Sustainable Technology Options for Safe Reuse of Wastewater

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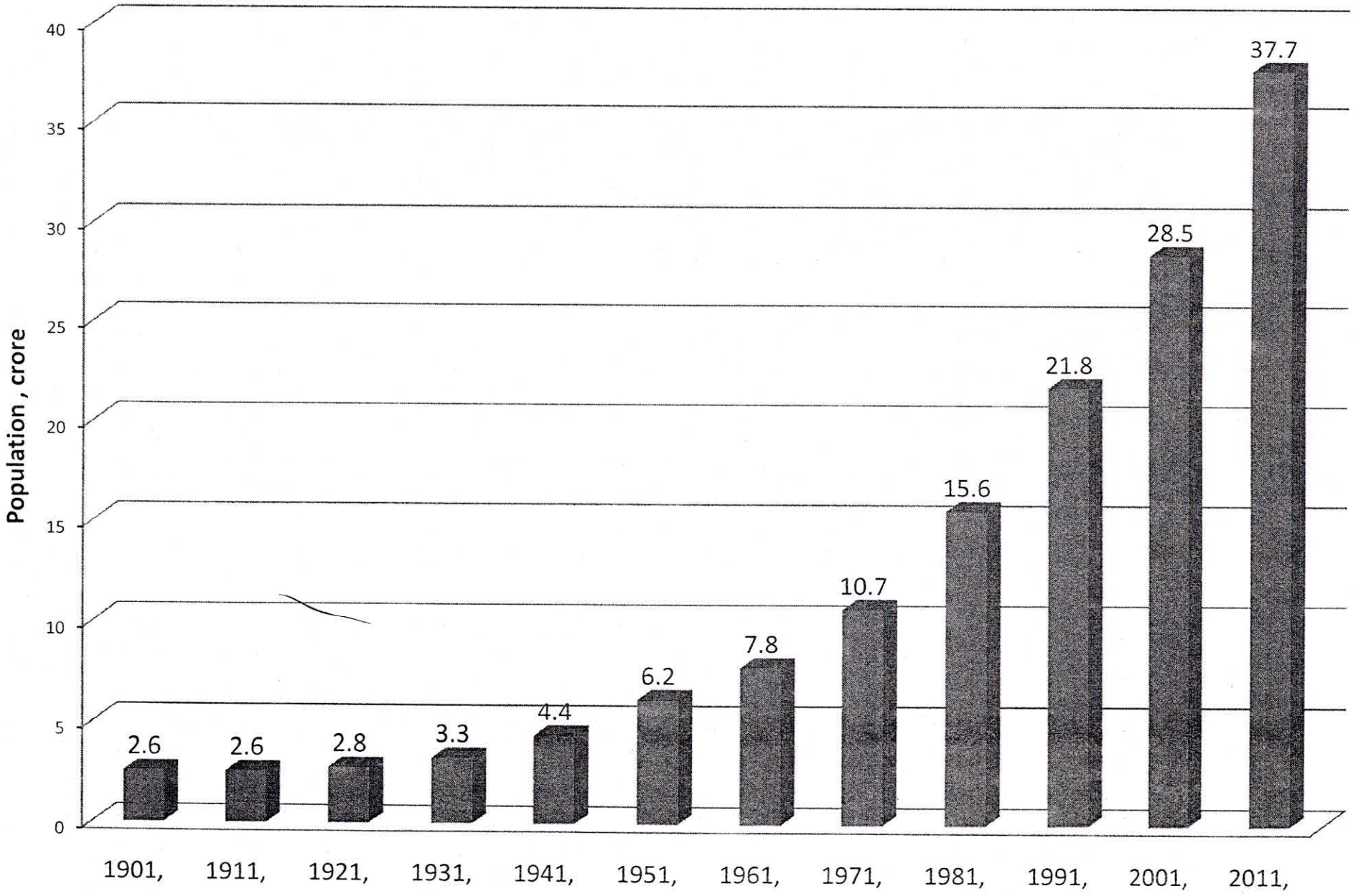
Why Sewerage Systems in India?

- Fast Urbanization
- Urban Population: 377.1 million in 2011 will increase to 500 million in 2017 (World Bank 2006)
- Steep increase in wastewater generation
- A study by World Bank and others estimated impacts of inadequate sanitation at Rs 2.44 trillion/yr equivalent to 6.4% of India's GDP in 2006 or Rs 2180/person/yr

