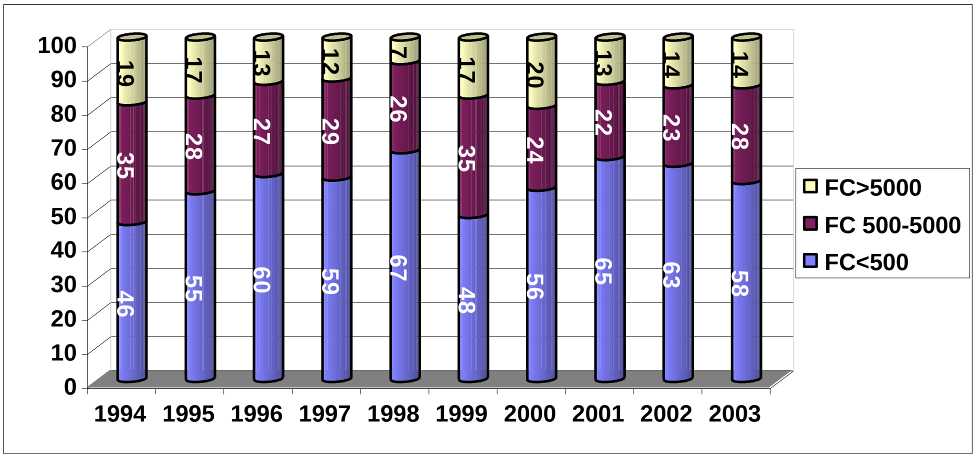
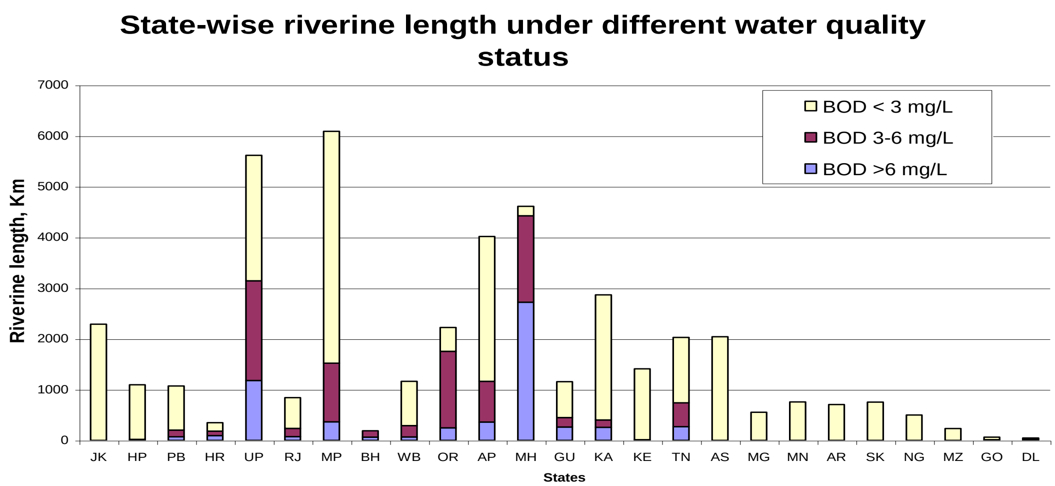
Water Quality Status & Trend from Year 1994 to 2003







BOD: Biochemical Oxygen Demand; TC: Total Coliform; FC: Faecal Coliform



TECHNOLOGICAL OPTIONS FOR TREATMENT OF MUNICIPAL WASTEWATER

There are a large variety of treatment techniques designed to remove pollutants from wastewater. The objective of wastewater treatment is to separate wastes from water. In one sense, all wastewater treatment processes can be considered separation processes. There are physical, chemical and biological separation processes. Sedimentation and screening are examples of physical processes. Coagulation, ion exchange and pH adjustment are typical chemical processes, while various forms of biological digestion belong to the category of biological processes. In the biological processes living organisms, while in the physical and chemical processes physical and chemical properties are utilized for waste separation metabolizes organic wastes.

Major Elements of Wastewater Management Systems and Associated Tasks

Elements of Wastewater Management	Associated Tasks
Source of generation	Quantification of wastewater, evaluation of techniques of wastewater reduction and determination of wastewater characteristics
Source control	Design of onsite systems to provide partial treatment of the wastewater
Collection	Design of sewers used to remove wastewater from the various sources of generation
Transmission and pumping	Design of large sewers used to transport wastewater to treatment facilities
Treatment	Selection, analysis and design of treatment operations and processes to meet specified treatment objectives related to the removal of wastewater contaminants of concern
Disposal and reuse	Design of facilities used for the disposal and reuse of treated effluent in the aquatic and land environment, and the disposal and reuse of sludge on land

Treatment of sewage is accomplished by adopting various treatment schemes, each incorporating one or several different treatment units such as Screens, Grit chambers, Plain Sedimentation, Chemical Precipitation, Trickling Filter, Activated Sludge, Anaerobic digestion, Up flow Anaerobic Sludge Blanket (UASB) reactor, Waste Stabilization Pond and Maturation Pond.

CPCB has carried out a series of studies on performance of Sewage Treatment Plants (STPs) in different parts of the country to evaluate their performance. The findings revealed that a majority of the treatment plants are based on Primary Settling followed by Activated Sludge Process (PS+ASP) technology (with anaerobic digesters for sludge), Oxidation Pond or Waste Stabilization Pond (OP or WSP) technology and UASB followed by Polishing Pond (UASB+PP) technology. Findings have also revealed that most of the STPs are not being utilized to the full capacity due to various reasons.

It has been found that low capital and low operational cost sewage treatment method such as Waste Stabilization Ponds (OP or WSP) technology and low operational cost sewage treatment method such as (UASB+PP) technology are quite effective in BOD removal as well as Fecal Coliform (FC) removal. Overall efficiency of STPs based on these low cost technologies in terms of BOD and FC removal can be further improved if effluent suspended solids (SS) are controlled by improvement in final outlet structures. These technologies are best suited for towns and small cities.

