

Current condition of the Yamuna River - an overview of flow, pollution load and human use

Deepshikha Sharma and Arun Kansal, TERI University

Introduction

Yamuna is the sub-basin of the Ganga river system. Out of the total catchment's area of 861404 sq km of the Ganga basin, the Yamuna River and its catchment together contribute to a total of 345848 sq. km area which 40.14% of total Ganga River Basin (CPCB, 1980-81; CPCB, 1982-83). It is a large basin covering seven Indian states. The river water is used for both abstractive and in stream uses like irrigation, domestic water supply, industrial etc. It has been subjected to over exploitation, both in quantity and quality. Given that a large population is dependent on the river, it is of significance to preserve its water quality. The river is polluted by both point and non-point sources, where National Capital Territory (NCT) – Delhi is the major contributor, followed by Agra and Mathura. Approximately, 85% of the total pollution is from domestic source. The condition deteriorates further due to significant water abstraction which reduces the dilution capacity of the river. The stretch between Wazirabad barrage and Chambal river confluence is critically polluted and 22km of Delhi stretch is the maximum polluted amongst all. In order to restore the quality of river, the Government of India (GoI) initiated the Yamuna Action Plan (YAP) in the 1993 and later YAPII in the year 2004 (CPCB, 2006-07).

Yamuna river basin

River Yamuna (Figure 1) is the largest tributary of the River Ganga. The main stream of the river Yamuna originates from the Yamunotri glacier near Bandar Punch ($38^{\circ} 59' N 78^{\circ} 27' E$) in the Mussourie range of the lower Himalayas at an elevation of about 6320 meter above mean sea level in the district Uttarkashi (Uttaranchal). The catchment (table 1&2) of the Yamuna river system covers parts of the states of Uttaranchal, Uttar Pradesh (U.P.), Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh and the entire state of Delhi. The river Yamuna traverses a distance of about 1370 km in the plain from Saharanpur district of Uttar Pradesh to the confluence with river Ganga at Allahabad. The major tributaries of the river are Tons, Betwa, Chambal, Ken and Sindh and these together contribute 70.9% of the catchment area and balance 29.1% is the direct drainage of main River and smaller tributaries. On the basis of area, the catchment basin of Yamuna amounts to 40.2% of the Ganga Basin and 10.7% of the country.

Table 1: The catchment of River Yamuna

<i>Name of state</i>	<i>Total catchment area in Yamuna (in Sq. Km.)</i>	<i>%age contribution</i>
U.P. (including Uttranchal)	74208	21.5
Himachal Pradesh	5799	1.6
Haryana	21265	6.5
Rajasthan	102883	29.8
Madhya Pradesh	14028	40.6
Delhi	1485	0.4