Trend of Urban Population Growth in India



Trend of Growth of Sewage Generation and Treatment in MLD

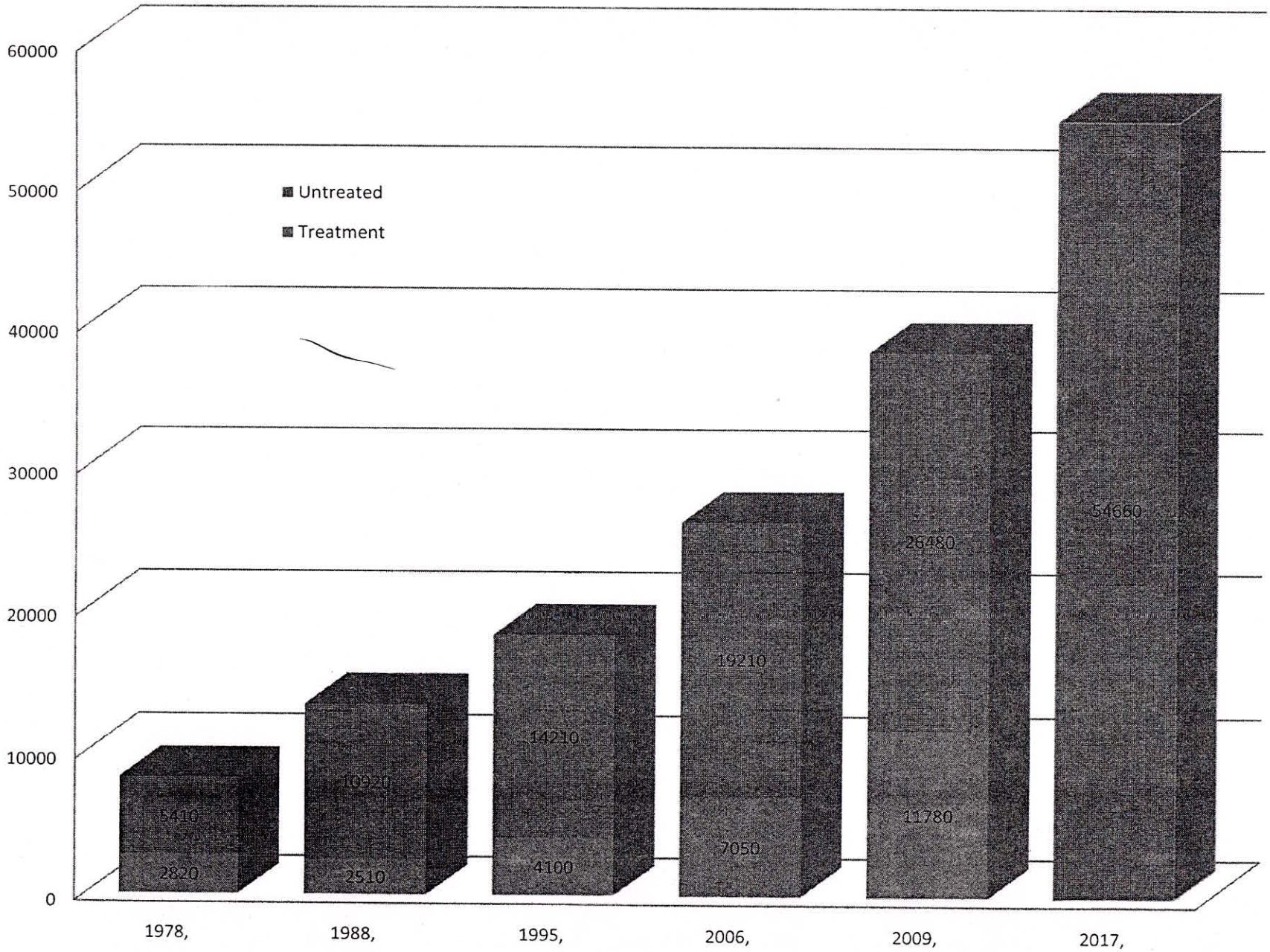


Figure 1: Water supply and sewage disposal status in class I cities

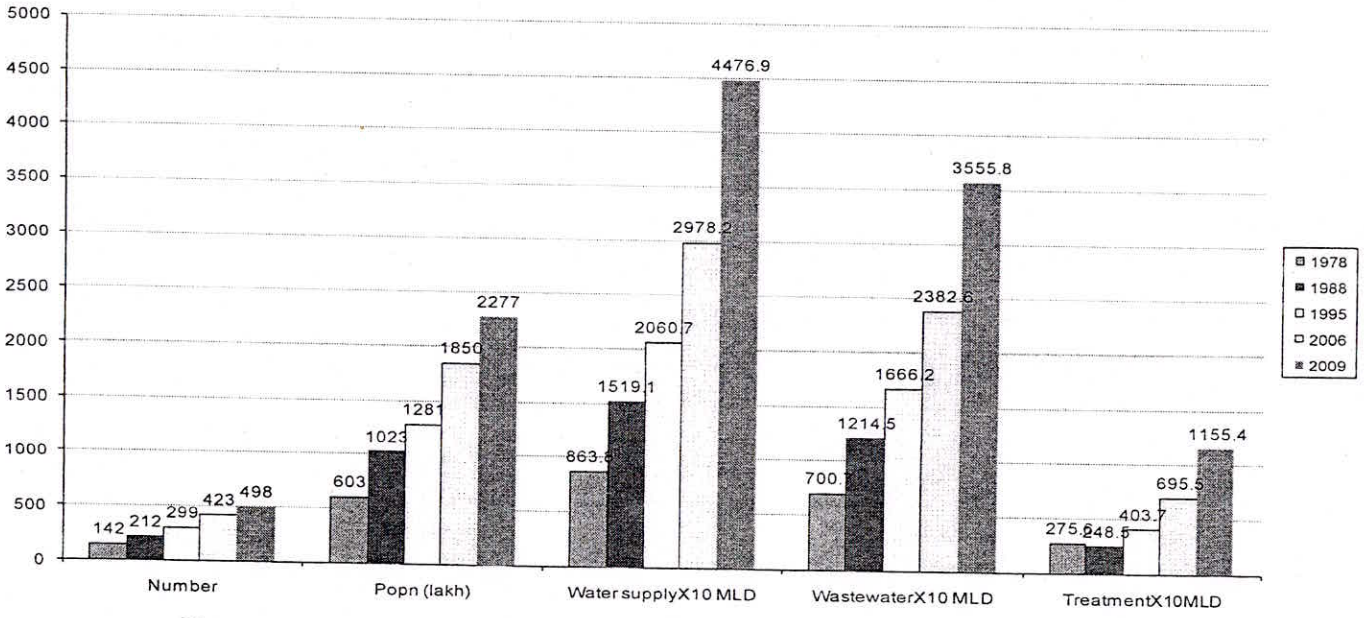
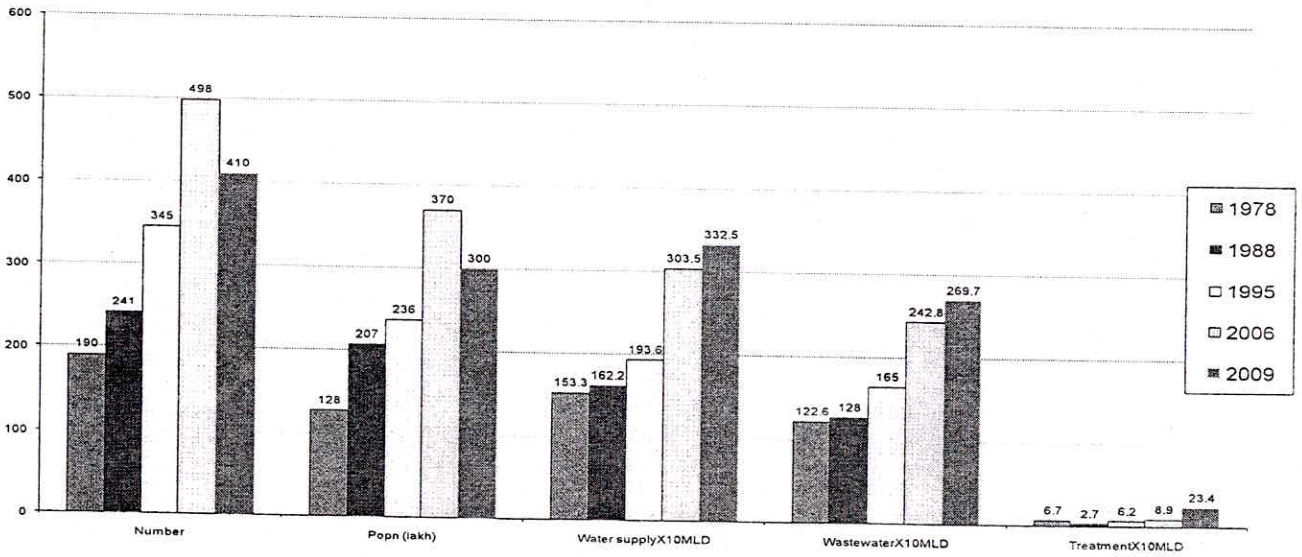