In such situations where sewage of a large city is discharged into a receiving water body having insufficient dilution and/or requires to be maintained at high bacteriological quality, the conventional sewage treatment schemes based on (PS+ASP) technology need augmentation with tertiary treatment units for further removal of BOD and FC . Low cost tertiary treatment method such as series of Polishing Ponds is the best option for tertiary treatment. However if land availability is a constraint then other tertiary treatment options such as coagulant aided flocculation+tertiary sedimentation (TS), TS+Filtration, TS+Chlorination may be adopted.

Conventional wastewater treatment

Conventional wastewater treatment consists of pretreatment, primary sedimentation, secondary biological treatment, secondary sedimentation and chlorination before being discharge. Historically, biological techniques have been widely utilized since they are generally economical to build and operate as composed to physico-chemical techniques. Moreover, they are more efficient as natural means of treatment are utilized in optimized conditions.

Treatment systems could be classified according to the degree of pollutant removal into pretreatment, primary, secondary, tertiary and ultimate treatment. They could be classified according to the means of pollutant removal into biological or physico-chemical treatment. Essentially, pretreatment and primary treatment involves screening and grit removal, equalization and the removal of high concentration of solids that might decrease the efficiency of subsequent treatment processes. The term secondary treatment is commonly used to describe any of the following biological processes: activated sludge, extended aeration, trickling filters, aerobic and anaerobic lagoons and anaerobic and facultative (mixed) ponds. In the typical aerobic process the removal of oxygen-demanding dissolved organics through microorganisms takes place.

Organic material + Bacteria + Oxygen → More bacteria

Organic material + Bacteria + Oxygen → CO_2 + H_2O + Stabilized residual

In an activated sludge process, the incoming waste effluent is continuously fed into biological reactor (aeration tank) in which bacterial mass, in a desired concentration, is maintained in suspension. Organic matter in the incoming effluent is partially oxidized by the bacterial mass and partially converted to excess sludge. The sludge in the out-flow of aeration tank is then separated in a clarifier. This sludge is continuously recycled back to the aeration tanks, however, a portion of sludge (excess sludge) is sent to the sludge beds for drying and in this way a desired concentration is maintained. The conventional type activated sludge process could remove as much as 85% of the BOD load.

The extended aeration is essentially similar to the activated sludge process, but yields less sludge for disposal. Through sufficient retention time, biological solids are oxidized, thus minimizing resultant sludge.

In aerobic lagoons, oxygen is usually supplied through surface aerators that keep solids in suspension, allowing for about 50 to 60 percent BOD removal.

Trickling filters are packed with rocks, on the surface of which bacteria are allowed to grow, while wastewater is trickled over through nozzles, allowing for consumption of dissolved organics by bacteria. The relative effectiveness in BOD removal of trickling filters is relatively low compared to other secondary treatment systems.

Tertiary treatment aims at further removal of BOD, suspended solids etc., as well as colour, nitrates, phosphates and other pollutants not adequately removed by secondary treatment processes. Tertiary treatment could involve carbon adsorption, coagulation and sedimentation, ion exchange, membrane filtration, and other processes.

Treatment Processes and Purpose of each Process in a Treatment System

Principal purposes of Unit Processes	**Unit Processes**
Grit Removal	Grit Chambers
Removal or grinding of coarse solids	Bar Screens
Odour control	Perchlorination, Ozonation
Gross solids-liquid suspension, BOD reduction	Plain primary settling
Gross removal of soluble BOD and COD from raw wastewater	Biological treatment
Removal of oxidized particulates and biological solids	Plain secondary settling
Decomposition or stabilization of organic solids, conditioning of sludge for dewatering	Anaerobic sludge digestion
Ultimate sludge disposal	Sludge drying beds, land disposal, land reclamation
Removal of colloidal solids and turbidity from wastewater	Chemical treatment, sedimentation, mixed-media filtration
Phosphates removal	Chemical coagulation, flocculation and settling
Nitrate removal	Ammonia stripping
Removal of suspended and colloidal materials	Mixed-media filtration
Disinfections	Chlorination, UV treatment

OPTIONS FOR ADOPTION OF NEW TREATMENT METHODS

Upflow Anaerobic Sludge Blanket (UASB)

Among the high rate reactors for wastewater treatment, the UASB process has gained popularity in recent years all over the world. Under the Ganga Action Plan, this system is installed at Kanpur and Mirjapur. Several distilleries in the country have also adopted UASB treatment system because of its advantage over the conventional treatment. In the last 20 years, over 150 UASB units have been built in the world for treating high BOD industrial wastes (distilleries sugar, milk etc.). Since 1982, their use has been extended to include typical municipal sewage which has a relatively low BOD of only 200-300 mg/l. The world's first full-scale demonstration plant for municipal sewage was built in Kanpur, India in 1989 (5 mld capacity) under the Indo-Dutch project. This is working successfully. Subsequently, under the same project, a 14 mld unit was designed and built in Mirzapur (UP) and another 36 mld unit is commissioned for Kanpur to treat sewage mixed with tannery wastes. A similar plant of 50 mld capacity is being designed for Hyderabad City sewage as a part of its master planning for Hyderabad with the World Bank funding. The advantages and contraints of UASB system are as follows:

Advatnages :

The hydraulic retention time is only 8-10 hrs,No prior sedimentation is required, The anaerobic unit does not need to be filled with any stones or other media, The upflowing sewage itself forms millions of small "granules" which are held in suspension and thus provide large surface area, No mixer or aerators are required, thus conserving energy and operation cost,the gas produced can be collected and used, Daily operation of UASB requires minimum attention, No special instrumentation is necessary for control, and Surplus sludge is easy to dry. The UASB has already secured acceptance in the new edition of CPHEEO's Manual of Sewerage & Sewage Treatment Practice (1993) and it is expected to pick-up faster. It will depend on the success of plants already installed and acceptance by those who have been accustomed to waste water treatment plants with sizable investment in construction. The UASB system is uncommonly simple and it does not require elaborate equipment and construction activities.

Constraints :

The most difficult problem with the UASB system is corrosion. Hence, all construction materials used to be carefully chosen. The UASB is not yet widely used in India. Its application for treatment of municipal wastewater is only 6 years old and the manipulates are not geared to adopt new technologies. However, its applications in industry are increasingly rapidly. Through the Ganga Action Plan, a begining has been made which will be consolidated in the National River Action Plan.

