JAPANESE ASSISTANCE FOR RIVER POLLUTION CONTROL - A CASE STUDY OF YAMUNA ACTION PLAN, INDIA

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ABSTRACT

In view of the rapid growth of urban population, industrialization and inadequate infrastructure, the river water quality across the country has been found to be deteriorating alarmingly. Recognizing the gravity of the problem, Government of India launched a massive plan for river conservation across the country. Ganges, being one of the most sacred and largest rivers in the country, was identified for priority intervention in 1985. In the subsequent stage river Yamuna was selected which is one of the major tributaries of Ganges and passes through some of the major urban centres including the national capital of Delhi. Combined effect of modified flow regime due to water holding structures and the cumulative discharge of domestic, industrial and agricultural wastewaters has converted Yamuna into almost an open sewer and very often fish kills are observed in the Delhi stretch and downstream upto Etawah. Yamuna Action Plan (YAP) was formulated to mitigate the level of water pollution from major urban centres. The Plan was implemented during 1993 – 2003, wherein sewage treatment plants for 14 Class-I cities were constructed with emphasis on energy efficient treatment processes viz. UASB and oxidation pond. A number of pilot projects on innovative technologies for decentralised sewage treatment and Coliform removal were implemented. One such pilot - a down hanging sponge biofilter that was provided as a polishing unit to a UASB plant has given very encouraging results. In all, a total investment of USD 141 million was made with the assistance of the Japanese Government and a total STP capacity of 3.5 million population equivalents was created. In addition, the plan also laid emphasis on creating low cost sanitation facilities for low-income communities, community awareness on sanitation, improved crematoria, development of river fronts, etc.

The plan has met with reasonable level of success, however, a number of constraining issues have emerged. Shorter design horizon and focus on 'end of the pipe' solutions has led to under-utilisation of the STP capacity. There is a need to augment the capacity of the upstream delivery infrastructure as well as widen the geographical and demographical coverage. Delhi, the all-important contributor of organic load requires special focus and renewed efforts need to be channelised to improve the river water quality in that stretch. Lastly, YAP did not address the issues of sustainability of treatment plants and capacity building of local bodies who would eventually be responsible for operation and maintenance of the sewage treatment plants. In view of the scale of the problem and to capitalise on the infrastructural assets already created under the original programme, there is a strong felt need for continuation of the efforts through formulation of second phase of YAP.

YAMUNA BASIN

In Hindu mythology, river Yamuna is considered as one of the most sacred rivers after Ganges. Lord Krishna is believed to have spent his childhood and early adolescent years on the banks of this holy river almost 5000 years back. Several mythologically profound stories and folklores are woven around this river and historical descriptions can be found in scriptures. Thus it is not just another river but it has a major religious and cultural significance.

River Yamuna originates from a glacier in the Himalayas. It is one of the major tributaries of the river Ganges. Total length of Yamuna up to its point of confluence with Ganges is around 1370 km. Its catchment area is spread over 366,220 sq.km. and it falls in six different states of Himachal Pradesh, UP, Haryana, Delhi, Rajasthan and Madhya Pradesh. However, the riparian states are Himachal Pradesh, Haryana, Delhi and UP. Vastness of the catchment can be gauged from the fact that it is almost 10% of the total landmass of the country.

Yamuna has four main tributaries in the Himalayan region viz. Rishi Ganga, Hanuman Ganga, Tons, and Giri. In the plains, the main tributaries are Hindon, Chambal, Sind, Betwa and Ken. The Yamuna basin is shown in Exhibit 1 of this paper.

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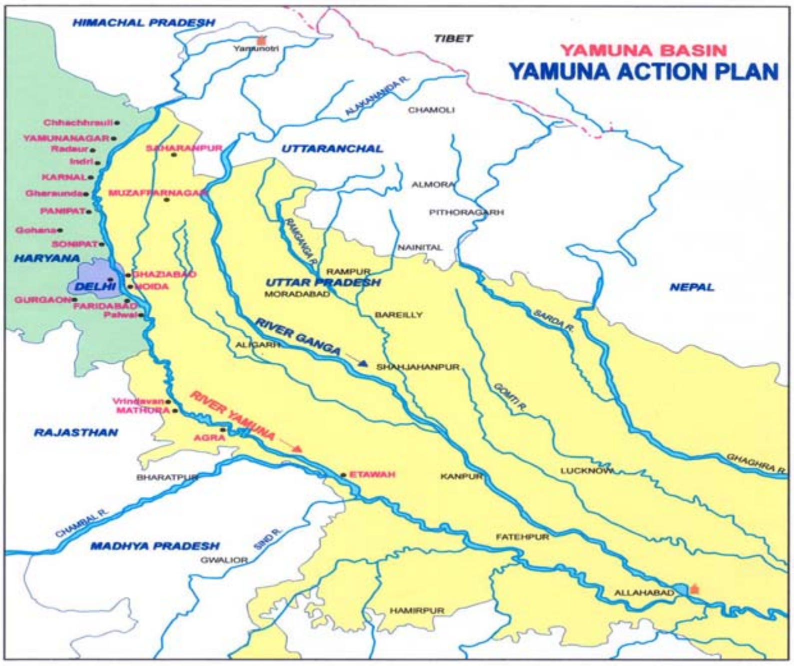
EXHIBIT 1