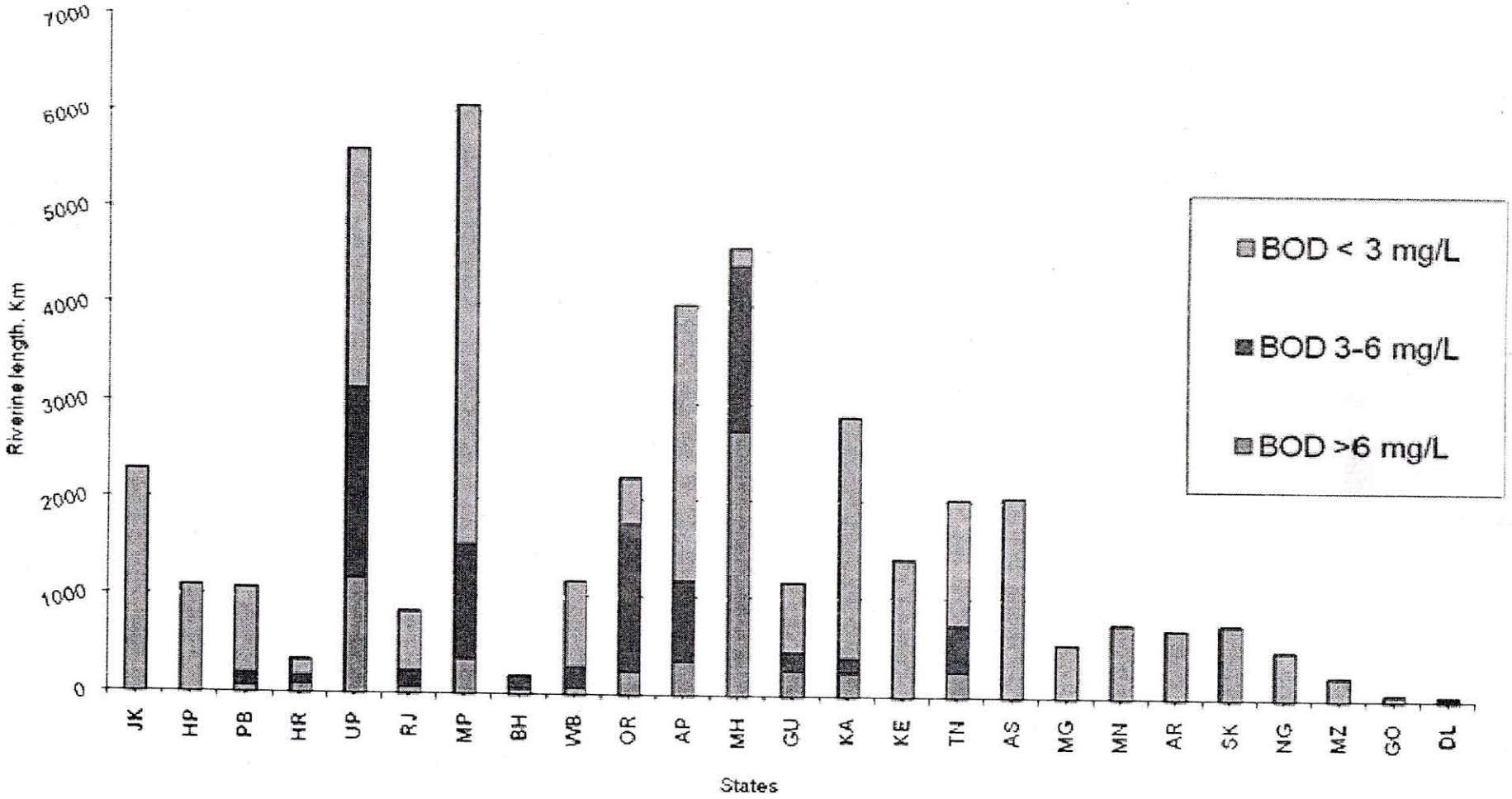
Figure 2: Water supply and wastewater generation and treatment in class II towns of India