Source: CPCB, 2006

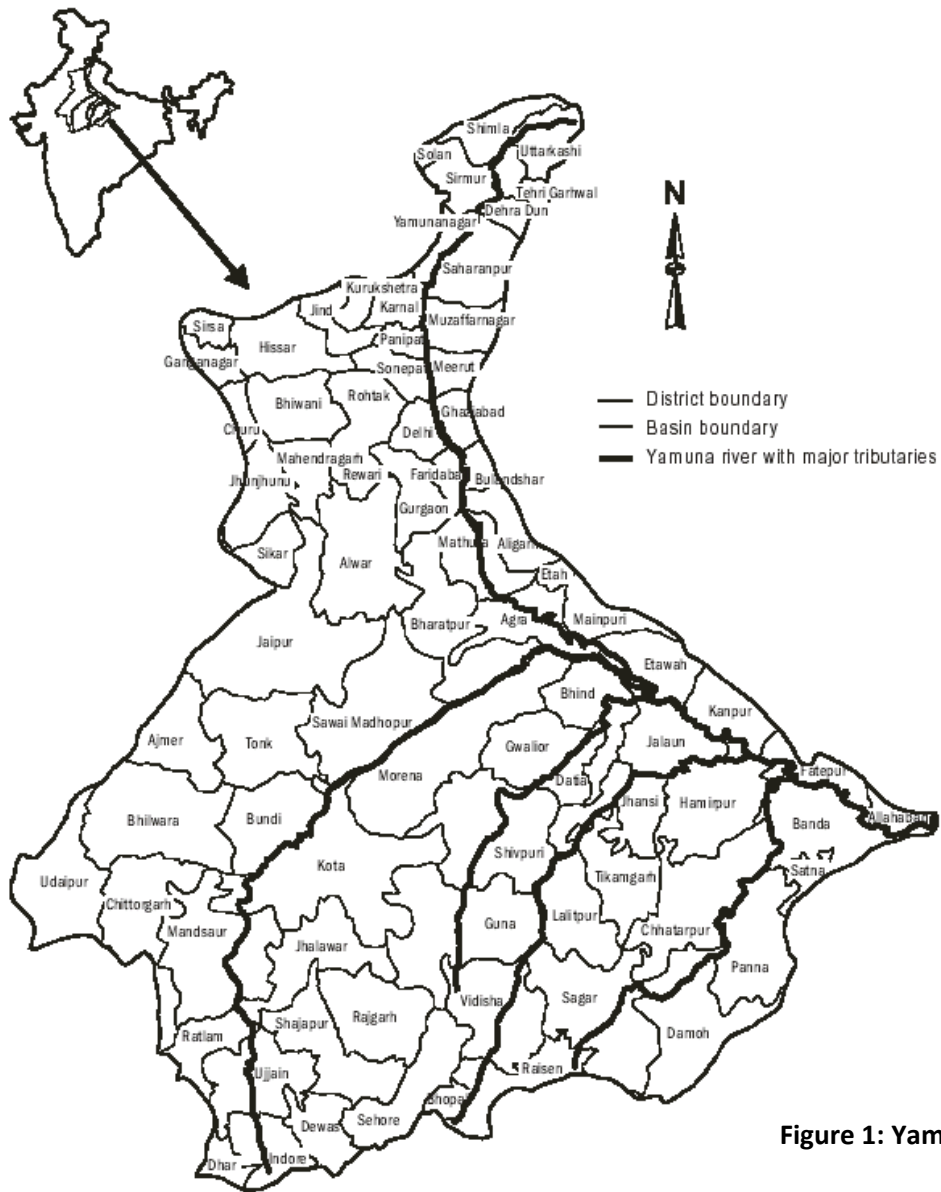


Figure 1: Yamuna River basin

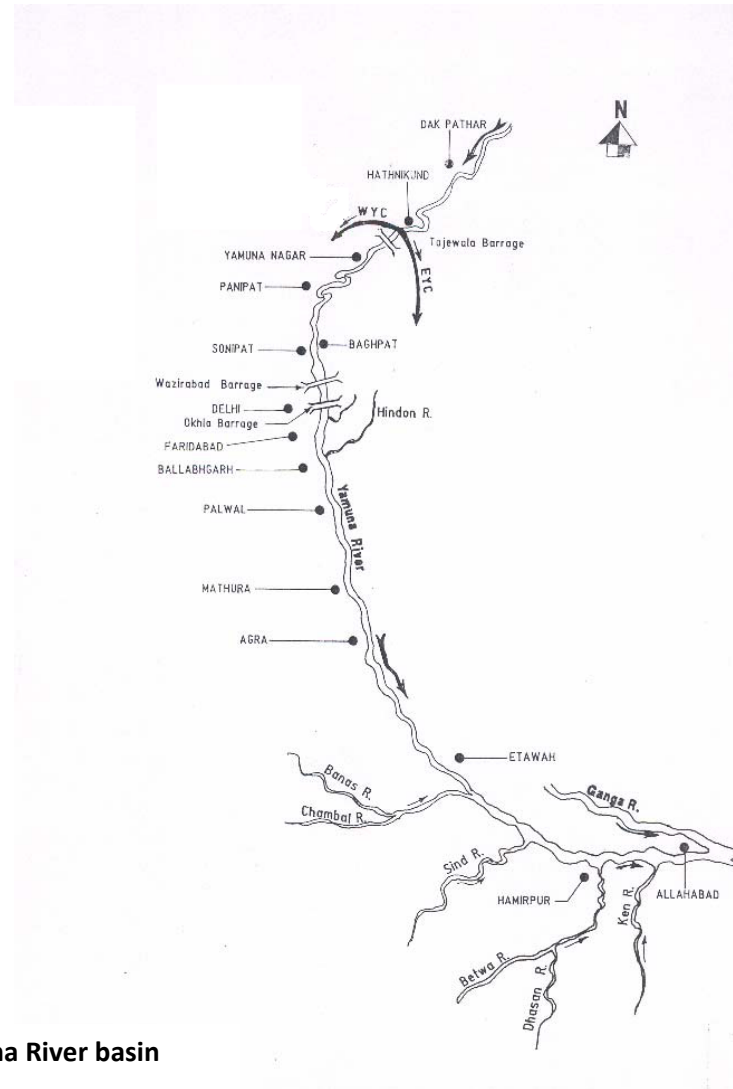


Table 2: Sub-catchments

<i>State/Territory</i>	<i>Area (in Sq. Km.)</i>	<i>Area in the major sub-basin (in Sq. km.)</i>					
		River Hindon	River Chambal	River Sind	River Betwa	River Ken	Other river Basin
U.P.	3771						3771
Uttranchal	70437	7083	452	748	14438	3336	44380
Himachal Pradesh	5799						5799
Haryana	21265						21265
Rajasthan	102883		79495				23388
Madhya Pradesh	140208		59838	25131	33502	21090	647
Delhi	1485						1485
Total	345848 (100%)	7083 (2.0%)	139785 (40.5%)	25879 (7.5%)	47940 (13.9%)	24426 (7.1%)	100735 (29.1%)

Source: CPCB, 2006

Table 3 shows the gradient of the river. In the upper stretch, upto a distance of 200 Km, it draws water from several streams. The combined stream flows through the Shivalik range of Himachal Pradesh and Uttaranchal and enters into plains at the point called as Dak Pathar, located in Uttranchal. From this point onwards, the river water is regulated through weir and diverted into canal for power generation. From Dak Pathar it flows to the Poanta Sahib (a famous Sikh religious place). On the right side of the Yamuna basin is the hill station of Mussourie. Flowing through Poanta Sahib it reaches Hathnikund/Tajewala in Yamuna Nagar district of Haryana state, where the river water is again diverted into Western Yamuna canal and Eastern Yamuna canal for irrigation. During dry season, no water is allowed to flow in the river downstream to Tajewala barrage and the river remains dry in some stretches between Tajewala & Delhi. The river regains water because of groundwater recharge and contributions of feeding canal through Som nadi (seasonal stream) upstream of Kalanaur. It enters Delhi near Palla village after traversing a distance of about 224 Km. River is again tapped at Wazirabad through a barrage for drinking water supply to Delhi. Generally, no water is allowed to flow beyond Wazirabad barrage in dry season, as the available water in itself is not sufficient to fulfill the water demand of Delhi.

Table 3: Rate of fall in Yamuna River stretches

<i>Stretch</i>	<i>Length of stretch (in km)</i>	<i>Rate of fall (m/km)</i>
----------------	----------------------------------	----------------------------

Upper Himalaya Stretch	25	59.0
Himalaya Stretch	152	19.1
Total Plain Stretch	1224	0.2
Lower Plain Stretch	768	0.08

Source: CPCB, 2006

Whatever water flows in the downstream of Wazirabad barrage is the untreated or partially treated domestic and industrial wastewater along with the water transported by Haryana Irrigation Department from Western Yamuna Canal (WYC). After 22 Km downstream of Wazirabad barrage there is another barrage named as Okhla barrage, through which Yamuna water is diverted into Agra Canal for irrigation. Again, no water is allowed to flow through barrage during dry season. Whatever water flows in the river beyond Okhla barrage is contributed through domestic and industrial wastewater generated from East Delhi, Noida and Sahibabad and joins the river through Shahdara drain. The Yamuna after receiving water through other important tributaries joins the river Ganga along with an underground River Saraswati at Prayag (Allahabad). Table 4 shows the major soil types and Table 5 provides the land-use pattern.

Table 4: Soil types in the Yamuna River basin

<i>Types of Soil</i>	<i>% of Total basin area covered</i>	<i>Locations</i>
Red Sandy	2.5	Along U.P.-MP border in districts of Jhansi, Hamirpur, Chhattarpur etc.
Red and Yellow	5.0	Parts of Jaipur, Alwar, Sawai Madhopur, Banda, Panna districts and along western boundary of basin in Rajasthan
Calcareous Seirozemic	0.5	Parts of Mohindergarh and Bhiwani districts in Haryana
Deep Black	5.5	On the southern boundary of the basin in Sehore, Bhopal, Raisen, Vidisha, Sagar & Damoh districts
Medium Black	25.5	Most of the basin in MP and strips north of river Chambal in Rajasthan
Mixed Red and Black	15.0	Chittaurgarh, Bhilwara, Banda, Mandasaur, Shivpur, Lalitpur, Tikamgarh, Panna and Chattarpur districts
Brown Hill	4.0	Hills and foot hills in the north

Alluvial	42.0	Plains and valleys
----------	------	--------------------

Source: CPCB, 2006

Table 5: State-wise land use pattern in Yamuna river catchment

<i>State</i>	<i>Area (% of total catchment)</i>	<i>Land use pattern</i>			<i>Land actually cultivated %</i>	<i>Land under habitational use %</i>
		Non-arable land %	Forest land %	Cultivable land %		
Himachal Pradesh	1.6	25.0	59.4	15.6	14.2	1.5
Haryana	6.1	18.1	2.4	79.5	59.9	3.6
NCT – Delhi	0.4	51.0	1.0	48.0	46.5	43.7
Uttaranchal	1.1	5.0	22.0	23.0	14.3	1.6
Uttar Pradesh	20.4	14.5	3.9	81.1	68.0	5.1
Rajasthan	29.8	40.8	8.8	50.4	43.9	2.2
Madhya Pradesh	40.6	26.0	18.0	56	50.7	1.8
Total	100.0	27.5	12.5	60.0	51.9	2.9

Source: CPCB, 2006

Flow

The river has extremes of dry as well as flood conditions during a year. Due to high population density of the catchment, the river remains almost in dry state during January to June in many parts of its stretch and under flooded conditions during July-September. Figure 2 shows the annual flow condition of river Yamuna. During the non-monsoon period (October to June), the river flow reduced significantly and some rivers stretches become totally dry, whereas, during monsoon period (July-September), the rivers receives significant amount of water, which is beyond its conveyance capacity resulting in flood (CPCB, 2006). The river is dissected at 5 barrages during its course i.e. at Dak Patthar (about 160 km from origin in Uttaranchal); at Hathnikund (172 km distance from origin, just at foothills in Haryana); at Wazirabad (in NCT Delhi, 396km distance from origin); at Okhla (in NCT – Delhi, 418 km distance from origin); and at Mathura (Near Gokul village in U.P. about 570 km distance from origin). These barrages are the major water abstraction locations on the river. The water is contributed into the Yamuna River, not only through its tributaries but also by the canals and drains from various urban centers. The flow in Delhi is shown in Figure 3.