YAMUNA BASIN COVERING NORTHERN PART OF INDIA



Stages of the river

Exhibit 2 shows the major barrages across the river and other elements of the system constructed from water abstraction point of view. The network of canals is very intriguing and interesting in respect of inter-basin transfer of water from Ganges and Sutlej rivers to Yamuna. As a result of construction of barrages at Tajewala, Wazirabad and Okhla, the hydraulic regime along the river has been modified to a great extent. Based on this aspect and the consequent ecological characteristics, the river can be divided into five distinct stages, which are summarised in Exhibit 3.

A brief description of the indicative flow regime of the river is included here to place the subsequent water quality issues in the right context. To start with, the variation of flow along the course of the river is presented in Exhibit 4. The flow downstream of Tajewala barrage is around 5 m^3/s. Subsequently 'Munak escape' (a branch canal) joins Yamuna in the mid reach of stage II and transfers water from upstream of Tajewala barrage as well as from Sutlej river basin.

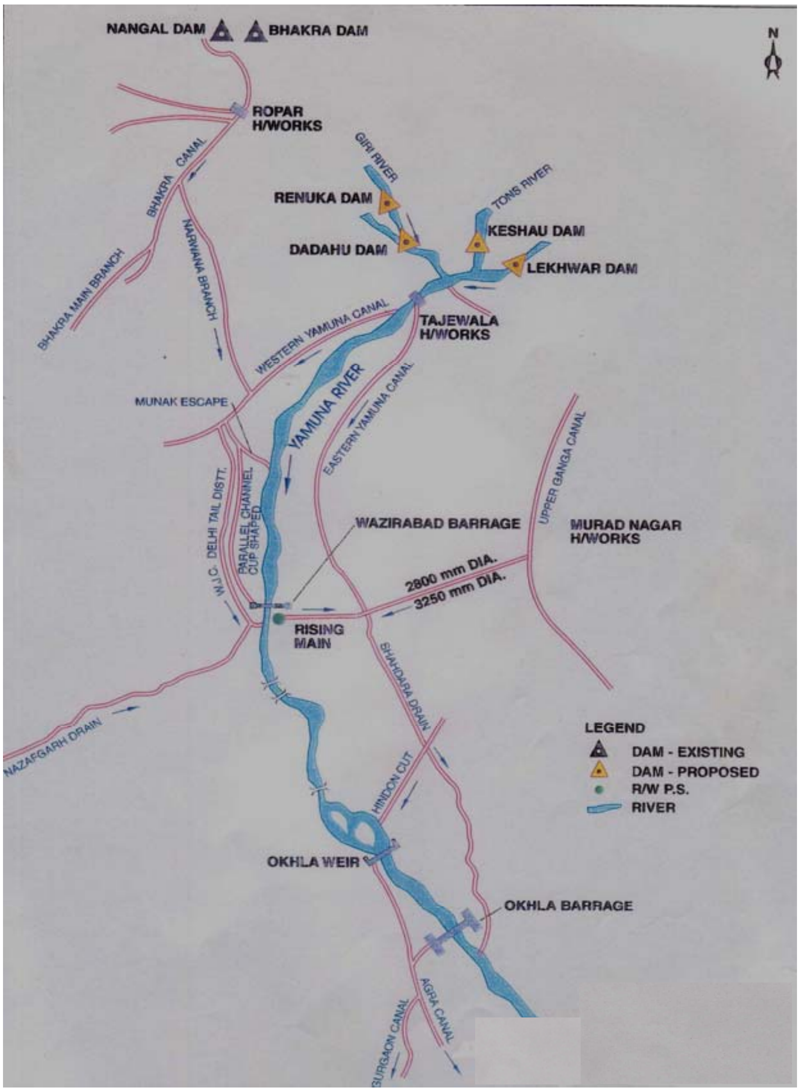
In Delhi stretch of the river, no fresh water is released from the upstream barrage at Wazirabad. However, the stretch receives almost 2450 million litres per day (mld) (28.4 m^3/s) of partially treated and untreated wastewaters from domestic, industrial and dairy farming sectors. This stretch also receives around 450 mld (5.2 m^3/s) of fresh water from Western Yamuna Canal and 2246 mld (26 m^3/s) from Hindun Cut (a canal bringing water from Ganges). The peak observed in Exhibit 4 between 240-260 km chainage is essentially due to this factor.

