Sick Yamuna, Sick Delhi

Searching a Correlation

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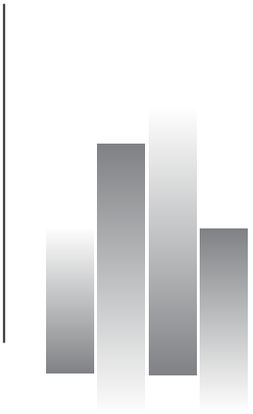
PEACE Institute Charitable Trust

2009



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Abbreviations

AIIMS	All India Institute of Medical Sciences
ASP	Activity Sludge Process
ASSOCHAM	The Associated Chambers of Commerce and Industry of India
ATR	Action Taken Reports
BOD	Biochemical oxygen demand
BPS	Booster Pumping Stations
CAG	Comptroller and Auditor General
CBHI	Central Bureau of Health Intelligence
CBPCWP	Central Board for the Prevention and Control of Water Pollution
CCS	Centre for Civil Society
CGWB	Central Ground Water Board
CLC	Carrier Lined Channel
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSE	Centre for Science and Environment
CSIR	Council for Science and Industrial Research
DALY	Disability-Adjusted Life Year
DDT	Dichloro Diphenyl Trichloroethane
DGS&D	Director General Supplies and Disposal
DHDR	District Human Development Report
DHS	Directorate of Health Services
DJB	Delhi Jal Board
DMRC	Delhi Metro Rail Corporation
DO	Dissolved Oxygen
Dte	Directorate
DUEIIP	Delhi Urban Environment and Infrastructure Improvement Project
ECG	Electrocardiogram
EYC	Eastern Yamuna Canal
FAB	fluidized aerobic bioreactor
GNCTD	Government of National Capital Territory of Delhi
Govt.	Government
GPCD	Gallon Per Capita per Day
HAV	Hepatitis A Virus
HC	High Court
HID	Haryana Irrigation Department
HSPCB	Haryana State Pollution Control Board
JJ	Jhuggi-Jhopadi
LPCD	Litres Per Capita per Day
MCD	Municipal Corporation of Delhi
MGD	Million Gallon per Day
MH&FW	Ministry of Health & Family Welfare
MIS	Management Information System

MLD	Millions litres per day
MoEF	Ministry of Environment & Forests
MPN	Most Probable Number
NCMH	National Commission on Macroeconomics and Health
NCT	National Capital Territory
NDMC	New Delhi Municipal Corporation
NEERI	National Environmental Engineering Research Institute
NGO	Non Government Organisation
NICD	National Institute of Communicable Diseases
NRCD	National River Conservation Directorate
NWQMP	National Water Quality Monitoring Programme
PAC	Poly-Aluminium Chloride
PATH	Programme for Appropriate Technology in Health
pH	pondus Hydrogenium
PIL	Public Interest Litigation
RNA	Ribonucleic Acid
RTI	Right to Information
RV	Rotavirus
RWA	Residents Welfare Association
SAFF	Submerged Aerobic Fixed Film Process
SC	Supreme Court
STP	Sewage Treatment Plant
TB	Tuberculosis
ToI	Times of India
TPD	Tonnes Per Day
UGR	Under Ground Reservoirs
UK	United Kingdom
UNICEF	The United Nations Children's Fund
UP	Uttar Pradesh
USA	United States of America
UT	Union Territory
WHO	World Health Organisation
WTP	Water Treatment Plant
WYC	Western Yamuna Canal
YAP	Yamuna Action Plan

Acknowledgement

‘Sick Yamuna, Sick Delhi – Searching a Correlation’ is part of a Ford Foundation sponsored project for mainstreaming the river as a popular civil action ‘cause’ through *“motivating actions for the revival of the people- river close links as a precursor to citizen’s mandated actions for the revival of the life-line river in the city.”* The said project has been implemented by the PEACE Institute Charitable Trust, (PEACE in short) Delhi.

Manoj Misra at PEACE has been a constant advisor in this work, reviewing the progress and giving very useful guidance and tips from time to time. This is to heartily acknowledge his help.