Two-Stage, Aerobic Unitank System (TSU-System):

The two stage, aerobic Unitank system and the tri-stage, anaerobic-aerobic Unitank system with biological nitrogen removal (3SU - N System) has been developed in Europe. This is a cost-effective alternative to conventional activated sludge systems. The main advantages are reduction in capital and operational costs, flexible and reliable operation and high process performance. After the preliminary treatment (screening, grit removal equalization, no primary settling) the wastewater is first treated in a high loaded combined aeration-sedimentation stage. The BOD reduction is about 80-85%. The partially purified water then flows by gravity to a low loaded combined aeration-sedimentation stage where the residual BOD is removed to obtain a high quality effluent resulting in more than 98% removal of BOD.

Advantages:

(a) Less capital costs, No primary settling, Less total aeration volume, No separate sedimentation tanks, No sludge scraping, No sludge recycling facilities Rectangular tanks, compact construction possible, full use of available land, cheaper and easier to construct as compared to circular tanks, economical lengths of connecting pipes and channels, Compact system: smaller land area required.

Natural or naturally based wastewater treatment technologies are defined as those that employ natural processes (biological, physical or solar elements) to achieve a desired level of treatment. Naturally-based approaches usually have one or more of the following characteristsics:

- *Achieving acceptable level of treatment*
- *Requiring low capital investment*
- *Requiring low ongoing operation and maintenance costs*
- *Requiring less-skilled operator knowledge than many conventional technology*
- *Potentially having longer life-cycles than conventional electro-mechanical technology*

(b) Less operational costs, Less energy for aeration, No energy for sludge recycle, Less maintenance costs (less moving parts).

(c) Better process performance, High treatment efficiency, Control of sludge bulking, Simple and reliable process, reduced need for supervision.

(d) Easily controlled by microprocessor

(e) Flexible operation, Flexibility of temporary operation with half capacity, Restoration of full capacity without long time lag, Possible applications, brewing and malting wastewater treatment, Municipal wastewater treatment, Food processing wastewater treatment, Industrial wastewater treatment, Aerobic post treatment of anaerobic effluents from distilleries.

Root Zone Treatment:

The process is a natural way of treating industrial or domestic wastes. The method developed in Sixties in Germany, is now commercialized for treatment of domestic and industrial wastewater, economically and efficiently. It has got three integrated components; reeds, reed bed and microbial organisms. In this system, contaminated water is allowed to flow underground through the root zones of especially designed reed beds. The reeds and the reed bed on the soil the surface provide an efficient treatment system. The reed bed serves as the host for more than 2000 species of bacteria and thousands of fungal species. These microbial organisms oxidise the organic matter both aerobically as well as anaerobically. Phosphate, sulphur and carbon compounds, nitrogenous materials reduce to their elemental forms. Heavy metals precipitate from solution and are bound into the soil matrix. Due to the high biodiversity of microbes, the root-zone system is capable of shock loads.

The root zone system is suitable for concentrations from a few mg/l upto 20,000 mg/l of COD & 4000 mg/l of nitrogen. It can be built for effluent throughout from about lm^3/day to more than 10,000 m^3/day. For domestic sewage the land requirement is around 0.2 m^2/person. But for the larger area requirement as compared to conventional methods, the root zone treatment system offers an ideal option for biological effluents because of its simplicity and ruggedness. Even in areas where land is a constraint, the system could be adopted with innovations like vertical treatment facility.

Land treatment for waste management

While indiscriminate discharge of wastes on land is an issue of serious environmental concern, it needs to be recognised that land is he best available sink for ultimate disposal of wastes. This becomes particularly relevant in the context of a developing country where it is unlikely that all the wastes would be provided fullest treatment at source before their disposal.

Controlled application of wastes on land can help in achieving a desired degree of treatment through the physical, chemical and biological processes within the plant-soil-water matrix. Partially treated waste water can be further treated through land application and land can serve as a 'living filter' comprising interaction of soil, vegetation cover and soil micro-organisms.

The various purposes for which land application could be resorted are :

* Extraction of useful constituents in the wastes to provide plant nutrients or soil amendments.
* Revegetation and reclamation of degraded lands,
* Dedicated disposal of recalcitrant wastes.

Depending on the methods of application and percolation, the land treatment of wastes may be of three types viz : Slow Rate System, Rapid Infiltration System and Overland Flow System.

To ensure safety and precautionary measures in land treatment of wastes, it is essential to ascertain the background concentration of pollutants, possible fate of the pollutants added to the land and the risks involved in terms of assimilative capacities and acceptable limits. Decisions in this regard are to be necessarily guided by a clear understanding of the reaction processes and transport phenomena within and among various sinks namely living systems, soil, water and air. Pilot projects undertaken in selected areas have shown encouraging results based on which it is possible to establish cost effective approaches for waste management through land treatment.

SEWAGE UTILIZATION

Land Application of Wastewater

Broadly, land application can be defined as a technique which utilizes the interaction between natural soil, vegetation and wastewater to upgrade the quality of wastewater. The traditional sewage farming with innovations to suit location specific conditions could be a cost effective method for treatment and utilization of waste water. The value of wastewater as a substitute of organic manure in agriculture (also of water in arid regions) has been recognized for over a century but its use has been restricted by the constraints of social acceptability and the high incidence of diseases in human beings. The municipal sewage has very high economic value. In our country, nearly half of the sewage generated is used for irrigation. The major constraints in sewage farming practices are as follows :

(a) Application of raw (untreated) sewage on land causes serious problems of stinking odour, water logging and mosquito breeding.

(b) Long term application of sewage effluents and/or sludge results in accumulation of chlorides, sulphates and toxic elements like cadmium, Nickel, copper, chromium, manganese, arsenic and mercury in the soil, and consequently reduce crop growth. Irrigation generally results in gradual building up of salinity and this is accelerated by the use of municipal wastewater. Changes in soil texture and consequent water logging also may occur in certain areas.

(c) Depending upon the soil texture and the flow velocity of water through the soil layers, the nutrients (especially nitrates), organic toxic substances and also the pathogens (bacteria and viruses) move to the groundwater.