Riverine length having different level of pollution

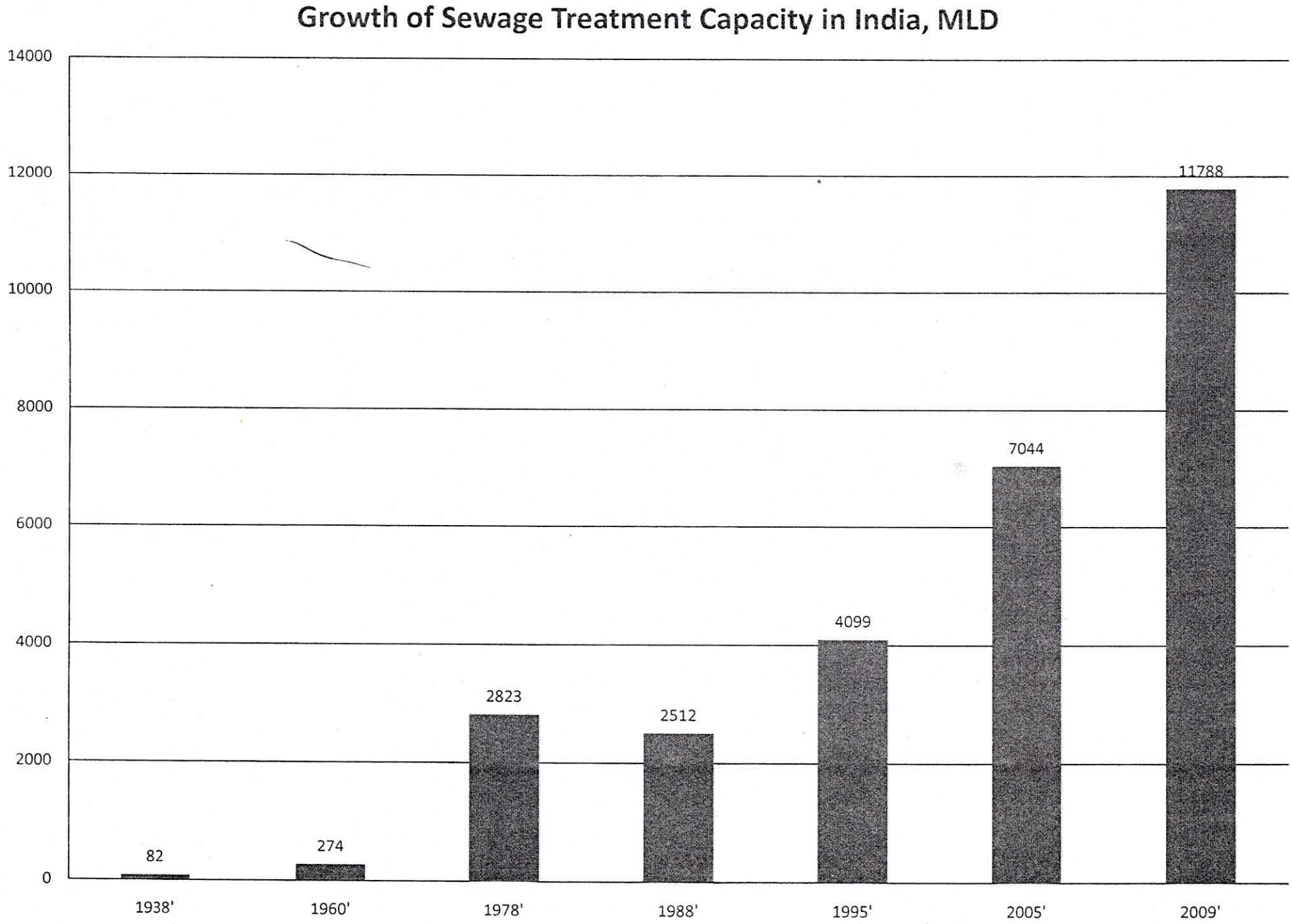
S.NO.	Level of Pollution	Riverine Length km	Riverine Length percentage
1	High pollution (BOD >6 mg/L)	6086	14
2	Moderate pollution (BOD 3-6 mg/L)	8691	19
3	Relatively clean (BOD <3 mg/L)	30242	67