Flow in the subsequent stretch (IV) is again affected since there is no release from Okhla barrage. DWF varies between 3 to 9 m^3/s which essentially comprises sewage discharges from eastern parts of Delhi, Ghaziabad, Noida, Faridabad, Mathura, Agra etc. Stretch V, the last stretch is characterised by availability of large quantity of dilution waters from the four tributaries, Chambal being the largest of them. Almost 7776 mld (90 m^3/s) of water is brought in by these rivers which serve the southern part of Yamuna basin.

The modified flow regime on the down stream of various barrages has a tremendous impact on the water quality and river ecology. The evolved mechanism for sharing of water resources among the riparian states has put the water quality in stretches III and IV in critical conditions. This aspect is discussed in a subsequent section.

EXHIBIT 2

MAJOR HYDRAULIC STRUCTURES ACROSS RIVER YAMUNA



(Source ECFA, Japan. 2000)

Land-use pattern, demography and economic activity

Utilisation of Yamuna water is dependent on land-use and demographic pattern and the associated economic activity in the basin. These aspects are briefly covered in this section, which puts the subsequent sections on water allocation and water quality in right perspective.

The entire land-use pattern in the Yamuna basin is classified into three categories viz., (i) non-arable, (ii) forests, and (iii) cultivable. According to one conservative estimate 28 percent of the total land in the basin is currently classified as non-arable and is devoid of vegetation. Forests occupy only 12 percent of the area and 60 percent area is classified as cultivable.

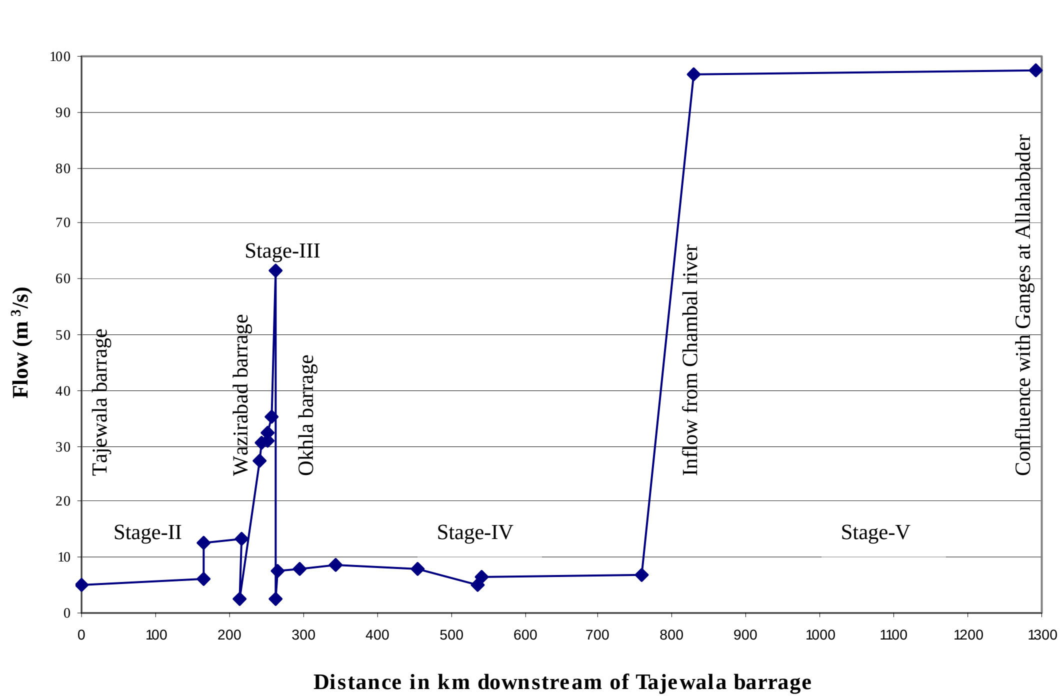
Agriculture sector is quite extensively developed in the Yamuna basin and it is characterised by high application of chemical fertilizers and insecticides. Out of 16.78 million hectares of cultivated land in the basin, about 23 % of the total cropped area has irrigation facilities. Yamuna river plays an important role in meeting the demand for irrigation.

EXHIBIT 3

STRETCHES OF YAMUNA – AN OUTCOME OF WATER RESOURCES MANAGEMENT

SL. NO.	Stretch	Stage	Length Km.	Remarks
I	From origin to Tajewala	Himal-ayan	172	Turbulent stream. Almost pristine water quality. Barrage at Tajewala blocks entire dry weather flow (DWF). Canals on both banks withdraw water for various uses.
II	Tajewala to Wazirabad (upstream of Delhi)	Upper	224	DWF comprises of wastewater from urban and rural settlements in the catchment. Barrage at Wazirabad stores water for meeting the demand of Delhi.
III	Wazirabad to Okhla (Delhi)	Critically polluted	22	No water is released from Wazirabad barrage. The DWF comprises of wastewater originating in Delhi. Barrage at Okhla diverts water to states of Haryana and UP for irrigation.
IV	Okhla to confluence with Chambal	Eutro-phied	490	No water is released from Okhla barrage. DWF comprises wastewater from urban settlements
V	Chambal to confluence with Ganges	Diluted	460	The river gets a fresh lease of life after dilution from Chambal waters. Other tributaries coming from Rajasthan and Madhya Pradesh join in this stretch as well.