Human population engaged in agriculture and fish farms supplied with municipal wastewater and sludge are directly exposed to the pathogens which cause different diseases. Several reports show that upto 70% of the farm workers suffer from helminth infection. Further risks to human health arise from the consumption of food contaminated with pathogens and toxic substances directly or through the food chain.

Nutrients in Human Waste Compared to Nutrients in Commercial Chemical Fertilizers (Mid 1990s)

Country	***Nutrient equivalent in commercial fertilizer (percent)***
Kenya	*136*
Tunisia	*25*
Indonesia	*49*
Zimbabwe	*38*
Columbia	*31*
Mexico	*31*
South Africa	*29*
Egypt	*28*
India	*26*

Studies show that the municipal sewage can be used profitably provided that the treatment procedures ensure that the sludge and municipal wastewater do not contain significant amounts of pesticides, detergents, heavy metals and pathogenic organisms. Conventionally, treated sewage appears best suitable for raising tree plantations, horticultural use (watering public gardens and roadside trees) and growing such plants which are tolerant to various pollutants and are not consumed directly by humans and cattle.

The effects of using municipal wastewater in forestry are not well known and therefore, long term studies are required on the impacts of sewage application on the tree growth, other biota and soil characteristics.

The utilization of sewage is also limited by the climate and soil types. Whereas sewage irrigation can be readily recommended in areas with limited water resources seasonally or throughout the year, it is not possible to utilize the effluents in high rainfall regions and during the rainy season elsewhere. Soils prone to salinity and water logging are not suitable whereas many wastelands can possibly be reclaimed with the sludge and sewage effluents.

Another major problem in sewage utilization is that of the long distances to which the sewage or the treated effluents have to be transported as the areas under agriculture and forestry are far off from the urban centers. Decisions about the location of treatment plants have to take into account a number of factors like the location of the urban centers and their physiographic features. The periodic failure of the treatment plants as well as their overflow during the rainy season also create problems in the utilization, and hence, better management of the treatment facilities is essential.

Use of Sewage in Pisciculture

Sewage contains all the essential major and minor fertilizing elements normally used in fish culture. Being in a digested and hence available form, its nutrients promote rapid growth of fish food organisms, which in turn results in greater production of fish per unit area. Fish spawn immediately after stocking needs plentiful supply of natural food in the form of planktons of restricted size, preferably rotifers and cladocerans. Unfortunately, fish culture has not yet been regarded as a means for recycling sewage effluents. It is extensively used in certain parts of the country as a convenient and cheap means of fertilizing the ponds and as such little money is spent on proper treatment. Sewage fed fish culturing is still to gain popularity on a wider scale although these are in the experimental stage at various research centres.

A number of field and experimental studies, particularly in West Bengal and Tamil Nadu have demonstrated that the utilization of the nutrients in the domestic sewage by aquaculture is profitable, and that using a favourable fish species, with judicious management and correct harvesting techniques, very high yields of fish can be obtained.

Sewage Utilization in Forestry

Though considerable effort has been made towards the utilization of municipal wastewater and sludge in natural forests as well as plantations in North America (Cole et al. 1986), it has received hardly any attention in India. Often suggestions have been made for applying sludge and irrigation with sewage effluents in tree plantations, orchards, gardens, lawns, golf courses and similar areas (Shende 1982, Kali and Swaminathan 1980), there is no information on the suitable species, their responses at different growth stages and adverse impacts, if any. A study in Haryana showed that sewage with a high concentration of heavy metals can be better used in forestry (Baddesha and Chhabra 1985) as the woody species normally grown are sturdy and the problems of toxicity, heavy metals and salinity stress are relatively negligible. As these are not consumed directly by humans or animals, no major hazards to life should be expected. Eucalyptus, Leuacnea and Poplar species have been recommended for plantation under sewage irrigation through ridges and trenches where water is not allowed to stagnate (Chhabra 1988).

Use of Vermiculture for Waste Management

Recently, verticulture technology (use of earth worms for bioconversion of wastes) has been used for the management of garbage, kitchen wastes, organic wastes from food industries etc. The effect of organic matter on earthworm populations and the ability of earthworms to promote the decomposition of organic matter have been described for decades. A combination of recycling and resource recovery through biogas and vermiculture could yield fuel (methane fertilizer (biogas plant effluents and nutrient rich vermucasts (and feed (worm biomass). Recently, the Central Pollution Control Board sponsired a project on development of design criteria for a small community sewage treatment plant based on vermiculture technology. The project was carried out by the Bhawalkar Earth Research Institute, Pune. According to the findings of the project, for sewage with less than 700 g/m^3 COD, a vemiflter can be designed with a hydraulic loading of only 0.5 m^3. For dilute waste water, hydraulic loading is the controlling factor governing the requirement of vernifitter area. On the other hand, for strong waste water containing more than 500 g/m^3 organics (equivalent to 700 g/m3 COD), the area requirement is to be governed by the organic loading. This needs further research to optimize the technical & economical aspects.

DECENTRALISED SMALL SCALE TREATMENT SYSTEMS

Promoting the development of decentralized wastewater treatment and recovery technologies that are linked with urban agriculture systems, at the neighbourhood level, appear to be a national approach to solving the human and environmental health dilemmas that result from under –managed wastewater. Decentralized small scale systems must be considered in planning and upgrading urban environments. Gravity flow, small bore sewage, and water borne conveyance systems offer the potential to decentralize urban environments into catchment systems, each with their own integrated treatment plants and at low costs. These systems would be based on the topography of the local water shed, and would result in small–scale facilities equally dispersed through environment. Pathogenic reduction and nutrient recovery would occur through the use of integrated biological processes, which are also low cost. This approach would allow for independent, self maintained, and self sustained facilities that are capable of recovering wastewater resources and immediately reusing them in decentralized urban farms.

The replication of centralised, highly engineered human waste management systems resultant of sanitary reforms of the 19th century have not been successful in many developing world contexts. Many reports suggest that emergent trends in low-cost, decentralised naturally-based infrastructure and urban wastewater management that promotes the recovery and reuse of wastewater resources are increasingly relevant. The concept of managing urban wastewater flows at a decentralised or "intermediate" level, based on micro-watersheds is being explored. The concept of planning integrated wastewater management strategies in conjunction with an urban agricultural "waste-sink" is suggested as a rational approach to waste management and the conservation of valuable urban resources.