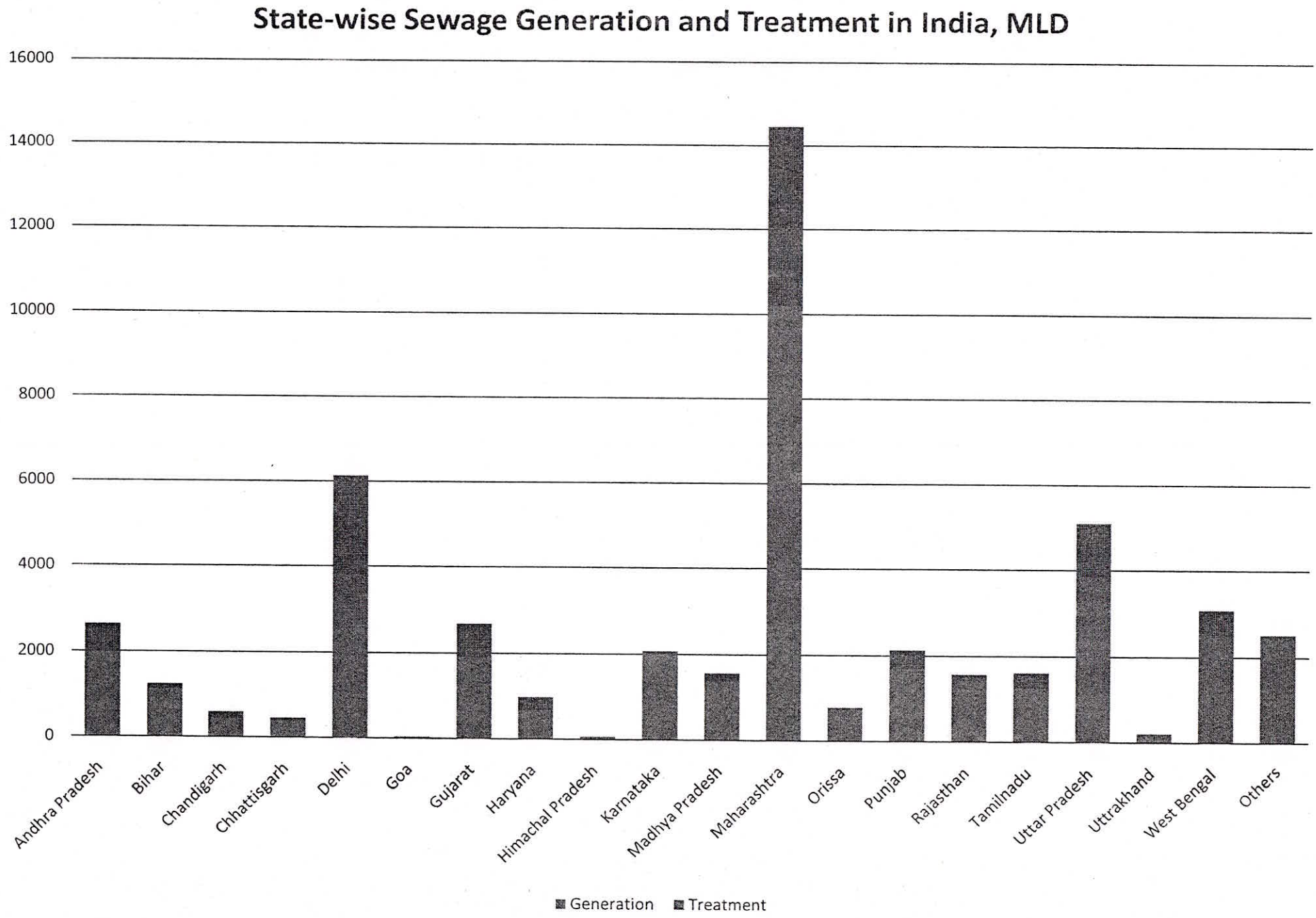
State-wise Total riverine length under different water quality status