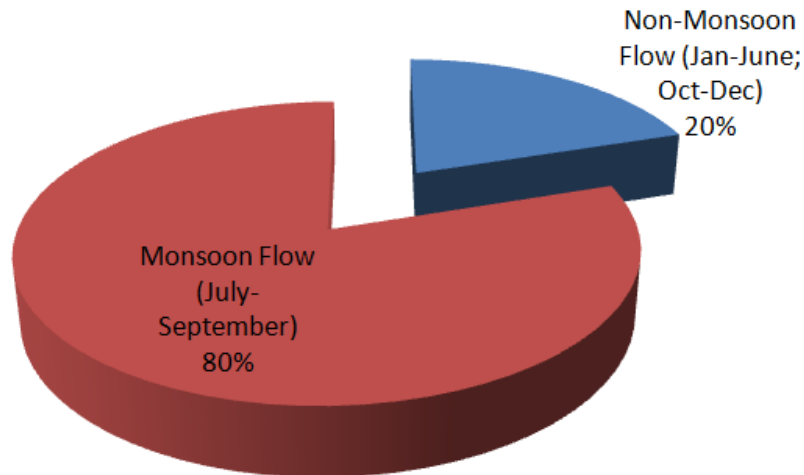


Figure 2: Water Flow Estimation in Yamuna River

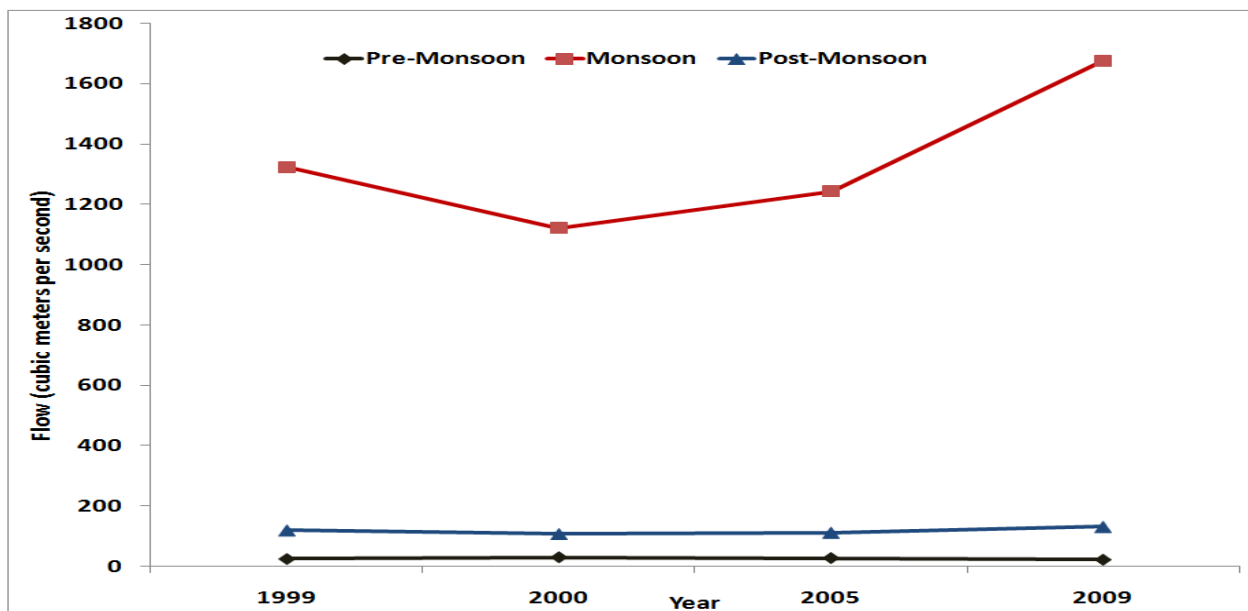


Figure 3: Annual Average flow in Delhi (Seasonally)

Uses of Yamuna River Water

The river water can be used either in abstracted form or as non-abstractive or in-situ water uses.

Abstractive Uses

The river water is abstracted at different locations for varied uses. At two places i.e. Hathnikund / Tajewala and Okhla, the water abstraction is significant. The points of abstraction and addition in water of Yamuna River are shown in Figure 4. The annual abstraction at various locations is given presented in Table 6 and percent use of abstracted water for various purposes is shown in Fig. 4. Figure 5 gives the

information on water sharing by various states.