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Regular consultations with few eminent doctors of medicine, on water and health issues were found to be extremely useful. These included a private physician, Dr Vijay Soni at Ashok Vihar, Delhi; a government hospital practitioner of medicine, Dr Rajesh Modi, at Ram Manohar Lohia Hospital, New Delhi and a Professor of microbiology, Dr Sarman Singh, Head, Microbiology Lab, AIIMS, New Delhi. All these who provided their time in a gratis manner, are sincerely thanked. Special thanks are due to Prof Sarman Singh, who spared his valuable time for discussion, sharing his research findings and finally even reviewing parts of the draft final report.

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Pushp Jain
September 2009
Delhi

Executive Summary

Rivers are the lifeline of any civilization. Since the time of its origins as Indraprastha, the kingdom of the Pandavas, through to modern times and the rise and fall of 10 powerful empires, Delhi has been sustained by the river Yamuna.

For the people of Delhi, the river Yamuna has always been the single largest water source. Today the Yamuna contributes 724 mcm (million cubic metre), a substantial part of surface water requirement of Delhi. With the river turning dark and dirty, and in no fit state to support any life form, PEACE Institute Charitable Trust (PEACE in short) initiated research to discover the correlation between the health of the river and the health of the community dependent on it.

This research was one component of a Ford Foundation-supported project aimed at mainstreaming the river through *"motivating actions for the revival of people-river close links as a precursor to citizens' mandated actions for the revival of the life-line river in the city"*.

The primary hypothesis or question with which this research began was - is the increasing contamination of the Yamuna river (and other sources of domestic use water) in Delhi placing an increasing/continuing burden on people's health in the city?

Even as the river Yamuna is visibly getting more and more polluted by the day, there have been efforts to clean it as well. Over the years, a large amount of public money has been spent on cleaning the river as well as creating health infrastructure and programmes for citizens of Delhi. What has been the impact of these programmes?

With these questions in mind, we tried to do a Health Impact Assessment by endeavouring to access time-series data on the following parameters:

- Pollution of Yamuna upstream and in Delhi
- Water demand and supply, and quality data in Delhi
- Waterborne and water-related diseases in Delhi
- Health infrastructure and spending in Delhi
- Population increase in Delhi

In addition, a KAP (Knowledge, Attitude and Practice) survey on the state of Yamuna, drinking water and health of the people was carried out in Delhi during the first half of 2009 by the project implementing agency, PEACE, in association with the Centre for Media Studies (CMS) Environment, New Delhi. With a sample size of more than 1,000 households covering areas at the entry (Palla) and exit (Jaitpur) of the river Yamuna in Delhi, as well as the rest of Delhi, especially in urban slum and rural areas, the study revealed amongst other things that:

- The main source of drinking water, overall, is DJB water (60.4 per cent) followed by hand pump/ boring (around 20 per cent).

- There is almost the same level of occurrence (around 25 per cent) of waterborne diseases in all segments of the city. In fact, occurrence is slightly more in the 'entry' area (28.8 per cent) where people use both piped water and ground water, whose quality is supposed to be better compared to other areas in the city.

Secondary research – online and library search - did not provide the kind of time-series data we were looking for. Our visits and communications to concerned government agencies also did not elicit the desired information. We thus made efforts to obtain the desired information through Right to Information (RTI) requests from MoEF, MH&FW/CBHI, CSIR/ NEERI, DJB and MCD.

At the end of the day, it was difficult to come up with a clear statistical linkage between increasing pollution of Yamuna and increasing morbidity from waterborne and water-related diseases in the city due to insufficient, fragmented, unorganised and poor quality data.

Yet, despite these drawbacks, this report has been able to find clear evidence that the pollution of Yamuna is increasing by the day and drinking water contamination is rampant. For instance, a 2008 report by the Central Pollution Control Board (CPCB) on status of water in the country finds that the Total Coliform and Faecal Coliform numbers are highest in river Yamuna with a count of $32X10^{7}$ MPN / 100 ml and $23X10^{7}$ MPN / 100 ml respectively against a bathing quality standard of 500 MPN / 100ml.

Given the indisputable presence in the river of bacteria, viruses and protozoa that cause diseases, the rising morbidity caused by waterborne diseases in Delhi can certainly be blamed on the river getting sicker. As shown in the report, the government's healthcare spends in tackling this area has also been increasing.

Nothing would be better example of relation of waterborne diseases and pollution of Yamuna drinking water when sewage water mixing with Yamuna raw water resulted in an outbreak of a new infection in Delhi in 1955-56 which was for the first time documented as hepatitis E virus (HEV) and infected more than 30000 people.