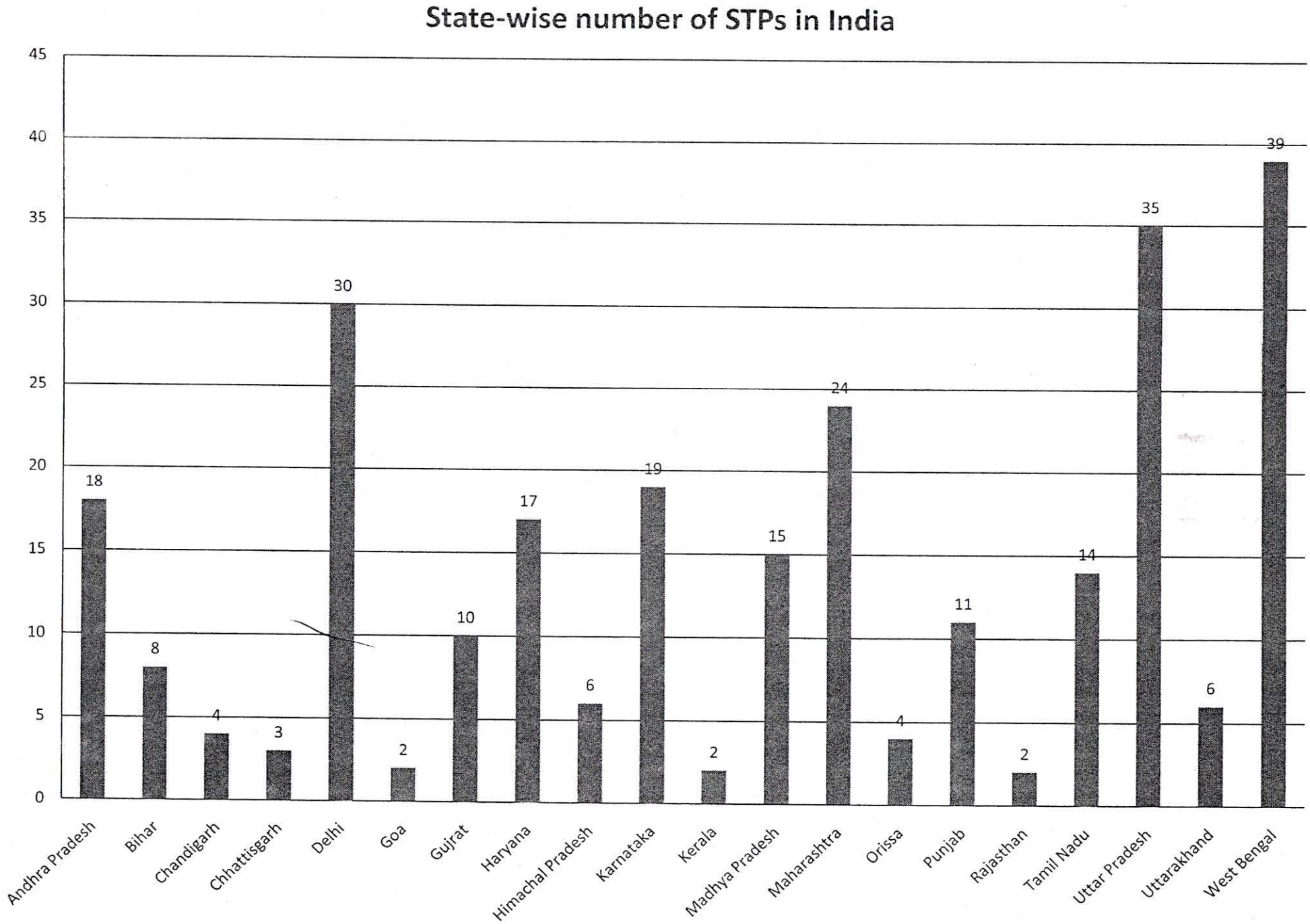


Main Cause of WQ Degradation

- Discharge of untreated sewage is main cause of water pollution in India
- Out 38,254 MLD of domestic sewage generated treatment facilities exist for only about 11,787 MLD
- Even these facilities are not effectively utilized
- Augmentation of sewage treatment facilities and their effective utilization is most crucial aspect for restoring rivers and other aquatic resources


Growth of Sewage Treatment Capacity in India, MLD
14000
12000
10000
8000
6000
4000
2000
0
82
274
2823
2512
4099
7044
11788
1938'
1960'
1978'
1988'
1995'
2005'
2009'


State-wise Sewage Generation and Treatment in India, MLD
16000
14000
12000
10000
8000
6000
4000
2000
0
Andhra Pradesh
Bihar
Chandigarh
Chhattisgarh
Delhi
Goa
Gujarat
Haryana
Himachal Pradesh
Karnataka
Madhya Pradesh
Maharashtra
Orissa
Punjab
Rajasthan
Tamilnadu
Uttar Pradesh
Uttrakhand
West Bengal
Others
Generation
Treatment


State-wise number of STPs in India
45
40
35
30
25
20
15
10
5
0
18
8
4
3
30
2
10
17
6
19
2
15
24
4
11
2
14
35
6
39
Andhra Pradesh
Bihar
Chandigarh
Chhattisgarh
Delhi
Goa
Gujrat
Haryana
Himachal Pradesh
Karnataka
Kerala
Madhya Pradesh
Maharashtra
Orissa
Punjab
Rajasthan
Tamil Nadu
Uttar Pradesh
Uttarakhand
West Bengal

Harmful Effects of Uncleaned Wastewater on Land & Waterway

LAND DISPOSAL

- Clogging of pores with suspended solids leading to soil sickness
- Degradation of soil with salinity
- Worm infestationwith farm workers
- Cross-contamination with produces
- Greatest risk with fruits and vegetables that are eaten raw

Raw DISPOSAL INTO RIVERS

- Oxidation of organic solids results in depletion of DO
- Very low DO in water leads to Fish kill
- Water quality degradation and contamination affects beneficial usesof down-stream
- Risk of spread of water-borne diseases

Wastewater as Resource

- Water value
  - Water demand is growing
  - Water scarcity
  - Pressure on water resources - GW, SW
  - Wastewater as a substitute of freshwater for irrigation
- Nutrient value
- Energy value