Transformation of Urban Waste Management

Urban waste management must be transformed from a disposal-based linear system to a recovery-based closed-loop system that promotes the conservation of water and nutrient resources and contributes to public health. Moreover, it is apparent that both the knowledge and the technology exist, can enable this transformation. There is a gap, however, between the current availability of innovative technology and the promotion/financing of demonstration level projects as well as the development of complementary socioeconomic methodologies to facilitate their implementation.

Conventional and highly engineered wastewater management technologies and strategies often focus on electro-mechanical solutions that are capital intensive and require ongoing capital investments for effective operation. Additionally, these systems have shorter life-cycles compared to many alternative and naturally-based technologies which also offer opportunities for resource recovery.

The development of zero-discharge urban wastewater management strategies will contribute to a reduction in the pathogenic contamination of surface and groundwater and aid in protecting the vitality of urban dwellers. Organic waste recovery can result in production inputs for urban agriculture, enhance food security and link different sectors of local economies. De-centralised, organic waste recovery systems that integrate the best available low-technology in the recovery of urban domestic wastewater flows are essential and appropriate components in the promotion of a comprehensive urban ecosystem health strategy.

Low Cost Systems

In the case of domestic wastewater, individual household are the polluters, and as per the concept of "polluter pays", every polluter should accept the burden of wastewater treatment. In the decentralised treatment system, a balance between the advantages of large scale treatment in terms of economics of scale and individual responsibility for domestic wastewater treatment can be obtained by providing colonywise/sectorwise treatment system. It does not necessarily mean the low cost treatment systems like root zone treatment, stabilization ponds, septic tanks and imhoff tanks, wherein installation cost and operation and maintenance cost of such treatment system are low in comparison with conventional energy intensive treatment system. Sometimes high-tech systems are also required for such projects. Each treatment technology has got its advantages and disadvantages and any technology for treatment should be selected after taking all necessary considerations.

Merits & Demerits of Different Low-cost Wastewater Treatment Systems

Type	Kind of treatment	Use for type of wastewater	Advantages	disadvantages
Septic tank	Sedimentation, sludge stabilization	Wastewater of settleable solids, especially domestic	Simple, durable, little space because of being underground	Low treatment efficiency, effluent not odourless
Imhoff tank	Sedimentation, sludge stabilization	Wastewater of settleable solids, especially domestic	Durble, little space because of being underground, odourless effluent	Less simple than septic tank, needs very regular desludging
Anaero-bic filter	Anaerobic degradation of suspended and dissolved solids	Pre-settled domestic wastewater of narrow COD/BOD ratio	Simple and fairly durable if well constructed and wastewater has been properly pre-treated, high treatment efficiency, little permanent space required because of being underground	Costly in construction because of special filter material, blockage of filter possible, effluent smells slightly despite high treatment efficiency
Baffled Septic tank	Anaerobic degradation of suspended and dissolved solids	Pre-settled domestic wastewater of narrow COD/BOD ratio,	Simple and durable, high treatment efficiency, less space required because of being underground, hardly any blockage, relatively cheap	Less efficient with weak waste water, longer start-up phase than anaerobic filter

Type	Kind of treatment	Use for type of wastewater	Advantages	disadvantages
			compared to anaerobic filter	
Root Zone Treatment System	Aerobic facultative – anaerobic degradation of dissolved and fine suspended solids, pathogen removal	Suitable for domestic wastewater where settleable solids and most suspended solids already removed by pre-treatment	High treatment efficiency when properly constructed, pleasant landscaping possible, no wastewater above ground, no nuisance of odour	High space requirement, great knowledge and care required during construction, intensive maintenance and supervision during first 1-2 years
Anaerobic pond	Sedimentation, anaerobic degradation and sludge stabilization	Domestic and strong and medium wastewater	Simple in construction, flexible in respect to degree of treatment, little maintenance	Wastewater pond occupies open land, there is always some odour, can even be stinky, mosquitoes are difficult to control
Aerobic pond	Aerobic degradation, pathogen removal	Pre-treated domestic wastewater	Simple in construction, reliable in performance if proper dimensioned, high pathogen removal rate, can be used to create an almost natural environment, fish farming possible when large in size and low loaded	Large space requirement, mosquitoes and odour can become a nuisance if undersized, algae can raise effluent BOD
Duck-weed Pond	Anaerobic except aerobic at top, Degradation of Suspended and dissolved Solids, Nutrient Removal	Sullage or Pre-treated sewage	Simple in construction, Revenue generation through pisciculture, suitable for rural and semi–rural area	High space requirement, possibility of odour can not be ruled out, proper harvesting of duckweed is must.

Centralised Vs. Decentralised Systems

Domestic wastewater management of any city consists of collection, treatment and disposal. In conventional centralised sewage treatment system, about 80% of the cost is accounted for the collection alone. The cost of collection of sewage and its conveyance to one terminal point in the larger cities is very high. Further, the depth of sewer goes on increasing with the increase in length of sewer line and pumping of the sewage at intermediate and terminal points requires a lot of energy. Further centralised treatment systems or conventional systems aggravate the environmental problem, as large volume of the wastewater of the entire city is discharged at one place.

In many situations, on site treatment and storage systems (e.g. anaerobic treatment-technologies and septic tanks) can be effectively used for the management of wastewater, but they require periodic emptying and the sludge must be transported to agro production units, In Calcutta wetlands are more than 3,000 ha in size, and are the site of the world largest traditional system for treating domestic wastewater and fertilizing fish production ponds is purified through a variety of nature forces (chemical , physical and solar), which act synergistically to achieve waste water treatment. A series of shallow ponds act as stablisation lagoons, while water hyacinth act to accumulate heavy metals and multiple forms of bacteria, plankton and algae act to further purify the water.