How serious is the state about water and its quality is reflected in the way it neglects Water Treatment Plants (WTPs). Chandrawal water treatment plant has been in dire need of renovation for about quarter of a century now. Despite approval of the renovation work as early as in 1988, the actual award and execution of work has been delayed for about 20 years. Findings from a CAG (2008) audit reveal that 'if the implementation was delayed further the units might totally collapse leading to reduction in filtering capacity and thus the production. The same CAG report has raised serious questions on the quality of the chemicals used for water treatment at WTPs.

Also, there are several reports which link quality of drinking water and waterborne and water-related diseases, which we have used in research. Furthermore, the logical linkage between waterborne diseases and unsafe drinking water cannot be refuted.

Finally, health does not merely connote physical well-being but encompasses all dimensions – spiritual, psychological and physical. Risk of physical illness is relatively easy to correlate given the connection between the presence of protozoa, viruses and bacteria that cause diseases like hepatitis, diarrhoea and so on. Also direct physical impact, in terms of infectious diseases, is perhaps treatable and a short-term worry.

Unsafe water and consequent, disease burden is not only a strain on government healthcare infrastructure and budget (and indirectly on tax payers) but also causes social agony, results in loss of man-days, and has an economic impact, particularly for the poor as well as an impact on the GDP of the country.

The worry is the long-term consequence of continued river pollution on the economic, spiritual, mental and emotional aspects of health of the people dependent on it. These are issues that are not too well understood, but as global studies on river pollution and health of communities show have potentially very large implications. In this context, the learnings and lessons from a 2002 public health project correlating the health of people in the Wairarapa with the health of river Ruamahanga in New Zealand (www.wairarapa.dhb.org.nz) are relevant.

It's clearly time to act – keeping in mind public health implications both in the short term as well as the long term. Otherwise, Yamuna known as the "sacred river" will only be remembered as the river of sorrow.

Introduction

A Lifeline that is Lifeless

Built thousands of years ago on the banks of the Yamuna, the city of Delhi has been the capital of at least 10 powerful empires. Through its historical transition from Indraprastha to Siri to Shahjahanabad to New Delhi, Yamuna acted as the lifeline of the city – nurturing millions with its sacred waters. According to Hindu mythology, bathing in the waters of the Yamuna freed one from the torments of death.

And yet, today, in the biggest ironies of fate, the river lies lifeless. It's a toxic black, stagnant ribbon today – a far cry from the days of its glory, when it was a blue, vibrant pure stream bubbling down from the Himalayas.

Legend has it that Yamuna is the sister of Yama, the God of Death and the daughter of the Sun God. Unfortunately, today, rather than taking after its life-giving father, the river now is more a symbol of its sibling, and a harbinger of death.

River Yamuna in Delhi Feb 2007

Take a trip down the river in Delhi and no tests are needed to tell you that it is very badly contaminated. Reeking of stench and garbage, the level of pollution in the river is unimaginable.

History tells us that rivers are the lifeblood of a region – whole civilizations have been set up on the banks of rivers and named after them, whether the Indus or the Nile.

Healthy rivers help build healthy communities as it is the water that is the main source of productivity and social and economic well-being of a region.

Conversely, when a river falls sick, it affects the health of the community that depends on it. Many fatal diseases like cholera, hepatitis and diarrhoea are the outcome of the dirty or infected waters. Now research is even relating other human health burdens like cancer and impotency with polluted waters in rivers finding their way into human use. The health of a river is the foundation of the health of the living beings of the region. Clean rivers create an environment rich in resources that are essential for a healthy existence.

In the pages ahead, we try and build a correlation to show how closely linked are the two phenomena – the deteriorating health of the river Yamuna and the declining health of the people in Delhi.

Aims and Objectives

Supported by a Ford Foundation grant, Delhi-based PEACE Institute Charitable Trust initiated a project to mainstream the river as a popular civil action 'cause,' through *"motivating actions for the revival of people-river close links as a precursor to citizens' mandated actions for the revival of the life-line river in the city".*

'Assessment of impact of the health of the river Yamuna on the health of the dependent people in Delhi' formed a component of this project, and is the basis of this report.