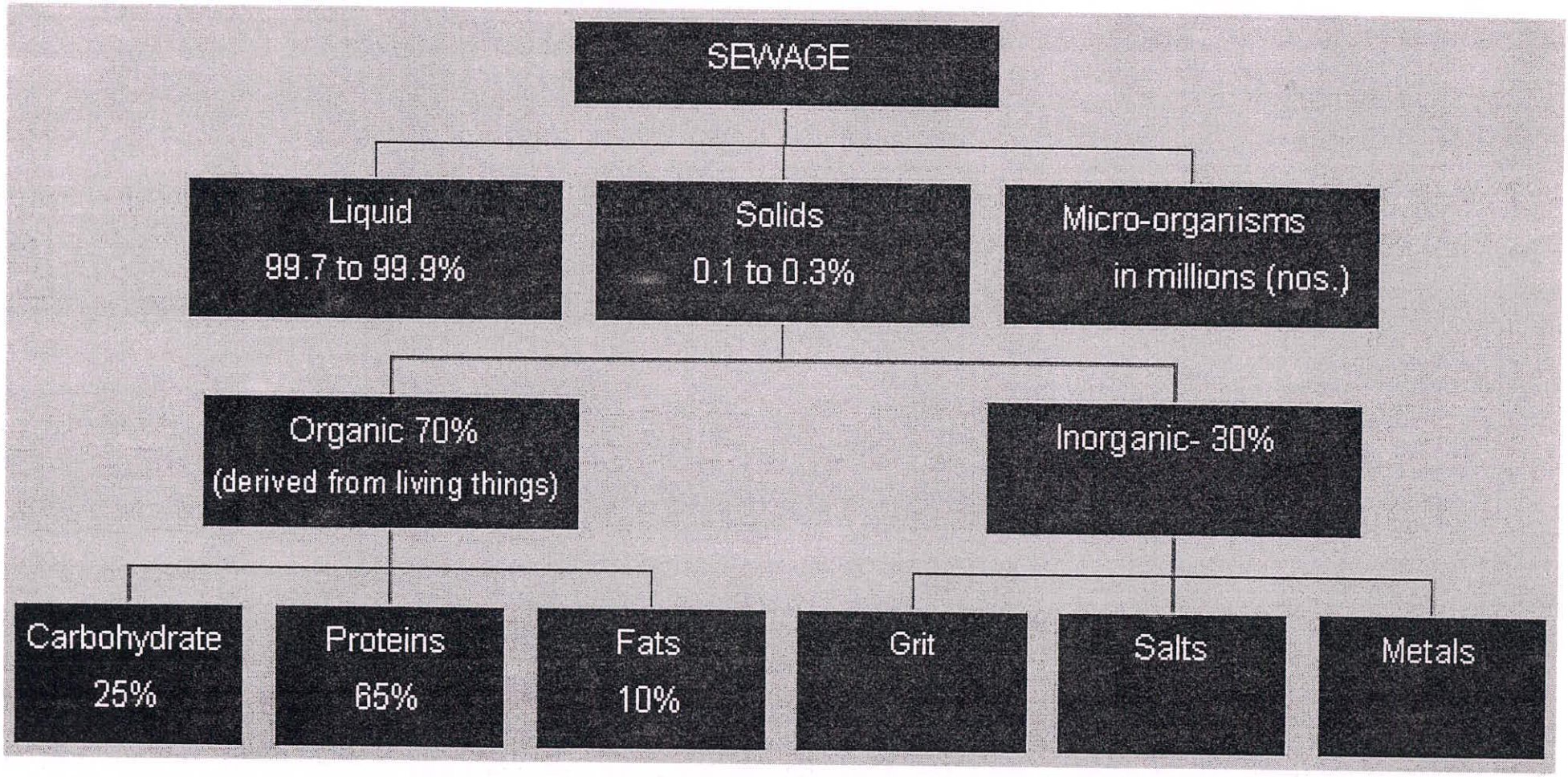
Option for Reuse

- Agriculture irrigation;
- Landscape irrigation;
- Industrial use;
- Cooling water;
- Toilet flushing; and
- Groundwater recharging

Advantages of recycle and reuse of wastewater

- Helps reduce pollution in the water bodies, as the wastewater is being used up
- Helps save water, since it supplements the demand for freshwater
- Saves vital nutrients that are otherwise lost when wastewater is discharged in water bodies. For example, recycled wastewater contains higher levels of nutrients than potable water. Thus application of recycled water for agricultural and landscape irrigation can provide an additional source of nutrients and lessen the need to apply fertilizers
- Treated wastewater and its various application (irrigation etc.) increases recharge of ground water and replenishes surface water bodies
- Treated wastewater also provides an opportunity to develop and use a reliable onsite water source especially at the building level
- Treated wastewater and its reuse helps reduce intake of fresh water cost and reduction in transmission, treatment and disposal of wastewater
- It is also an step towards zero discharge

Wastewater Composition



Wastewater Reuse

- Irrigation
  - agriculture
  - landscaping
  - horticulture
- Industrial
  - process
  - cooling
  - boiler feed
- Groundwater Recharge
- Other - recreation etc

Wastewater Reuse

- Agricultural irrigation
  - crop irrigation - crops not eaten raw
  - commercial nurseries
- Landscape irrigation
  - parks
  - school yards
  - golf course
  - cementaries
  - green belts
  - residential

Wastewater Reuse

- Industrial recycling and reuse
  - cooling
  - boiler feed
  - process water
  - heavy construction
- Groundwater recharge
  - groundwater replenishment
  - salt water intrusion control
  - subsidence control

Wastewater Reuse

- Recreational and environmental uses
  - lakes & ponds
  - marsh enhancement
  - stream flow augmentation
  - fisheries
  - wetlands

Wastewater Reuse

- Non-potable urban uses
  - fire protection
  - air conditioning
  - toilet flushing
- Potable reuse
  - blending in water supply
  - through surface water storage
  - through groundwater recharge

Wastewater Reuse - Water Quality Problems

- Irrigation - salinity, SAR
- Industrial cooling
  - scaling
  - metallic corrosion
  - biological growth
  - fouling

Water Quality classification for irrigation

Water class	Percent sodium	EC, 25 C	Boron		
			Sensitive crop	Semitolerant crop	Tolerant crop
Excellent	<20	<250	<0.33	<0.67	<1
Good	20-40	250-750	0.33-0.67	0.67-1.33	1-2
Permissible	40-60	750-2000	0.67-1	1.33-2	2-3
Doubtful	60-80	2000-3000	1-1.25	2-2.5	3-3.75
Unsuitable	>80	>3000	>1.25	>2.5	>3.75

Total dissolved solids

Class	TDS	Class	SAR	
Fresh water	0-1000	Excellent	<10	
Brackish	1000-10000	Good	10-18	
Salt water	10000-100000	Fair	18-26	
Brine	>100000	Poor	>26	

Mineral water quality

Cations	Concentration, mg/l	Anions	Concentration, mg/l
Sodium	1.3	Fluoride	0.15
Potassium	2	Chloride	2
Calcium	37	Sulphate	34
Magnesium	22	Bicarbonate	196
Strontium	0.15	Silicic acid	20.8
		Boric acid	0.07
		TDS	325

Wastewater Reuse - Groundwater Recharge

- Surface spreading
- Direct injection
- Water quality problem
  - fate of contaminants
  - chemicals
  - pathogens
  - colours, dyes

Wastewater Reuse - Guideline for groundwater recharge through surface spreading

- Treatment - source control of toxics, tertiary treatment using activated charcoal, disinfection
- Depth - percolation through undisturbed soil unsaturated aquifer 10-50 ft
- Retention time in GW - 6-12 months
- Maximum % of reclaimed WW - 20-50%
- Monitoring - extensive

Wastewater Reuse - Guideline for groundwater recharge through direct injection

- Treatment - source control of toxics, tertiary treatment using chemical coagulation, clarification and granular media filtration, activated charcoal adsorption, volatile removal, reverse osmosis, disinfection
- Depth - not applicable
- Retention time in GW - 12 months
- Maximum % of reclaimed WW - 20%
- Monitoring - extensive

Wastewater Reuse

- Recreational and environmental uses
  - lakes & ponds
  - marsh enhancement
  - stream flow augmentation
  - fisheries
  - wetlands

Economic Value of the Waste Water Generated from Class I Cities and Class II Towns.