EXHIBIT 4 : INDICATIVE FLOW PATTERN ALONG YAMUNA



(Source : Tokyo Engineering Consultants, 2002)

The rural areas in the north are well known for their agricultural and live stock activities. The state of Haryana in particular is know to have highest per capita income in the country due to the success of the green revolution. It is also known as the breeding centre of high yielding buffalos, and caters to the entire cattle market of the country.

The area in the vicinity of the national capital region is a hub of thriving economic activity. Major industrial centres are Yamunangar, Karnal, Panipat, Sonipat, Delhi, Gaziabad, Faridabad and Agra. Further down, along the course of the river, agriculture sector becomes predominant.

However, the river basin extends all the way up to Jaipur and Udaipur (Rajasthan) in the west and Ratlam and Indore (Madhya Pradesh) in the south, which are again industrially well-developed centres. There has also been high level of migration from rural to urban areas. The 1991 population of the entire basin was estimated to be well over 100 million (SAPROF, 1992). Tributaries of Yamuna bring water and wastewater from these far off places and join in the last stretch.

A closer look on urban habitations along the river shows that there are 15 major urban centres which are classified as Class-I towns (1991 population more than 100,000) and an additional 18 medium or small size towns with current total population of 0.8 million in Haryana. These 33 urban centres have placed high demand on the aquatic ecosystem of river Yamuna.

Allocation of water

Yamuna waters are shared by the four riparian states and two basin states under an agreement signed in 1993. Based on the available flow, a sharing mechanism has been evolved. The three main barrages mentioned earlier have been constructed to give effect to this sharing arrangement.

The barrage at Tajewala enables diversion of almost 98% of river water to Haryana and UP states for irrigation and other uses (SAPROF, 1992). The remaining 2%, i.e., about 432 mld (5 m^3/s) of flow is released for maintaining minimum flow in Stage II. The barrage at Wazirabad (upstream of Delhi) enables withdrawal of 950 mld (11 m^3/s) of water for domestic and industrial water requirements of the National Capital Territory of Delhi. However, a major part of the city also relies on ground water sources.

At the downstream end of Delhi stretch, the Okhla barrage enables large storage, wherefrom almost the entire flow i.e., 5080 mld (59 m^3/s) of diluted wastewater is diverted into Agra canal for meeting the irrigation demand in Haryana and UP. The flow downstream of Okhla barrage is minimal.

Unavoidably, about 328 mld (3.8 m^3/s) of water (essentially diluted wastewater) is withdrawn from the eutrophied stage of the river for meeting the drinking water requirements of the town of Gokul and the city of Agra.

BASELINE WATER QUALITY

From water quality point of view, Tajewala is the benchmark where water is still in pristine form. Average BOD and DO levels at this point are 1 mg/l and 10 mg/l respectively. On the downstream of Tajewala, in stage II, domestic and industrial wastewaters from urban and rural areas of Yamunanagar, Karnal, Panipat, Sonipat, Saharanpur, Meerut etc. are discharged into the river. Besides this, a large quantity of wastewater from livestock rearing activity and surface runoff from agricultural farms also join the river. However, the 224 km length of stretch II enables certain extent of self-purification and therefore, the water quality upstream of Wazirabad barrage (Delhi) is not very critical. Average BOD is observed to be in the range of 1.5-2.5 mg/l. Nevertheless, level of *Coliforms* and contamination due to pesticides and other industrial pollutants is of concern. Key indicators of water quality in different stretches of the river are presented in Exhibit 5.

EXHIBIT 5

WATER QUALITY IN DIFFERENT STRATCHES OF YAMUNA

			Recent status			
	Desired quality	**Status in 1993**	**BOD**	**DO**	***Faecal Coliform***	**Class**
Stretch/ Stage			mg/l	mg/l	MPN/ 100 ml	
I : Himalayan	A	A-B	1-2	10	100-1400	A-B
II : Upper	B	B-C	1-5	7-10	100-10,000	E
Remarks : Water quality in general is Class C-D. However, from bacterial point of view it falls in Class E.						
III : Critical	B	E	15-33	0-0.9	> 1 million	E
Remarks : This stretch approximates an elongated sewage lagoon or oxidation pond.						
IV : Eutrophied	B	D-E	10-37	4-17	10,000 – 1 million	E
Remarks : Shallow depths and wider sections enable higher re-aeration capacity in this stretch. As a result DO levels are observed to be high.						
V : Diluted	B	C-E	7-13	7-12	10,000	E
Remarks : At Allahabad, before confluence with Ganges, the BOD, DO and *Total Coliform* values are 2 mg/l, 8 mg/l and 3000 MPN/100 ml respectively.						