The river's deteriorating state and its implications on the health of the people is a matter of overwhelming concern since the river Yamuna remains the city's main source of water for domestic use, including for drinking purposes.

While there are several human-health related studies indicating the continued prevalence of waterborne and water-related diseases in Delhi, despite several programmes and policy investments to check these, the correlation of these increasing incidents of diseases with the steady deterioration of river Yamuna's quality has not been investigated earlier. In the larger public interest, it is a matter worth investigating.

Methodology

Activities

a) Internet and library search for information, reports and documents related to the existing knowledge on the state of the river Yamuna and the state of the people's health, over the years.

b) Accessing statistical data from the State and Central health, water supply, sewage management and pollution monitoring agencies for over 25 years through personal visits, official communications and RTI to gauge the pollution of Yamuna upstream and in Delhi, state and quality of water supply and waste water treatment and management, and prevalence of waterborne and water related diseases in the city.

c) Visiting Yamuna upstream (up to Hathnikund) and in Delhi and also Western Yamuna Canal system.

d) Meetings, interviews and discussions with researchers/experts at relevant institutions as well as NGOs working either in the field of river's rejuvenation and/or people's health to get insight into the linkage between the river's health and people's health.

e) Maintaining a regular communication and consultation with the concerned officials at the Central Pollution Control Board (CPCB), the key agency for monitoring water quality in river Yamuna.

f) References to a representative sister survey regarding the people's perception (Knowledge, Attitude and Practices) in Delhi about the linkage of river's health with their own as well as that of their near and dear ones.

g) Photo documentation.

h) Regular consultation with a private practitioner (Dr Vijay Soni at Ashok Vihar, Delhi); a government hospital practitioner (Dr Rajesh Modi, RML, New Delhi) and a professor of microbiology (Prof Sarman Singh, AIIMS, New Delhi).

i) Analysis of research findings and preparation of the report.

Limitations

In the course of the study, difficulties were encountered in accessing time-series data on disease burden of Delhi, which was easier said than done. Non availability of data was a serious constraint in arriving at reliable estimations of the disease burden in Delhi. The problem was compounded because two different agencies (CBHI and Directorate of Health Services, Delhi) had two different sets of estimations on disease prevalence. Thus, arriving at a statistical linkage – which was one of the aims of this report – proved to be a difficult exercise. Use of RTI queries to eliciting time series data on disease burden in NCT of Delhi also proved frustrating and not too fruitful.

CHAPTER 1

Water Situation and the Dependence of Delhi on the River Yamuna

1.1 Delhi - population and structure

Delhi, capital city of India, is a mega-metropolis situated on the banks of the river Yamuna. Spread over an area of 1,483 sq km divided into nine districts, it is teeming with people, currently an estimated 17.6 million. It has largely developed on the west bank of the river Yamuna but after Independence (1947) has spread across to the east bank with two of the most populated districts - North East and East - of the city, now located there.

The structure and composition of Delhi's population is fairly complex. Around 93 per cent of the population is urban. People of all castes and creed, from all states, and economic classes live here. The type of habitation ranges from shanties without basic infrastructure to palatial houses. Hundreds of migrants come to Delhi every day to make it their home. Table 1.1 illustrates the complexity of settlements in Delhi. It can be seen that apart from 24 per cent people living in planned colonies, 5.3 per cent in old villages, and 6.4 per cent in urban villages, the rest live in little serviced "unauthorised" (JJ Clusters; Slum designated areas; Regularised 'unauthorised' colonies etc) human settlements.

TABLE 1.1: TYPES OF SETTLEMENTS IN DELHI

Settlements	Estimated Population in lakhs (2000)	% of total Population
JJ Clusters (*Jhuggi-Jhopadi* – shanties of poor people)	20.72	14.8
Slum Designated Areas	26.64	19.1
Unauthorised Colonies (unplanned clusters of habitation with poor infrastructure)	7.40	5.3
JJ Resettlement Colonies (Shanties relocated by government to outskirts of city and provided with small plot of land and some infrastructure)	17.76	12.7
Rural villages (old villages)	7.40	5.3
Regularised Unauthorised colonies (old unplanned clusters of habitation with poor infrastructure which government finally accepts and provides improved infrastructure)	17.76	12.7
Urban Villages (old villages which now lie in the middle of urban development)	8.88	6.4
Planned Colonies	33.08	23.7
Total	**139.64**	**100**