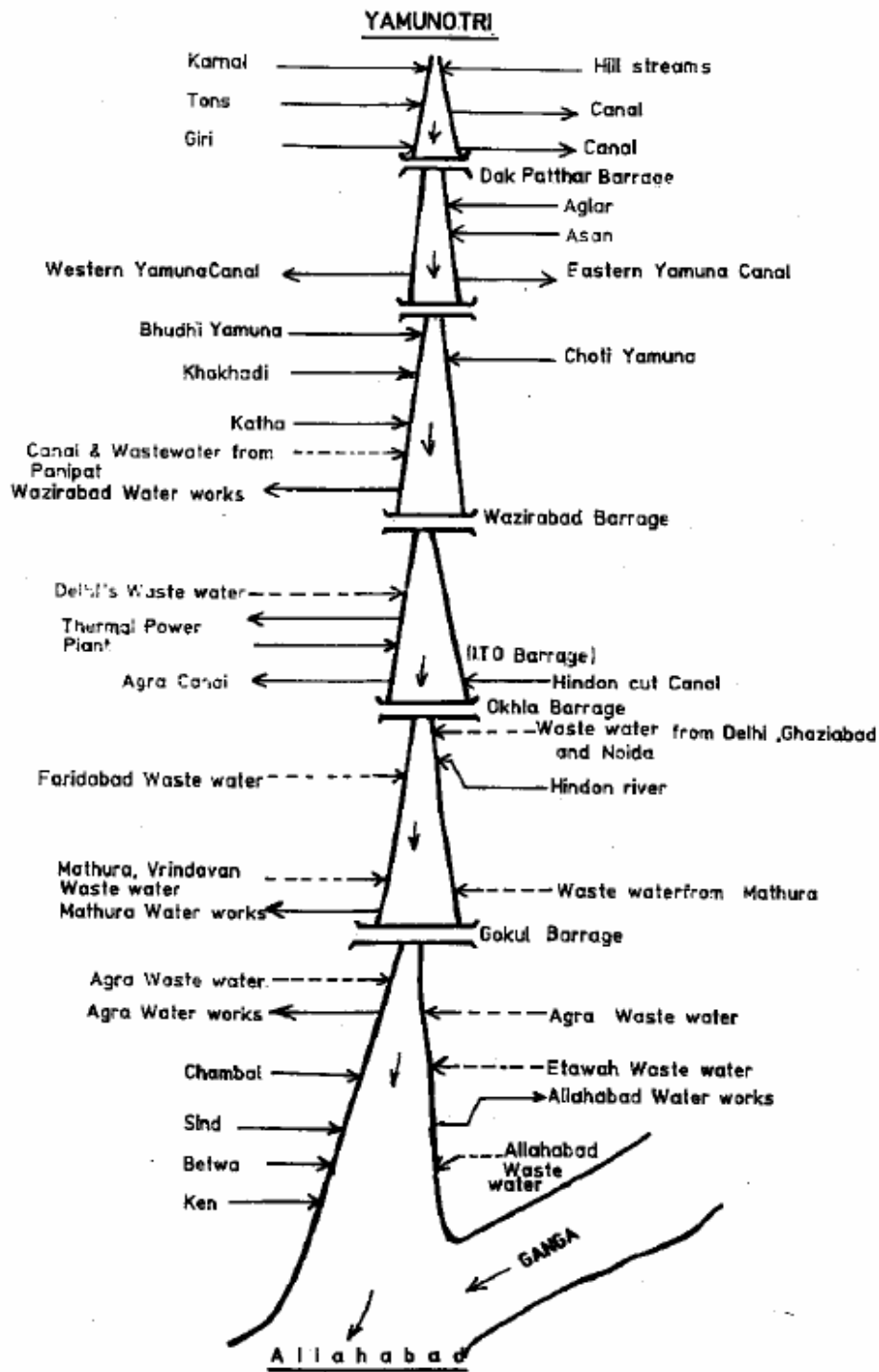


Figure 4: Points of Water Abstraction & Additions in Yamuna River (CPCB, 2006-07)

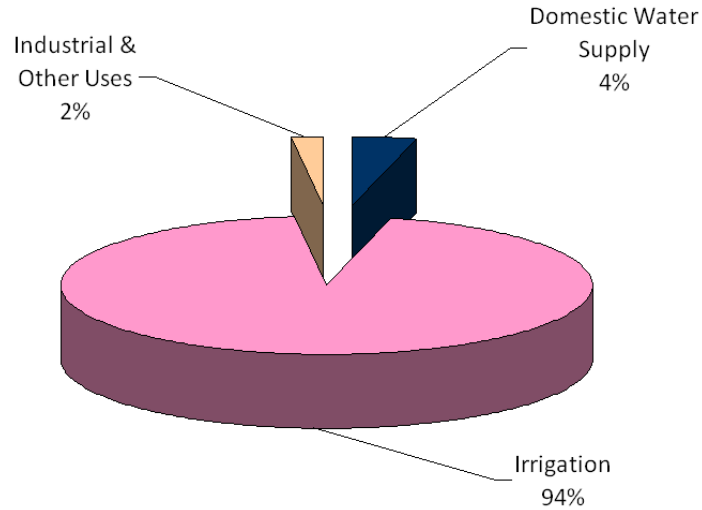
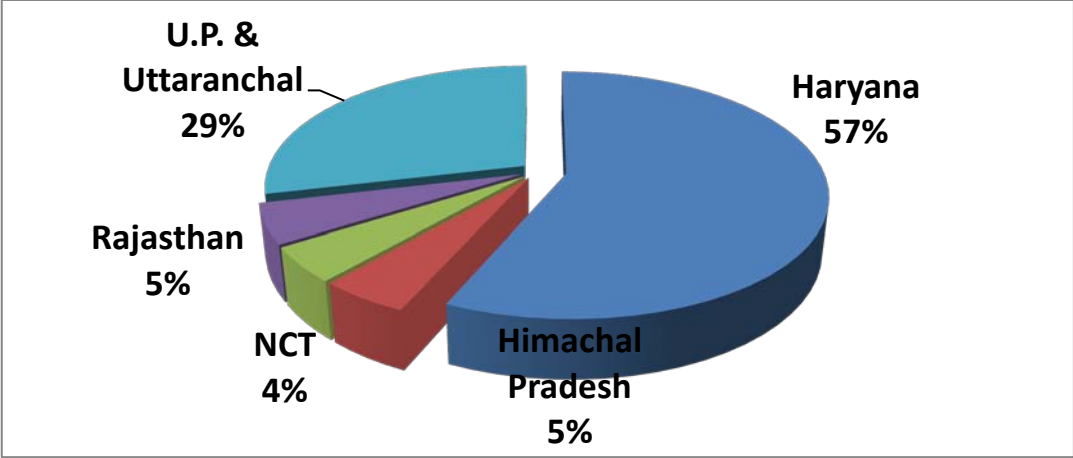


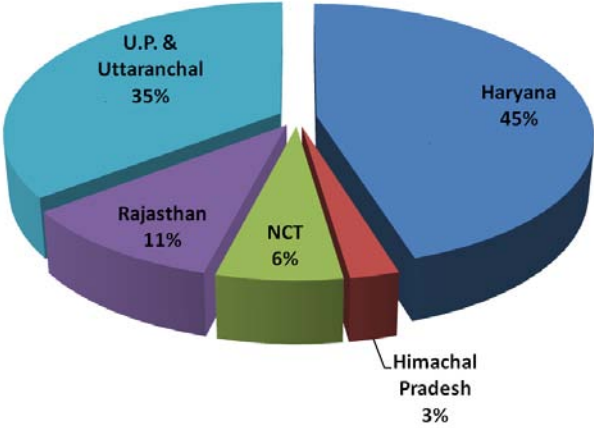
Figure 5: Percentage of water abstracted from River Yamuna for various uses (CPCB, 2006-07)

Table 6: Water Abstraction from Yamuna River (CPCB, 2006)

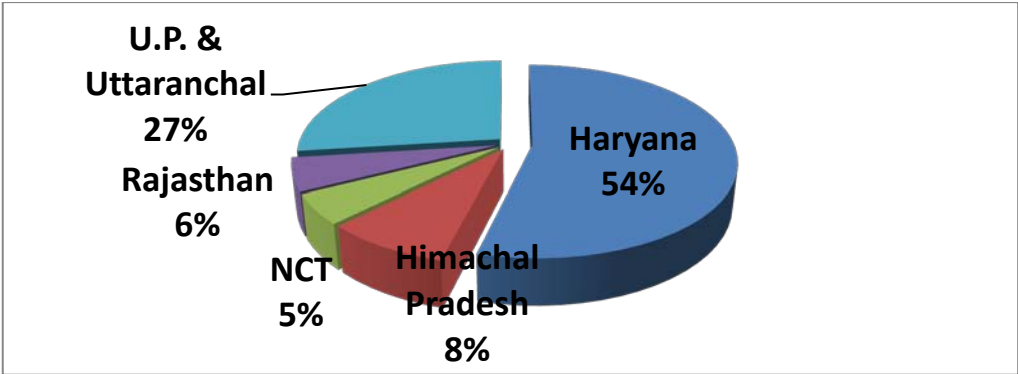
<i>Location</i>	<i>River water abstraction (MLD)</i>	<i>Abstraction use</i>
Hathnikund	20,000	Irrigation, Drinking water supply and others
Wazirabad	1,100	Drinking water supply
Wazirabad to Okhla Stretch	5,000	Irrigation and others
Okhla to Etawah Stretch	400	Irrigation, Drinking water supply and others
Etawah to Allahabad Stretch	475	Irrigation, Drinking water supply and others



Pre-Monsoon period (March - June)



Monsoon period (July to October)



Post-Monsoon period (November - February)

Figure 6: Sharing of Yamuna River Water among various States (CPCB, 2006-07)

Domestic Water Supplies

Significant use of Yamuna water for domestic water supply is found in urban agglomerations like Delhi, Mathura, Agra and Allahabad.

Irrigation

Irrigation is an important use of Yamuna river water. It has been estimated that about 92% of Yamuna river water is used for irrigation. In the entire Yamuna basin the irrigated land is about 12.3 million hectares and approximately half of it (about 49%) is irrigated exclusively from surface water. At present there are four irrigation canals transporting the Yamuna river water to the command areas (Table 7).