(Source : Data monitored and provided by Central Pollution Control Board (CPCB), New Delhi and TEC, 2002)

Note : Water quality classification for surface waters is as per the criteria recommended by the CPCB, New Delhi. The five categories are as follows :

A : Drinking water source without conventional treatment but after disinfection.
B : Bathing, Swimming and recreation.
C : Drinking water source after conventional treatment.
D : Propagation of wild life, fisheries.
E : Irrigation, Industrial cooling and controlled waste disposal.

As can be seen from previous sections and Exhibits 4 and 5, stretches III and IV are essentially carrying wastewater. The Delhi stretch (III) is in a unique situation, being located between two barrages and having no fresh water flows either from upstream or from lateral connections. These stretches have become extremely critical from water quality and public health point of view. Typically, water quality in Delhi stretch is classified as Class E and is characterised by *Total Coliform* MPN of the order of a million/100 ml.

Stretch IV i.e., downstream of Okhla barrage and up to the point of confluence with river Chambal is characterised as eutrophied stage which is a euphemism for ‘open sewer line’. Here again the water quality is classified as Class E with *Total Coliform* values being of the order of couple of millions/100 ml. Nonetheless, as mentioned earlier, water from this stretch is withdrawn for domestic supplies to some of the cities. Epidemiological data to correlate with river water quality are not available. Undoubtedly, the required level of treatment and chlorination for safeguarding public health would be high.

It is only in the last stretch of the river where of dilution waters from tributaries bring it back to a respectable stage. However, from bacteriological point of view, water quality still falls in Class E, signifying contamination due to sewage discharges from smaller towns and cities on the banks.

NEED FOR INTERVENTION

In view of the severe deterioration in water quality and associated public health implications, there was an urgent need for sustained and concerted intervention for water pollution control in Yamuna basin.

Water pollution along the river is generated from all the three sectors, i.e., domestic, industrial and agricultural/livestock. BOD loads for 1997 for the three sectors were estimated as 1195 t/d, 1053 t/d and 3824 t/d respectively. Thus the distribution among the three sectors is 20%, 17% and 63% respectively (SAPROF, 1992).

Control of water pollution from the industrial sector is addressed under the existing Environmental Protection Act, 1985 and the State Pollution Control Boards could enforce polluting industries to take the necessary measures for the 10% fraction. On the other hand, in case of dairy farming activities, under the existing institutional structure no specific agency had been given the responsibility for control of pollution. Moreover, while a major part of it is assumed to be reused for rural energy needs, it was also difficult to assign the responsibility for such non-point sources. Therefore, under the given circumstances and available information, these two sectors were considered comparatively difficult to address.

Pollution arising from domestic sector was considered to be of major concern from sanitation and public health point of view, it was un-addressed by municipal bodies and found to be most feasible to be tackled. Thus any strategy aimed at improving water quality in river Yamuna had to target the domestic sector on priority and develop interventions accordingly. At the time of project formulation it was estimated that by 1997 (the design year) the total population in 15 Class-I towns along the river would be 34.75 million. The corresponding sewage generation and BOD load were estimated to be 2953 mld (SAPROF, 1992). However, excluding Delhi, none of these towns had any sewage treatment arrangements. Thus there was a clear-cut need to prioritise and create sewage treatment capacity in these towns which could eventually lead to improvement in the river water quality. In this regard a balance had to be achieved for allocation of available resources among towns located along the banks and those away from the river in the larger basin. Evidently the former group would get priority in short term and the latter group could be covered under subsequent phases.

GENESIS OF YAMUNA ACTION PLAN

It was in 1985 that a concerted project called Ganga Action Plan (GAP) was launched by the Government of India to improve the water quality of river Ganges. The project was taken up with the assistance of the Government of the Netherlands. GAP targeted wastewater discharges from major urban and industrial centres along the river. Being first of its kind in the country, the project in its initial phase offered several lessons to the planning and executing agencies on effectiveness and sustainability of various technical interventions.

Yamuna being the largest tributary of river Ganges, it was the obvious target for the second phase of GAP. Yamuna Action Plan (YAP) was thus conceived to address wider area of the Ganga basin. It was formally launched in 1993 with the financial and technical assistance of the Government of Japan. A total of 17.77 billion Yen of financial support was extended as a long-term loan. By then the National River Conservation Plan had also evolved into a countrywide program targeting critically polluted stretches of major rivers and the Government of India had also allocated large resources from its own account for the programme. YAP was implemented over ten years and it came to a close by February 2003.