Most recently the term ecological engineering has been used is describe the treatment of waste water in ecologically based "green machines" or "living machines". The development of solar technologies and an increased understanding of the role of organisms in water purification process is providing both economic and environmental benefits. In these systems, enclosed greenhouses enhanced the growth of algae, plants & bacteria which in turn, act to degrade the biological and pathogenic components of waste water effluent.

Mechanised or conventional treatment systems are efficient, in terms of their spatial requirements (0.5-1 m^2 / Person Equivalent, PE - compared to natural treatment systems at 5-10 m^2/ PE), but depend on economies of scale to make them economically feasible. Electro-mechanical wastewater treatment technologies designed to remove high levels of biological oxygen demand (BOD) are not only huge capital investments, but also pose certain dilemmas if reuse of treated effluents is to be an option. Conventional, aerobic, treatment results in maximum reductions in BOD and nutrients while it is desirable to retain biomass BOD and nutrients for agricultural production. Often, the removal of pathogens requires chemical inputs to meet disinfection guidelines, which increases the operation cost and complexity of the system. Dependence on chemical disinfection also complicates effluent reuse in non-restricted irrigation schemes when compared to low-cost solutions such as wastewater stabilisation ponds (WSP), which are economical, produce similar reductions in BOD, nutrients, and greater pathogen reduction, but at a fraction of the cost.

Natural treatment technologies are considered viable because of their low capital costs, their cost of maintenance, their potentially long life cycle compared to electro-mechanical solution and their ability to recover a variety of resources.

Recommendations for Decentralised Systems

To propagate the concept of Decentralised Sewage Treatment System in the country a national workshop was organised on 24th January 2003. The recommendations of the workshop are as follows:

Policy and Rules for Promoting Decentralised Sewage Treatment System (DTS)

1. In view of the critical problem of increasing contamination of surface and groundwater and of the solid-mantle due to untreated or inadequately treated wastewaters and the unsatisfactory performance of the municipalities in handling the problems of existing dwellings, all new housing constructions should provide for appropriate treatment, recycling, reuse or disposal of the wastewater generated by them. This could be on the basis of a colony, co-operative group of houses or individual houses. The proposals should be cleared by the municipal

and pollution control authorities who would also be responsible for monitoring after commissioning of the system.

2. Consent to establish to be made mandatory for new townships or residential colonies, on the line of industry.
3. Use of EIA/EMP tool for township and residential colonies also to be encouraged.
4. For new piped water supply project, corresponding capacity of sewage treatment in terms of Decentralized Treatment System (DTS) or augmentation of STP capacity should be associated as part of the project.
5. Special standards for DTS under the Environment (Protection) Act, 1986/ the Water (Prevention & Control of Pollution) Act, 1974 may be considered.
6. Provision for DTS by developers may find place in municipal bylaws and Municipal Act.
7. Town planning in respect of sewerage and drainage network should be planned in such a way that it has scope for DTS.
8. Decentralized treatment should form part of development plan for all new settlement programme.
9. The designers and builders for sewerage/drainage systems should be made responsible for the treatment & utilization of wastewaters on long-term basis.
10. AICTE may consider including courses on DTS, Diffused Pollution Control, Environmental Protection and Pollution Control Rules & regulations in Degree & Diploma curricula.

Economic Incentives for DTS

1. Price for water supply may have two components

    a. for fresh water supply; and

    b. for sewage treatment.

    And the community which has DTS may be supplied water at lower cost.

2. The Resident Welfare Associations (RWAs) should be made responsible for operation and maintenance (O & M) of DTS and should be given rebate in house tax.

3. In the absence of clear policy framework from the government for DTS and since the recycling of treated wastewater only partially meets the O & M costs, the onus of meeting the O & M costs rests with public/people who set up DTS in colonies. The government in such a situation should provide immediate rebate in property/house tax for those participating in DTS in order to promote DTS.

4. Land development charges levied has a component for sewerage network, which should be kept separate and be spent on DTS or centralized STP.

Demonstration Projects, Documentation and Dissemination

1. Demonstration plants using onsite DTS should be promoted/funded throughout the country for which progressive builders and Resident Welfare Associations may show the way.

2. Pilot and nodal schemes should be promoted by MOEF/CPCB.

3. The development authority like DDA may install DTS at two colonies. Based on the experience, policy may be made for implementation in other colonies in future.

4. Mass awareness and public participation needs to be promoted.

5. Documentation and dissemination of case studies/practical experiences need to be taken up on a wider scale.

6. Advertisement in Press and on Television, Radio for Environment friendly sewage treatment for all housing colonies should be planned in such a way that it has scope for DTS.

Technology and Operation & Maintenance

1. Sewage fed lakes/ponds in urban centers may be converted to DTS so that water quality of lakes and ponds are improved.

2. Proper operation and maintenance of DTS to increase the social acceptance.

3. 'Polluters Pay Principle' should be adopted for O & M of the treatment plants.

4. Segregation & reuse of wastewater at household level be encouraged.

5. Resource recovery like energy should be part of technology to make the system sustainable.

6. Technology selection should be on case-to-case basis and the Auroville, Themax & Panchsheel Club, Delhi experience can be useful.

7. The decentralized treatment plant construction and O & M responsibility should be given to specialist agencies that can take the responsibility for technology risk.