Table 7: Canals in Yamuna River basin

Canal	Origin	Capacity	Area (hectares)	State
Western Yamuna Canal (WJC)	right bank of Yamuna River at Hathnikund / Tajewala barrage	163 m ³ /sec	486,000	Haryana
Eastern Yamuna Canal (EJC)	left bank of the River Yamuna at Hathnikund / Tajewala barrage	85 m ³ /sec	191,000	Uttar Pradesh
Agra Canal	right bank of Yamuna River at Okhla barrage	63.5 m ³ /sec	138,000	two districts of Mathura and Agra in Uttar Pradesh
Gurgaon Canal	takes off from Agra canal at a distance of around 8 km from its off take at Okhla barrage	14.15 m ³ /sec	40,000	interstate project between Rajasthan & Haryana and

Source: CPCB, 2006

In stream uses

Hydropower

The total potential for hydropower development in the entire Yamuna basin is about 1300 MW. The present utilization is only one third of total potential.

Fisheries

The Pisciculture is neither practiced on large scale nor undertaken in organized manner in the area. However, the entire river stretch and tributaries is being utilized for fishing in unorganized manner.

Growing aquatic plants

The most prevalent aquatic plant in River Yamuna is the water hyacinth, mostly found near barrages.

Navigation

River Yamuna and its tributaries are not suitable for Navigation. Low flow of river further restricts this activity. However, some potential exists to use the stretch between Agra and Allahabad for navigation.

River bathing and washing

River bathing and washing is one of the most prevalent uses of river water in the country. Much of this is attributable due to religious rituals.

Recreational uses

The Yamuna River is used very rarely for recreational purpose due to unsuitable conditions like rocky river bed, low water depth etc. However, at urban centers and at various barrages it has the potential for water sports like boating.

Cattle bathing and washing

It is estimated that about 70% of the total cattle population in the Yamuna basin uses flowing water of river and canals for bathing and watering purposes directly which impacts water quality substantially (CPCB, 2006-07).

Pollution sources of River Yamuna

In India, Central Pollution Control Board (CPCB), Central Water Commission (CWC), Delhi Pollution Control Committee (DPCC), State Pollution Control Board (SPCB) regularly monitors River Yamuna at 19 locations along with its main tributary, the Chambal River at Udi. In addition, twenty eight major drain outfalls into Yamuna are also being monitored. The organic pollution level increase significantly at Delhi and the biochemical oxygen demand (BOD) level do not conform to the stipulated standard for Class C category till the confluence of river Chambal. The same stretch of the river shows fluctuations in dissolved oxygen (DO) level from Nil to well above saturation level. This reflects the presence of organic pollution load and prevalence of eutrophic conditions. Bacteriological contamination is significantly high in the entire Yamuna River stretch. The annual average values for DO and BOD of March-June months are given in figure 7 and 8. Figure 9 and 10 shows the annual average of TKN and Total Coliform (TC) in the river Yamuna.

Amongst the heavy metals, Cadmium, Nickel and Lead are scanty present in the river, whereas, zinc and iron are generally present. Among pesticides, BHC is present in some stretch, whereas other monitored pesticides e.g. Aldrin, Dieldrin, endosulfan, and DDT are rare. The micro-pollutants are generally

observed during dry seasons and over the years they have declining trends. Based on the water quality, the entire Yamuna river stretches has been demarcated into five stretches i.e. Himalayan stretch, upper stretch, Delhi stretch, mixed stretch and diluted stretch (table 8).

Table 8: Distinguished segments of River Yamuna

<i>Section</i>	<i>Origin-End</i>	<i>Length (km)</i>
Himalayan Segment	From origin to Tajewala Barrage	172
Upper Segment	Tajewala Barrage to Wazirabad Barrage	224
Delhi Segment	Wazirabad Barrage to Okhla Barrage	22
Eutrophicated Segment	Okhla Barrage to Chambal Confluence	490
Diluted Segment	Chambal Confluence to Ganga Confluence	468

Source: CPCB, 2006

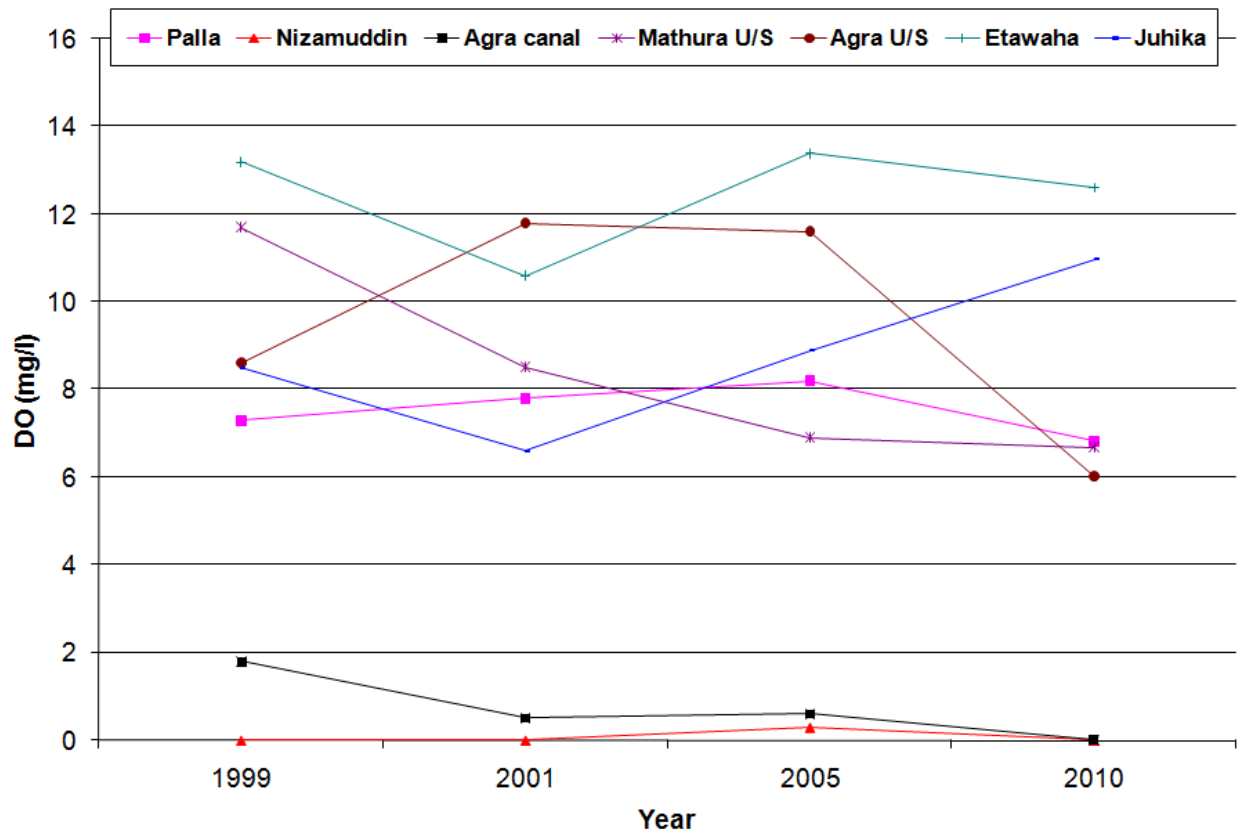


Figure 7: Longitudinal profile of DO in Yamuna River (CPCB, 2006-; moef.nic.in/modules/recent-initiatives/NGRBA/aa.pdf)