ACHIEVEMENTS OF YAP

YAP identified 15 Class-I cities along the river for priority interventions. These interventions were primarily tailored for creation of new infrastructure such that raw sewage overflows into the river could be prevented. The components involved construction of drain interceptors, pumping stations, diversion lines and renovation and construction of sewage treatment plants (STP).

Interestingly, while Delhi generates as much as 70% of the total wastewater load, it did not receive proportionate level of investment under YAP. There are two plausible explanations to this. First, the Govt. of National Capital Territory of Delhi (NCT) came forward to share the responsibility and second, the water from Delhi stretch was not perceived to be posing immediate threat to public health as it was not being used for drinking water supply for any towns in vicinity.

During the YAP implementation period, the Govt. of India and the Govt. of NCT of Delhi from their own resources created an additional sewage treatment capacity of over 1200 mld. YAP support in Delhi was miniscule and it comprised pilot scale plants of various types creating aggregate capacity of about 32 mld for demonstration of decentralised approach. By the time YAP came to a close, NCT of Delhi had an aggregate sewage treatment capacity of 2240 mld.

The focus of YAP was on towns along stretch II and IV of the river. In these towns, 26 STP were constructed and an aggregate sewage treatment capacity of around 700 mld was created. A listing of various engineering works implemented in Haryana, Delhi and UP states is provided in Exhibit 6.

EXHIBIT 6

WORKS AND ACTIVITIES CARRIED OUT UNDER YAMUNA ACTION PLAN

		States		
Components	**Unit**	**Haryana**	**Delhi**	**UP**
Sewerage/wastewater interventions				
A. Interception and diversion of open drains	km	172	-	42
B. Sewage pumping stations	Nos.	21	-	28
C. Sewage treatment plants				
Installations	Nos.	11	-	15
Capacity creation	mld	303	-	399
D. Low cost sanitation				
Community toilet complex	Nos.	75	958	561
Squatting seats	Nos.	1160	27000	2910
E. Pilot projects				
Decetralised sewage treatment				
Mini STPs (3 and 2 mld)	Nos.	-	4	-
Micro STPs (0.15 mld)	Nos.	-	10	-
Decentralised STPs on drains (10 mld)	Nos.	-	2	-
Disinfection of STP effluent (1 / 2 mld, various technologies)	Nos.	3	2	1
Non-sewerage interventions				
F. Improved wood based crematoria		24	4	70
G. River front development (Construction of bathing facilities)		2	-	7
H. Public participation workshops	Nos.	726	5382	915

Technology choices

Drawing lessons from the first phase of the GAP, the preferred technology options for STPs in YAP were upflow unaerobic sludge blanket (UASB) reactor and oxidation pond. The deciding factors in their favour were essentially their low energy consumption and low operation and maintenance costs. In all, 16 UASB plants and 10 oxidation ponds with aggregate capacity of 702 mld were constructed where UASB accounted for almost 75% of the capacity.

A UASB plant typically has a COD removal efficiency of 75-85 % and it perforce requires a follow up treatment step so as to comply with the discharge conditions. Thus all such plants in YAP have been provided with a waste stabilisation pond (WSP) typically with a detention period of 1day. The combined treatment system offers overall energy economy compared to conventional activated sludge process based STPs. The combined hydraulic capacity utilisation of 16 UASB plants is reported to be 73% and the BOD reduction efficiency is 85%.

Oxidation pond based system is a proven technology option for the climatic conditions in Indian sub-continent. While ten such plants could be constructed under YAP, wide scale application was not possible due to their large land requirements. Current combined hydraulic capacity utilisation of these ten oxidation ponds is 72%

while their BOD reduction efficiency is 77%. All the 26 plants put together are operating on 73% hydraulic capacity utilisation and their BOD removal efficiency is 83%.

Pilot on disinfection of STP effluents

The issue of *Coliform* organisms in STP effluent has emerged in recent years especially for UASB plants. C*oliforms* are obligate anaerobes and unlike in an activated sludge plant, they do not die out in UASB environment. Provision of the polishing waste stabilisation pond has also not helped in reducing the bacterial count in the final effluent due to short detention period. Recognising this aspect, CPCB has recently included *Faecal Coliform* number as one of the parameters in the national discharge standards for STP effluents. The desirable and maximum permissible limits for *Faecal Coliform* have been set at 1000 and 10,000 MPN/100 ml respectively.

In this context, YAP included four innovative sub-projects on pilot basis for polishing treatment. These disinfection operations comprised 2 mld combined system based on solar radiation and UV, 2 mld chlorination unit, 1 mld down hanging sponge (DHS) bio-tower at three different locations. While the solar energy cum UV based system has encountered operational problems due to higher suspended solids, the chlorination system turned out to be high in operation and maintenance costs. Operational performance and design parameters of these plants are being further evaluated for future strategy.