Nutrients/Organic Matter Average Concentration (mg/l)	Nitrogen 48	Phosphate 11	Potassium 21	Organic matter 400	Value of water
Class I Cities: Nutrients, T/D Nutrients, T/Y Total Value, Rs.in Mill.	1143.6 417431	262 95661 6957	500 182626	9530 3478596 522	- - 2174
Class II Towns: Nutrients, T/D Nutrients, T/Y Total Value, Rs.in Mill.	116.5 42538	26.7 9748 709	50.9 18610	971 354488 53	- - 221.5

Note: Nutrient concentrations are taken from the average of Indian cities. The values of nutrients and organic matter have been computed by assuming @ Rs. 10000/t (4000/t) of nutrients and @ Rs. 150/t (59/t) of organic matter. The value of water for irrigation is also an appreciable amount and have been computed @ Rs.250/mld (100/mld) Sengupta, 1984, (the values are based on the prevailing costs during 1984, which might have been increased appreciably and present cost was taken as 2.5 times the cost of 1984).

Economic Value of the Waste Water Generated from Class I Cities and Class II Towns.

Nutrients/Organic Matter Average Concentration (mg/l)	**Nitrogen** **48**	**Phosphate** **11**	**Potassium** **21**	**Organic matter** **400**	**Value of water**
Class I Cities:					
Concentration, T/D	583	134	255	4858	-
Concentration, T/Y	212795	48910	93075	1773170	-
Total Value, Rs.in Mill.		1419		105	443
Class II Towns:					
Concentration, T/D	62	14	27	519	-
Concentration, T/Y	22630	5110	9855	189435	-
Total Value, Rs.in Mill.		150		11	47

Comparison of Capital & operation Cost for four Different methods of Municipal Sewage Treatment capacity 30 mld

Sl. No.	Item	I Conventional Activated Sludge	II Extended Aeration	III Facultative Aerated Lagoon	IV UASB with gas rec
1.	BOD removal eff. %	85 - 90	90-95	75-80	75-85
2.	Capital Cost (Rs. Lakh)	376	351	220	360
3.	Capital Cost per mld	12.53	11.7	7.33	12.0
4.	Annual O & M cost Rs. (Crore)	0.92	1.11	0.72	0.56
5.	Land Required (ha)	12	8	8	6
6.	Power Required (HP)	350	537	354	45

Criteria for sustainability in the treatment of wastewater

- **No dilution of high strength wastes with clean water.**
- **Maximum of recovery and re-use of treated water and by-products obtained from the pollution substances. (i.e. irrigation, fertilization)**
- **Application of efficient, robust and reliable treatment/conversion technologies, which are low cost (in construction, operation, and maintenance), which have a long life-time and are plain in operation and maintenance.**
- **Applicable at any scale, very small and very big as well.**
- **Leading to a high self-sufficiency in all respects.**
- **Acceptable for the local population**

Some Examples of Wastewater Reuse at Building Level

Name	Building type	Area (sq meter)	Occupancy	Average Daily water use (litres)	Average Daily wastewater Generated*	Type of Wastewater Treatment	Recycling & reuse
CSE office building **	Office/ Institutional	1000	100 (+ 25 visitors, daily)	6600	5280	Anaerobic baffled reactor and Planted horizontal gravel filter	Yes
**	Educational/ Institutional	3, 15,380	2,400 (1750 visitors)	342000	273600	Septic tanks	No
Residence at Saket, **	Residential	250	6	1251	1000	Municipal Sewerage Line	No
ITC Maurya Delhi	Hotel/ Commercial	24281	1500- 2000	571000	456800	Membrane bio Reactor	Yes
S.N. Realtors Pvt. Ltd. (Construction of Group Housing Complex at Sector 78, , Haryana	Group Housing/ Residential	86013	2866	420000	307000***	STP	Yes
Commercial Complex Sector-14, Gurgaon Haryana****	Commercial Complex	41971	NA	260000	202000	STP	Yes ,'0'Discharge

Major Issues/constraints in Reuse of Wastewater

Wastewater reuse categories	Issues/constraints
• Agriculture irrigation • Crop irrigation • Commercial nurseries • Landscape irrigation • Parks • School yards • Freeway medians • Golf courses • Cemetries • Greenbelts • Residential	1. Surface and groundwater pollution if not managed properly 2. Marketability of crops and public acceptance 3. Effect of water quality, particularly salts, on soils and crops 4. Public health concerns related to pathogens (bacteria, viruses and parasites) 5. Use for control of area including buffer zone 6. May result in high user costs
• Industrial recycling and reuse • Cooling water • Boiler feed • Process water • Heavy construction	1. Constituents in reclaimed wastewater related to scaling, corrosion, biological growth and fouling, 2. public health concerns, particularly aerosol transmission of pathogens in cooling water
• Groundwater recharge • Groundwater replenishment • Salt water intrusion control • Subsidence control	1. Organic chemicals in reclaimed wastewater and their toxicological effects 2. total dissolved solids, nitrates and pathogens in reclaimed wastewater
• Recreational/environmental uses • Habitat wetlands • Lakes and ponds • Boating • Marsh enhancement • Streamflow augmentation • Fisheries	1. Health concerns of bacteria and viruses, 2. Eutrophication due to nitrogen (N) and phosphorus (P) in receiving water, 3. Toxicity to aquatic life
• Miscellaneous uses • Fire protection • Air conditioning • Toilet flushing	1. Public health concerns on pathogens transmitted by aerosols, 2. Effects of water quality on scaling, corrosion, biological growth and fouling 3. cross-connection
• Aquaculture	1. Constituents in reclaimed wastewater, especially trace reservoir organic chemicals and trheir toxicological effects 2. Aesthetics and public acceptance 3. health concerns about pathogen transmission, particularly viruses

Various Technologies Available in India for Wastewater Recycling