8. People who contribute wastewater should be a party right from planning, construction to operation & maintenance.

STANDARDS FOR DISCHARGE OF SEWAGE

S. No.	Parameter	Standards			
		Inland surface water	Public sewers	Land for irrigation	Marine/coastal areas

S. No.	Parameter	Standards			
		Inland surface water	Public sewers	Land for irrigation	Marine/coastal areas
	2			3	
		(a)	(b)	(c)	(d)
1.	Colour and odour	See 6 of Annexure-I	-	See 6 of Annexure-I	See 6 of Annexure-I
2.	Suspended solids mg/l, max.	100	600	200	(a) For process waste water (b) For cooling water effluent 10 per cent above total suspended matter of influent.
3.	Particle size of suspended solids	shall pass 850 micron IS Sieve	-		(a) Floatable solids, solids max. 3 mm (b) Settleable solids, max 856 microns
4.	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
5.	Temperature	shall not exceed 5^0C above the receiving water temperature	-	-	Shall not exceed 5^0C above the receiving water temperature
6.	Oil and grease, mg/l max,	10	20	10	20
7.	Total residual chlorine, mg/l max.	1.0	-	-	1.0
8.	Ammonical nitrogen (as N), mg/l, max.	50	50	-	50
9.	Total kjeldahl nitrogen (as N); mg/l, max.	100	-	-	100
10.	Free ammonia (as NH3), mg/l,max.	5.0	-	-	5.0
11.	Biochemical oxygen demand (3 days at 27^oC), mg/l, max.	30	350	100	100
12.	Chemical oxygen demand, mg/l, max.	250	-	-	250
13.	Arsenic(as As).	0.2	0.2	0.2	0.2
14.	Mercury (As Hg), mg/l, max.	0.01	0.01	-	0.01
15.	Lead (as Pb) mg/l, max.	0.1	1.0	-	2.0
16.	Cadmium (as Cd) mg/l, max	2.0	1.0	-	2.0
17.	Hexavalent chromium (as Cr + 6), mg/l, max.	0.1	2.0	-	1.0
18.	Total chromium (as Cr) mg/l, max.	2.0	2.0	-	2.0

	2			3	
		(a)	(b)	(c)	(d)
19.	Copper (as Cu) mg/l, max.	3.0	3.0	-	3.0
20.	Zinc (as Zn) mg/l, max.	5.0	15	-	15
21.	Selenium (as Se)	0.05	0.05	-	0.05
22.	Nickel (as Ni) mg/l, max.	3.0	3.0	-	5.0
23.	Cyanide (as CN) mg/l, max.	0.2	2.0	0.2	0.2
24.	Fluoride (as F) mg/l, max.	2.0	15	-	15
25.	Dissolved phos-phates (as P), mg/l, max.	5.0	-	-	-
26.	Sulphide (as S) mg/l, max.	2.0	-	-	5.0
27.	Phenolic compounds (as C_6H_50H) mg/l, max.	1.0	5.0	-	5.0
28.	Radioactive materials:				
	(a) Alpha emitters micro curie mg/l, max.	10^{-7}	10^{-7}	10^{-8}	10^{-7}
	(b)Beta emitters micro curie mg/l	10^{-6}	10^{-6}	10^{-7}	10^{-6}
29.	Bio-assay test	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100%effluent	90% survival of fish after 96 hours in 100% effluent
30.	Manganese	2 mg/l	2 mg/l	-	2 mg/l
31.	Iron (as Fe)	3mg/l	3 mg/l	-	3 mg/l
32.	Vanadium (as V)	0.2 mg/l	0.2 mg/l		0.2 mg/l
33.	Nitrate Nitrogen	10 mg/l	-	-	20 mg/l

Note:

1. *6 of Annexure I states that "all efforts should be made to remove colour and unpleasant odour as far as practicable"*
2. *These standards shall be applicable only if such sewer leads to a secondary treatment including biological treatment system otherwise the discharge into sewers shall be treated as discharge into inland surface waters.*

WHAT YOU CAN DO TO MINIMIZE SEWAGE POLLUTION

* Don't hose down your lawn or corridor to clean it. Sweep it off.

* Run your dishwasher, washing machine, and dryer only when you have full loads.

* When possible, use an outdoor clothesline instead of a clothes dryer.

* When it comes time to buy or replace the one you already own, consider a front-loading washing machine. Front loaders will use up to 40 per cent less water than a comparable top-loading model.

* Fix leaks promptly. A dripping joint can waste more than 76 litres of water a day.

* Install low-flow shower-heads.

* Take showers instead of baths. Showers use less water - if you limit them to five minutes.

* Turn off the tap! Running the tap while shaving, brushing teeth, or washing dishes wastes about 10 litres of water every minute.

* Install a `greywater' tank to reuse some household water that might otherwise go down the drain.

* Cut down on pesticide use in the lawn and garden - only one per cent of pesticides actually reach a pest. Consider using organic pesticides.

* `Xeriscape' your lawn. The term refers to a method of landscaping that uses the least amount of water. Plant grass, shrubs and flowers that require little water and use other techniques that conserve water.

* **Do not leave food in the plate – this may help reducing BOD load of Yamuna by 40 tonnes per day in Delhi alone.**

DEFINITIONS OF WORDS OR TERMS

Activated Sludge: Flocculent sludge produced by the growth of bacteria and other organisms in raw or settled sewage, when it is continuously aerated.

Activated Sludge Process: A biological treatment process in which a mixture of sewage and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated sewage by settlement and may be re-used.

Aerobic action: A biological process promoted by action of bacteria in the presence of dissolved oxygen.

Anaerobic action: A biological process promoted by the action of bacteria in the absence of dissolved oxygen.

Biochemical Oxygen Demand (BOD): The amount of dissolved oxygen consumed by micro-biological action when a sample is incubated, usually for 5 days at 20 deg. C (expressed as BOD5) or for 3 days at 27 deg. C (expressed as BOD3).

Biological Filter: A bed of relatively inert material to promote or assist natural aerobic degradation of sewage.

Biological Treatment: This is a stage in the treatment of sewage or other effluents which biologically treats the pollution frequently by the natural aerobic degradation of the pollutant.

Chemical Oxygen Demand: The amount of oxygen used in the chemical oxidation of the matter present in a sample by a specified oxidising agent under standard conditions.

Colloidal Material: The finely divided solids which will not settle but which may be removed by coagulation.

Crude Sewage: Sewage which has received no treatment.

Digestion: The biochemical decomposition of organic matter using anaerobic bacteria, which results in the formation of simpler and less offensive compounds.

Dosing Chamber: A small tank which receives settled sewage until the desired quantity has accumulated, when it is discharged automatically to the distributor of a biological filter.

Drains: These are usually the smaller pipes that serve a single property, and they join up to form a Drainage System. There may be foul water, and surface water drains, which are usually in separate systems. Many queries are caused by drainage problems, and odours or smells from these systems.

Effluent Polishing or Tertiary Treatment: A further stage of treating sewage or effluents, by removing suspended solids and or pollutants. Consequential removal of suspended solids may also remove residual BOD or other pollutants.