The DHS biotower system is based on an innovative technology which was developed in the Nagaoka University of Technology, Japan, especially for treated effluents from UASB reactors. Under YAP, one such plant was tried out on a pilot basis at Karnal and it has met with a reasonable level of success. While the final effluent quality from suspended solids and BOD points of view is excellent (8-12 and 11-15 mg/l respectively), the MNP for *Faecal Coliform* is between 1700-1900/100 ml. Though the MNP is still above the desirable discharge limit specified by CPCB, it is well below the maximum permissible limit and thus the plant is considered to be running satisfactorily. Further R&D work is required to achieve the objective of desirable limit, however this pilot has offered a rather effective and low cost (O&M) technology option for achieving high quality STP effluent standards.

Low cost sanitation

While Delhi did not receive major support in terms of creation of new STP capacity, it warranted an alternative decentralised approach for managing wastewater from domestic sector. This stems from the fact that almost 45% of its population lives in low-income communities which are not covered by conventional sewerage system. A large fraction of this population resorts to open defecation which is a major public health hazard. Wastewaters from such area sources eventually join the river and undermine the effectiveness of other components of the project.

In view of this, a separate component for providing appropriate sanitation facilities to the low-income communities was formulated. It involved construction of community toilets which was supported by a public participation and awareness campaign with the help of voluntary organisations. Considering the public health aspects, the component was extended to project towns in Haryana and UP as well. A total of 1594 community toilet complexes were constructed which provide around 31,000 squatting seats. Out of this, Delhi alone accounts for 87% of the seats. These complexes are being run by voluntary organisations on ‘pay and use’ basis and have generated mixed response among the target community. This has particularly benefited women and children. Long term social, public health and environmental benefits will have to be assessed as more experience is gained on their acceptability and operational efficiency.

Pilot on decentralised STPs

Typically the low-income communities are located on low-lying lands along storm water drains and riverbanks. Connectivity of such areas with city sewerage system posed major challenges. Besides the technical difficulties, the cost of conveying wastewater by pumping was found to be unsustainable. As in the case of the low cost sanitation strategy, this problem also required a different approach.

The concept of decentralised treatment of wastewater was tried out on pilot basis. This is again a unique approach in the Indian context where typically centralised facilities are encountered in most metros. In places where land was available, treatment of wastewater near its place of generation was found to be more feasible. In case of Delhi, feasibility of this approach and suitability of new technologies was tried out in fourteen low-income localities and along two storm water drains.

STPs attached to community toilets

Selected low-income communities where community toilets have been constructed were identified. In two resettlement communities ‘fluidised aerobic bed’ (FAB) technology based STPs each of 3 mld were constructed. Similarly in other two resettlement communities ‘submerged aeration fixed film’ reactor (SAFF) technology based STPs each of 2 mld were constructed. These plants are termed ‘mini STPs’ and they are connected to a number of community toilets. In addition, 10 ‘micro STPs’, each of 0.15 mld were constructed for individual community toilets. These plants are compact forms of sedimentation and attached growth technology system involving primary and secondary treatment. Experience from these plants has been varied and further monitoring is required to assess the suitability of the entire intervention.

STPs along drain side

Two STPs each of 10 mld have been constructed on the side of storm water drains with the objective of assessing the performance of a patented technology called ‘bio-for’. The treated wastewater is used by nearby thermal power plant for cooling purpose. In exchange the power plant provides electricity to the STPs free of cost.

Non-sewerage components

In addition to the conventional engineering interventions for sewerage system and low cost sanitation, YAP also included a few unconventional interventions which had a bearing on river pollution. These are summarised below :

Improved crematoria	:	It is a common practice among poor communities living along the river to release dead bodies into the river. This socio-religious practice is purely due to economic compulsions. Cheaper alternative in the form of improved crematoria were provided to prevent this practice. Results are varied, however their acceptability within the community is gradually improving.
River front development	:	This was done again to address socio-cultural aspirations of the riverbank communities. On special occasions it is considered auspicious to take a dip in the holy river. This offered an opportunity to build bridges with the community by constructing ‘ghats’ (stone steps on the banks) and bathing facilities.
Public participation and community awareness	:	In order to have higher acceptability of various interventions e.g., low cost sanitation, crematoria etc. it was considered essential to increase the awareness among the community regarding the objectives of YAP. Voluntary organisations were involved to carry out and facilitate these activities.

Total investment on YAP

YAP loan disbursement took place in two distinct stages, first from 1993 till 2000 and the unutilised money was then disbursed during the extended phase from 2000 till 2003. Total expenditure on various components has been Rs. 6759 million, which is equivalent to USD 141 million (exchange rate in March 2003, 1USD ≈ Rs. 48). The break up of expenditure over two time periods for three states is presented in Exhibit 7 below.

It is noteworthy that NCT of Delhi accounted for only 2.6 % of the total expenditure during the first 7 years i.e., during the original programme while it contributes almost 70 % of the wastewater in the river. Subsequently, during the extended period of three years, this fraction increased to 23%, which was directed on construction of community toilets, pilot STPs and community participation.