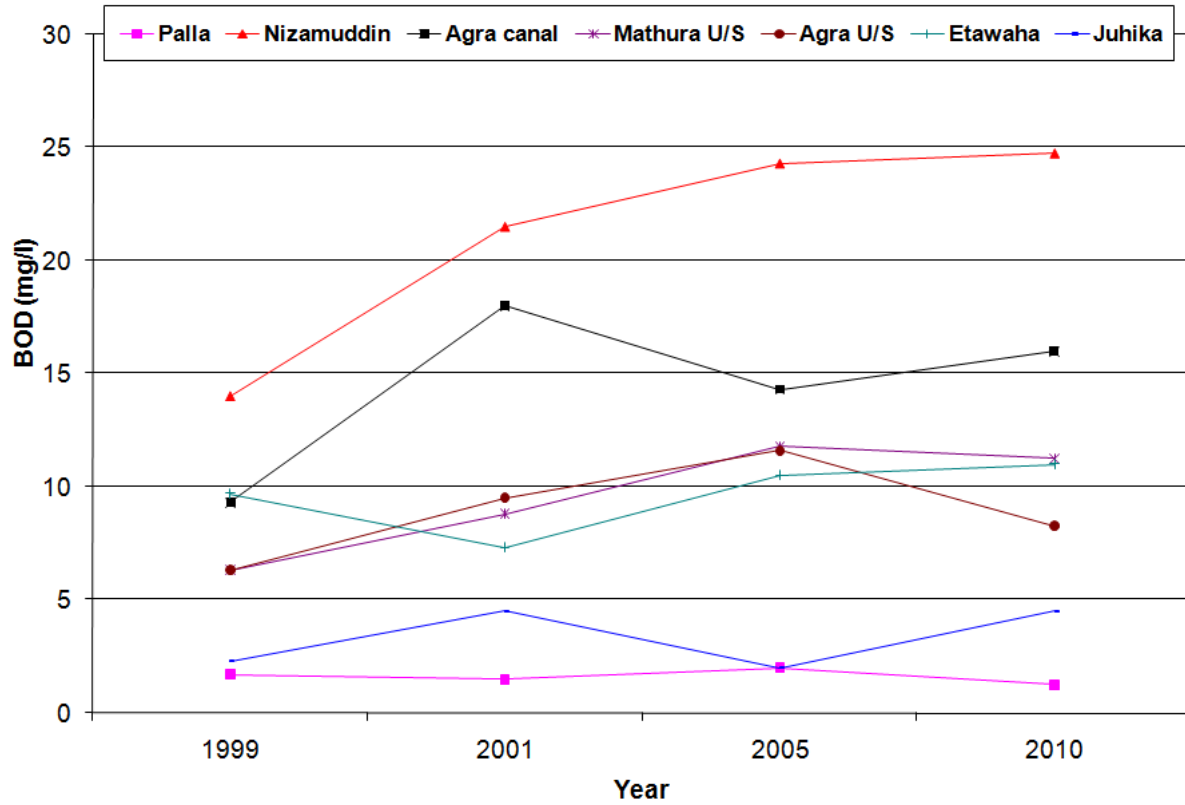


Figure 8: Longitudinal profile of BOD in Yamuna River (CPCB, 2006; moef.nic.in/modules/recent-initiatives/NGRBA/aa.pdf)

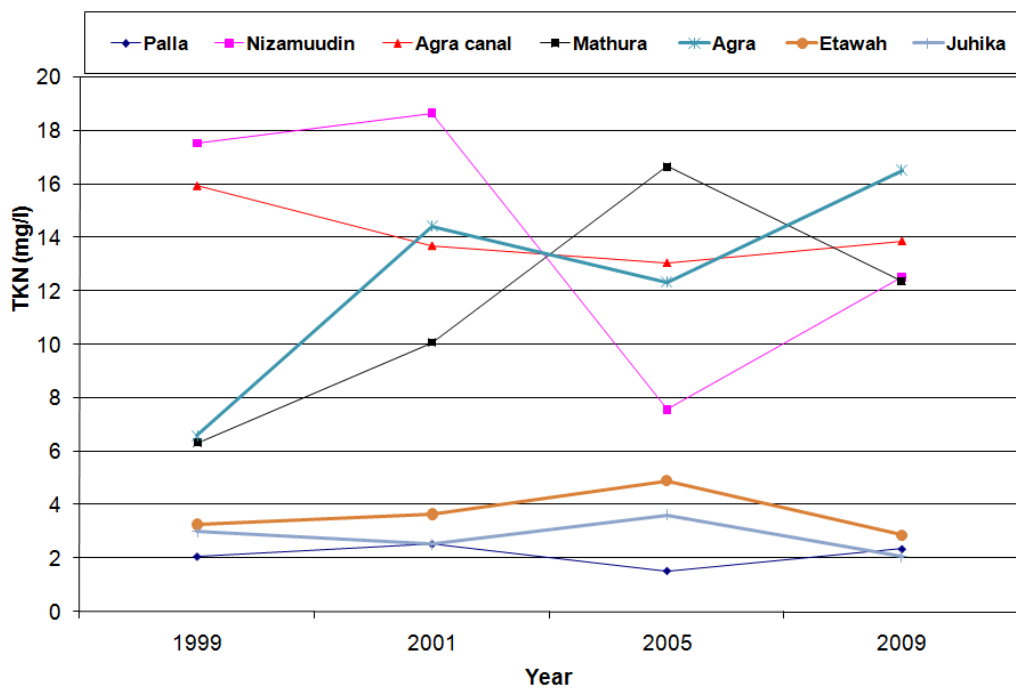


Figure 9: Longitudinal profile of TKN in Yamuna River (CPCB, 2006; Personal Communication)