Eutrophication: The enrichment of water in watercourses and lakes by chemical substances, especially compounds of nitrogen and phosphorous.

Filter medium: The material of which the biological filter is formed and on which a biological film (or biomass) containing bacteria and fungi develops.

Final Effluent: The effluent discharged from a sewage treatment plant.

Membrane: New technology has been developed whereby the pollutants in liquids can be removed by the use of ultra fine membranes, such as the Reverse Osmosis method in the treatment of fresh potable water, or membranes in the treatment of polluted water or effluents.

Odours: Sewage by its very nature will produce odours, and these can sometimes be a problem at sewage pumping stations or sewage treatment works.

Oxidation: The chemical change which a substance undergoes when it takes up oxygen.

Primary Settlement Tank: A tank, in which the majority of settleable solids are removed from the crude sewage that will flow into it.

Reed Beds: These are usually specially constructed beds which contain reeds (frequently the *Phragmites Australis* reed) to biologically treat sewage and other effluents. Many natural reed beds exist in wetland areas.

Rotating Biological Contactor (RBC): This is a system of sewage or effluent treatment, that uses closely spaced parallel discs mounted on a horizontal shaft, which rotate about a horizontal axis, and the discs are alternatively exposed to polluted liquors and air as the shaft rotates to biologically treat the sewage.

Secondary Settling tank: A tank in which settleable solids or humus is separated from the effluent flowing through it, from biological filters or other biological treatment units.

Septic Tank: A type of settlement tank in which the sludge is retained for sufficient time for the organic matter to undergo anaerobic decomposition.

Settling (or Sediment) Tank: This is a tank which is used in the treatment of sewage or effluents to settle out the suspended solids contained in the liquids. The tank may be sited near the works inlet as a 'primary settlement tank' or alternatively after biological treatment as a final (humus) settlement tank.

Sewage: The water-borne wastes of a house or community.

Sewage Treatment Works: The site which contains all the necessary plant for the treatment of sewage.

Sewage Treatment Plant: The items of equipment or structures which treat the sewage.

Sewerage: This term is used to describe such items as a 'sewerage system' or 'sewerage network'. (for example - sewage runs in a sewerage system.)

Sludge: A mixture of solids and water produced during the treatment of waste water or sewage. This will frequently have to be removed from the treatment system by de-sludging.

Sludge Removal or De-Sludging: This is the process of removing sludge from treatment systems or tanks and can be carried out manually or automatically. All sludge's removed from tanks or systems should be transported with care and in accordance with current legislation.

Storm Sewage (or Surface Water Sewage): Sewage flowing to a treatment works in wet weather or discharged from storm overflows when the sewage is diluted with rainwater.

Suspended Solids (SS): Solids in suspension in sewage liquors as measured by filtration through a filter paper followed by washing and drying.

Tertiary Treatment: There are many differing types of tertiary treatment of effluents, the most common being, Grass Plots, Reed Beds, Upward flow Clarifier. Rapid Gravity Sand Filter, Microstrainer, Sand Filter, Drum Filter, Lagoons, Nitrifying Filter.

Toxicity : This usually refers to the toxic element of waterborne wastes, and the toxic elements may comprise of metals, pesticides, or other chemicals which cause pollution of streams, watercourses, rivers, beach's, or ground water.

Water Quality: This term is used to describe the quality of water in rivers, lakes, streams or watercourses, as well as the quality of Potable or Drinking Water

Wetlands: Many natural wetland areas exist throughout the world and these are frequently found where this is some form of pollution that they use as a nutrient feed. In some areas these natural wetlands have been constructed by man to treat sewage or other forms of effluent pollution.

FURTHER READINGS

CUPS/4/1978-79	Status of Water Supply and Wastewater Collection, Treatment & Disposal in Class-I Cities – Status & Action Plan
CUPS/6/1978-79	Status of Water Supply and Wastewater Collection Treatment & Disposal in Class-II Towns of India
CUPS/30/1989-90	Status of Water Supply and Wastewater Collection, treatment and Disposal in Class-I Cities
CUPS/31/1989-90	Status of Water Supply and Wastewater Collection, treatment and Disposal in Class-II Town
CUPS/41/1994-95	Management of Municipal Solid Wastes - Status and Options
CUPS/42/1996-97	Status of Water Supply & Waste Water Generation, Collection, treatment and Disposal in Metrocities
CUPS/44/1998-99	State of Water Supply and Wastewater Generation, Collection, Treatment and Disposal in Class – I Cities
CUPS/45/99-2000	Sewage Management in Trans-Yamuna Region of Delhi : Status and Needs
CUPS/49/99-2000	Status of Water Supply and Wastewater Generation, Collection, Treatment and Disposal in Class-II Towns
CUPS/54/02-03	Status of Sewage Treatment Plants in Ganga Basin
PROBES/80/2001-02	Guidelines for Health & Safety of Workers in Wastewater Treatment Facilities

PROBES/83/2001-02	Status Report on Dinapur Sewage Treatment Plant and Surroundings
COPOCS/27/2002-03	Municipal Sewage Pollution Along Indian Coastal Waters
MINARS/21/2002-03	Water Quality Status & Trends (2000)
PCLS/2/1992	Pollution Control Acts, Rules & Notifications issued thereunder
PCLS/4/1994-95	Environmental Standards for Ambient Air, Automobiles Fuels, Industries and Noise
ADSORBS/32/99-00	Water Quality Status of Yamuna River
CPCB Annual Report	Various Years
CPCB Highlights	Various Years

Published By : Dr. B. Sengupta, Member Secretary, Central Pollution Control Board, Delhi – 32
at ENVIS Centre – 01
Text : Dr. R.C. Trivedi, Sh. R.M. Bhardwaj, Dr. S. Agrawal, Sh. Nazimuddin, Ms. Kokil Malhotra and Sh. Mahendra Pandey
Printing Supervision & Layout : P.K. Mahendru, Anamika Sagar and Mohd. Javed
Fax : 91-11-22307079/22304948 EPABX : 22305792, 22302073, 22302856
TELEX : 031-66440 PCON IN
e-mail : cpcb@alpha.nic.in; Website : www.cpcb.delhi.nic.in
Printed at : NISCAIR