EXHIBIT 7

DISTRIBUTION OF EXPENDITURE INCURRED DURING YAP

Rs. in million

Programme phase	Haryana	Delhi	UP	Total	%
Original programme (1993-2000)	1957	175	2515	4647	69
Extended programme (2000-2003)	251	1541	320	2113	31
Total (1993-2003)	2208	1716	2835	6759	100
% distribution	33	25	42	100	

(Source : TEC-DCL, January 2003)

River water quality

From Exhibit 5 it is seen that the river water quality in various stretches has not recorded a measurable improvement. The pre-YAP status in stretch II was Class B while the current status is Class E. The critically polluted stretch along Delhi largely remained unaffected and water quality continues to be in Class E. In 1996, BOD in this stretch was measured at 9.1 mg/l and in 2002 at the same reference point it was measured at 32 mg/l.

Stretch IV and V are also falling under Class E. Stretch IV from where water is withdrawn for domestic supply is characterised by *Total Coliform* count of more than 2 million/100 ml. Downstream of Agra, BOD at a particular reference point has increased by 67%from 12 in 1996 to 20 mg/l in 2002, while over the same period COD has recorded an increase of 81% from 47 to 85 mg/l.

Factors responsible for underachievement

Key factors which have affected the attainment of ultimate objective of YAP are related to original strategy on geographical and demographical coverage, ‘end of pipe’ approach, technology and limited time horizon. These are briefly described below:

- While wastewater loads from Delhi alone was estimated to be 70% of the total from 15 urban towns, the city-state was completely left out under sewerage/wastewater component of YAP. Moreover, the STP capacity created by the city government concurrently with YAP remains unutilised to the extent from 25-45% on account of severe limitations in the delivery system. As a result, untreated sewage continues to flow into the river through a series of storm water drains.

- Similarly, STPs in stretch II and IV are under-utilised due to a combination of limitations in delivery system and power availability. Municipalities and line agencies which are responsible for operation and maintenance of the sewerage infrastructure are constrained to maximise the operational efficiency of the system due to a combination of factors related to skills, management systems and upstream sewerage infrastructure.

- Initial estimate for BOD load generation from livestock activities in the study area was as much as 63% of the total. Even if half of this load is assumed to be reaching the river, it constitutes 46% of the total BOD load on the river system. However, the strategy in YAP did not address this non-point source of pollution at all.

- While community toilet complexes have been able to prevent to a certain extent the practice of open defecation and have yielded consequent benefits in terms of improved hygiene and sanitary conditions in target communities, they have not led to a proportionate reduction in the organic load flowing into the river.

- There was an inordinately high emphasis on public participation and community awareness in Delhi vis-à-vis their potential in achieving reduction in pollution loads from low-income communities. While these aspects are important, the benefits have not been commensurate with the efforts that have gone in. There is a need to refine the strategy for increasing the acceptability of low-cost sanitation interventions.

- From bacteriological water quality point of view, it must be noted that when YAP schemes were being designed, the Indian wastewater discharge standards did not mandate STP effluents to comply on this aspect. The standards on *Coliform* are of rather recent origin. As a result, the STPs did not include disinfection as the tertiary treatment step.

- Lastly the aspect of sewage treatment capacity available along the river needs to be looked at. In YAP the major consideration was to target and control the immediate pollution loads from domestic sector. Coupled to this, the limited budget availability was the major constraining factor in deciding for a shorter design period. Accordingly, whatever sewage treatment capacity was created, it was designed for 1997 population loads. For instance YAP was able to create 3.5 million Population Equivalent (PE) of net STP capacity in 14 towns in Haryana and UP. However the present (year 2002) total population of these towns itself is close to 6.7 million and thus the shortfall is 3.2 million PE. When Delhi is also included, the gross available STP capacity is around 14.7 million PE while the present population load is 21.3 million, indicating a shortfall of 6.6 million PE. Furthermore, when all the 33 major, medium and smaller towns along the river are considered, the corresponding numbers are 15 million PE versus 23.3 million and the shortfall in STP capacity is 8.3 million PE.

FUTURE DIRECTIONS

In view of the above discussion on water quality and the factors leading to underachievement of the ultimate objective of YAP, it is necessary to address these issues in a strategy to be evolved for the future. The strategy should aim to first maximise the performance of the assets already created during YAP and then widen its scope to cover additional population. In this context, it is imperative that the implementing agency, i.e., National River Conservation Directorate of the Ministry of Environment and Forest (Government of India) is formulating second phase of Yamuna Action Plan. YAP-II is proposed to be implemented during 2003-07 and it will cover 33 towns. The infrastructure will be designed for the year 2032. In addition, the second phase of the plan also envisages a component on capacity building of the municipal bodies as well as the implementing and executing agencies, so as to enhance the sustainability of the engineering interventions.

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