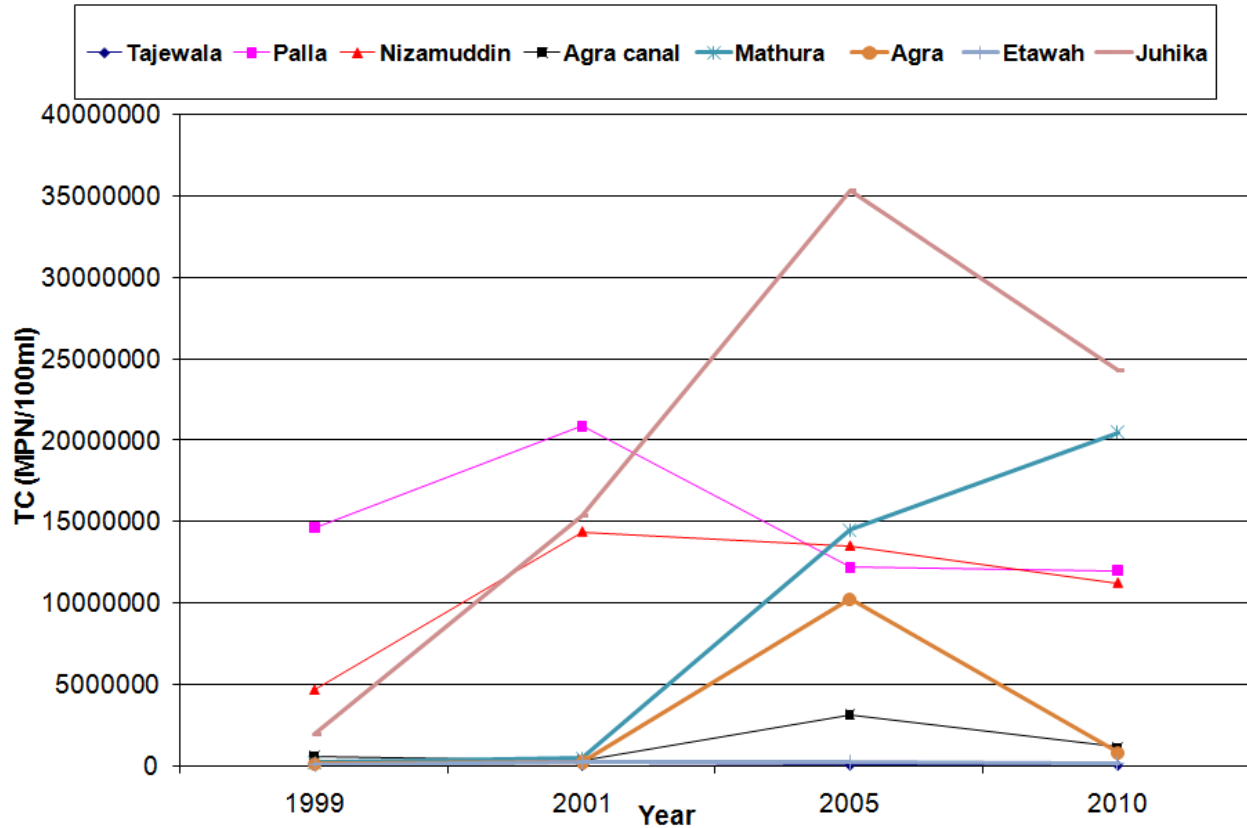


Figure 10: Longitudinal profile of TC in Yamuna River (CPCB, 2006; Personal Communication)

National Capital Territory

It is a mega-metropolis situated on the banks of the river Yamuna. Spread over an area of 1,483 sq km, it is divided into nine districts having a population of approximately 17.6 million. Approximately, 93 per cent of the population is urban. Figure11 illustrates the settlement pattern of NCT (Delhi Urban Environment and Infrastructure Improvement Project (DUEIIP), 2001).

Sources of water for NCT, India

The main sources of raw water in Delhi are river Yamuna (surface water and Western Yamuna Canal WYC), the Ganga (Upper Ganga Canal), Bhakara-Beas storage, groundwater through tube wells and ranney wells (specially designed high-capacity wells named after founder Leo Ranney). The estimated water availability of NCT of Delhi from surface water sources, viz. the Yamuna, the Ganga and the WYC is about 1150.2 million cubic metres (mcm). The river Yamuna contributes 724 mcm which is a substantial part of the total water requirement. It enters at Palla, traverses through NCT and leaves at Jaitpur in the South. The total area of river zone is about 9700 Ha, out of which approximately 1600 Ha of land is irrigated and 8100 Ha is dry land which contributes as runoff pollution into the river (Jain, 2009).

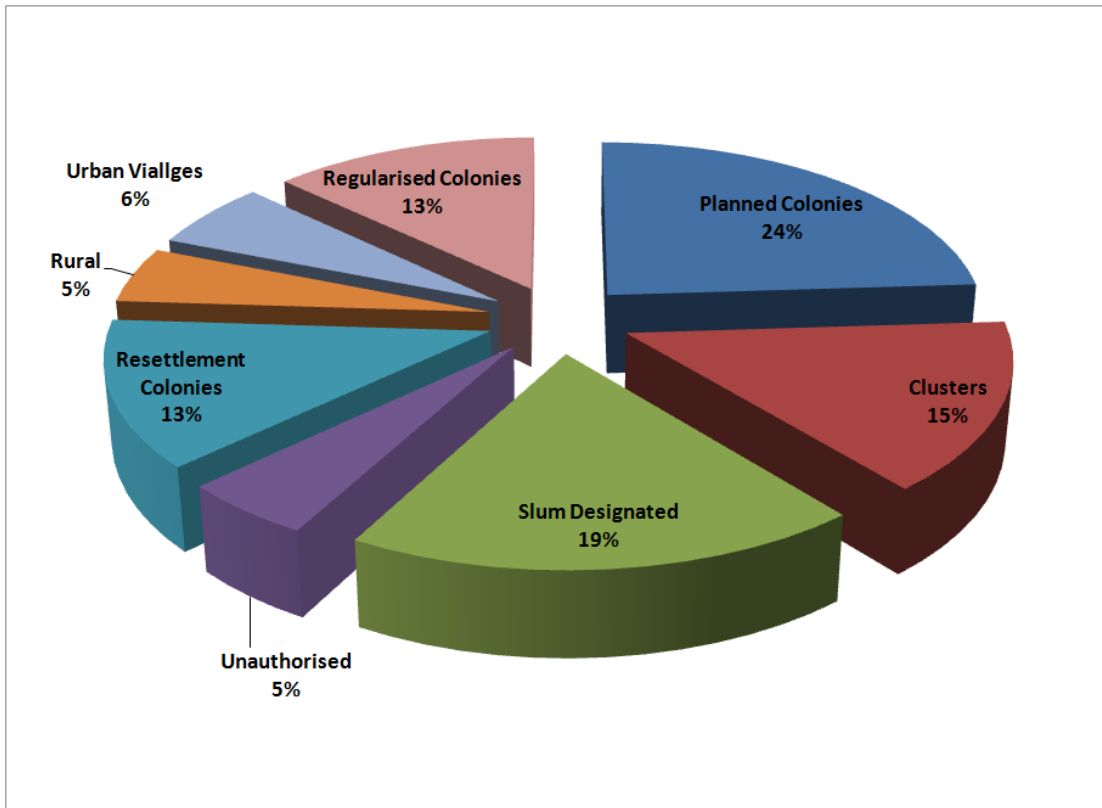


Figure 11: Types of settlements, Delhi

Pollution of River Yamuna, NCT

Although the river is polluted almost throughout its journey in plains but maximum of pollution occurs during its journey through NCT. The main sources of pollution in NCT are:

- Rising density of human population on the river banks and poor sanitation practices by residents;
- untreated domestic wastewater;
- untreated industrial effluents;
- diffuse pollution (agricultural runoffs; dead body dumping and cattle washing)
- undetected and untreated pesticide residues leave a toxic mark all across the river
- religious activity and immersion of idols.

Monitoring data shows that pollution measured in terms of BOD load has increased 2.5 times from 1980-2005. BOD load, which was 117 tonnes per day (tpd) in 1980 increased to 276 tpd in 2005. The river has no fresh water flow for virtually nine months. Delhi impounds water at the barrage constructed at Wazirabad. Water that flows subsequently is only sewage and waste (Table 9).The anaerobic

condition in the river is frequently observed and as evident from the presence of masses of rising sludge from the bottom, gas bubbles and floating solids on the surface (CPCB, 2000).

As on March 2007, the sewage treatment capacity of STPs in Delhi is 512.4 MGD (2321 MLD) with only 50% of treatment. Rest of the untreated sewage falls into the river Yamuna and is the major cause of river pollution (Delhi Economic Survey, 2008). Statements by Sarkar et al (2007) and MoS Jairam Ramesh's in the Lok Sabha (as on 08.07.2009), confirmed that together in NCT 17 sewage treatment plants have a treatment capacity of around 2,330 MLD. However, due to silting and settlement of trunk sewers, treatment capacity of only 1,570 MLD is in use at present (Jain, 2009). The BOD and coliform profile for 2002-2008 in NCT has been shown in figure 12 and 13.

Table 9: Water quality of River Yamuna at Nizamuddin, Delhi, India

1988			1996			2009		
DO	BOD	Total coliforms	DO	BOD	Total coliforms	DO	BOD	Total coliforms
1.9	18	1600000	0.30	25.00	147818	0.0	23.00	22516660

Source: CPCB (2006) and personal communication

Water quality trend indicated increase in the number of coliform bacteria, TKN, ammonia concentration upstream of Delhi. After Delhi, the organic pollution and microbial contamination reflect increasing trend upto Allahabad.

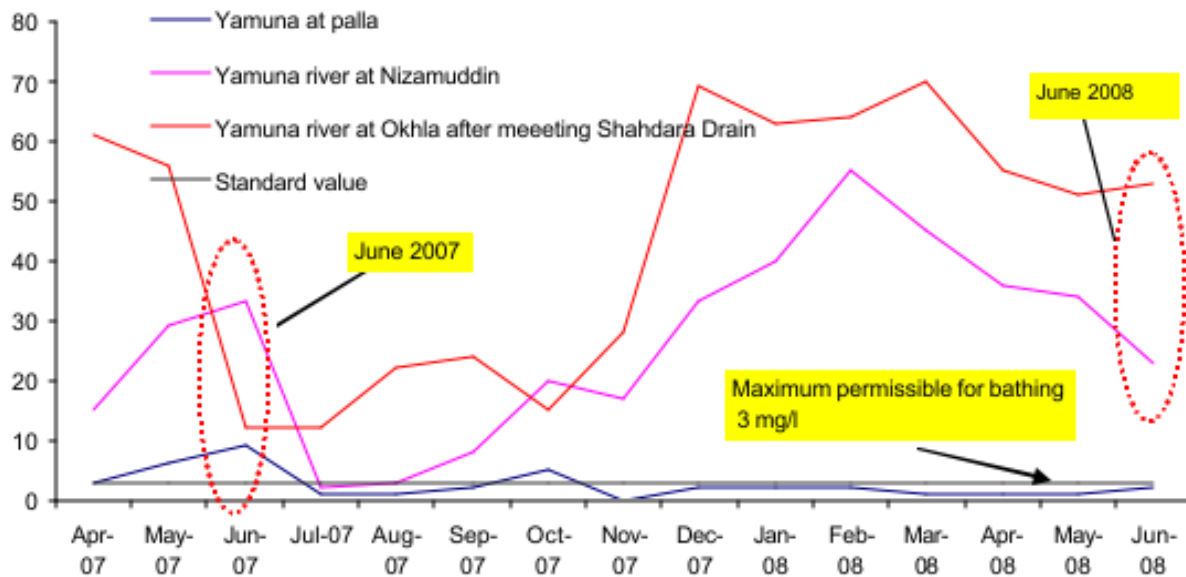


Figure 12: BOD in the river during 2007-2008

(Source: Compiled from the water quality monitoring reports of CPCB during 2002-2008; CSE, May 2009)

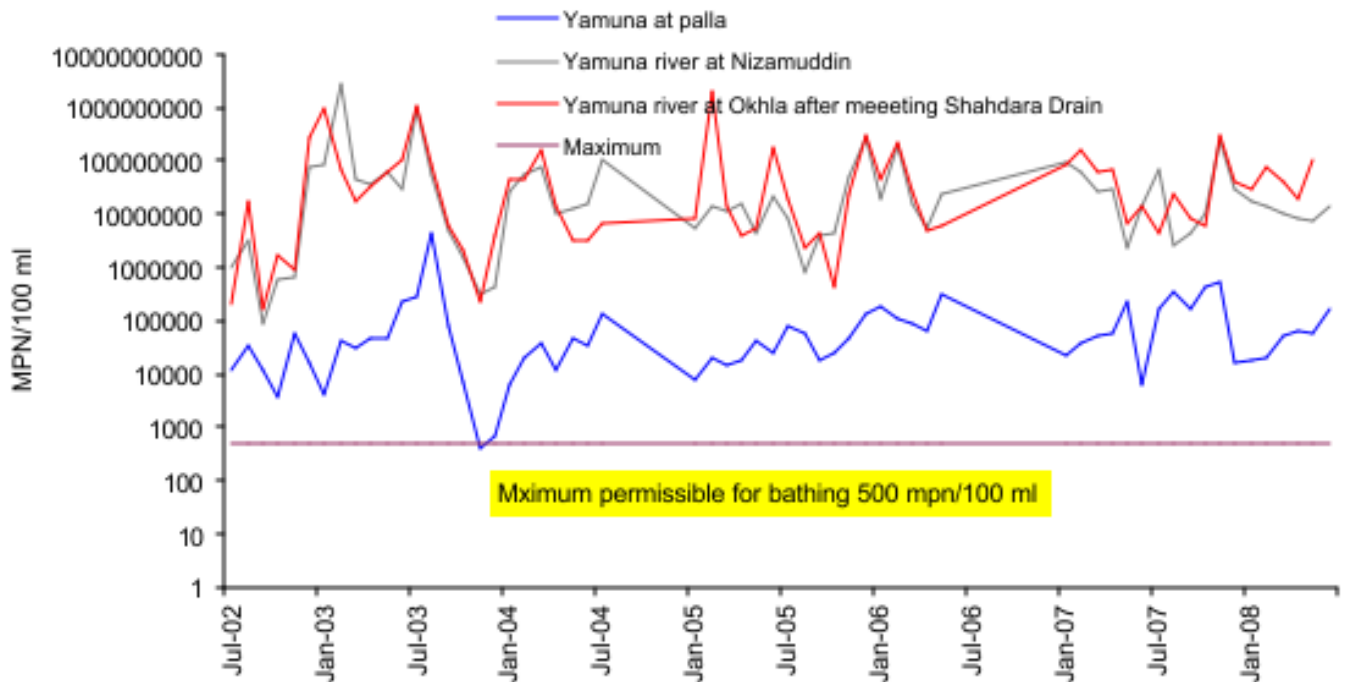


Figure 13: Coliform levels in the Yamuna 2002-2008

(Source: Compiled from the water quality monitoring reports of CPCB during 2002-2008; CSE, 2009)

References:

CPCB, 1980–81. The Ganga River—Part I—The Yamuna basin, ADSORBS/2, Central Pollution Control Board, Delhi, India.

CPCB, 1982–83. Assimilation capacity of point pollution load, CUPS/12, Central Pollution Control Board, Delhi, India.

CPCB, 2000. Status of water quality of river Yamuna and drains adjoining river Yamuna in Delhi. Information submitted to the Hon’ble Supreme Court,

CPCB, 2006, Water Quality Status Of Yamuna River (1999 – 2005), Central Pollution Control Board, Ministry Of Environment & Forests, Assessment and Development of River Basin Series: ADSORBS/41/2006-07

CSE, 2009. State of Pollution in Yamuna, Centre for science and environment, Delhi, India

Delhi Urban Environment and Infrastructure Improvement Project (DUEIIP), 2001, Govt. of India, Ministry of Environment and Forests and Govt. of National Capital Territory of Delhi, Planning Dept.

Economic Survey of Delhi, 2008. Delhi Economic Survey, Govt. of India.

MoEF, Water Quality Data for River Yamuna (Summer Averages : March-June); <moef.nic.in/modules/recent-initiatives/NGRBA/aa.pdf>, Accessed on 12th November 2010

Jain P., 2009. Sick Yamuna, Sick Delhi- Searching a correlation. Peace Institute Charitable Trust