Delhi Urban Environment and Infrastructure Improvement Project (DUEIIP), 2001

FIG 1: YAMUNA FROM ITS ORIGIN TO ITS CONFLUENCE WITH GANGA

Note: It can be seen that the river Yamuna after originating in the Himalayas (Uttaranchal and Himachal Pradesh), flows through the plains of Haryana and UP before skirting through eastern parts of Delhi to once again border states of Haryana and UP. It finally flows entirely through southern parts of UP before merging into river Ganga at Allahabad (*Prayag*). It is notable that the river Yamuna has with the sole exception of river Hindon, no tributary worth the name for large part of its length before river Chambal joins it south of Etawah in UP.

1.2 Origin and course of the Yamuna

The river Yamuna is a major Himalayan river originating from Yamunotri glacier (20,000 ft above sea level) descending from Mount Kalindi and forming into a regular river from Yamunotri onwards. It is the largest tributary of the Ganga, one of the three main rivers originating from the Himalayas. During its 1,376 km journey from Yamunotri to its confluence with the river Ganga in the gangetic plains at Allahabad, it sustains millions of people.

The Ministry of Environment and Forests (MoEF) has classified the river into five segments based largely on geographical and quality of water parameters (see Table 1.2).

TABLE 1.2: THE LENGTH AND COURSE OF THE RIVER YAMUNA

Segment	Course covered	Length in km
Himalayan Segment	Yamunotri – Tajewala	172
Upper segment	Tajewala – Wazirabad	224
Delhi Segment	Wazirabad – Okhla	22
Eutriphicated Segment	Okhla to Chambal Confluence	490
Diluted Segment	Chambal Confluence to Ganga Confluence	468
Total		**1,376**

Haberman (2006)

1.3 Sources of water for Delhi

The main sources of raw water in Delhi are the Yamuna (surface water and Western Yamuna Canal WYC), the Ganga (Upper Ganga Canal), Bhakara-Beas Storage, and ground water through tube wells and ranney wells (specially designed high-capacity wells named after founder Leo Ranney).

The estimated water availability of NCT (National Capital Territory) of Delhi from surface water sources, viz. the Yamuna, the Ganga and the WYC is about 1150.2 million cubic metre (mcm). The river Yamuna contributes 724 mcm, a substantial part of the surface water requirements of Delhi.

Delhi Jal Board (DJB) an autonomous body of the Government of NCT of Delhi is the only network supply agency in Delhi. In areas under the administrative control of New Delhi Municipal Corporation (NDMC) and Delhi Cantonment Board, the DJB supplies water in bulk to them. This, in turn, is further distributed ahead. DJB receives raw water, treats it and supplies it to the network. There are reportedly 1.637 million water connections serviced by the network.

1.4 Water Demand and Supply

As per the norm set by the Central Public Health and Environmental Engineering Organisation (CPHEEO) of the Ministry of Urban Development, Delhi's per capita daily water requirement is around 274 litres. (ASSOCHAM, 2008)

According to DJB estimation, water demand is to the tune of 4077 million litre per day (mld) while its average production is 3262 mld against the installed capacity of 3606 mld (See Table 1.3). This leaves a gap of about 20 per cent.

The performance audit of Water Management System of Delhi (CAG, 2008) covering the period from 2002-03 to 2006-07 finds the capacity of the water treatment plants in Delhi to be of the order of 710 million gallons per day (MGD). In addition, 100 MGD of ground water is lifted through various ranney wells and tube wells. Hence, DJB provides 810 MGD against the requirement of 1050 MGD of water due to shortage of raw water. Thus this audit also indicates the demand-supply gap of more than 20 per cent.

DJB has a network of 306 UGRs (Under Ground Reservoirs) and 468 BPSs (Booster Pumping Stations), 3222 tube-wells and several ranney wells. Besides the network, the DJB supplies water through tankers also.

TABLE 1.3: PRODUCTION CAPACITY OF DJB

Water Treatment Plant	Source	Capacity in MGD	Capacity in MLD
Wazirabad	Yamuna	120	543.60
Hyderpur I	BBMB	100	4530
Hyderpur II	Yamuna (WYC)	100	453.00
Chandrawal	Yamuna	90	407.70
Bhagirathi	Ganga	100	453.00
Nangloi	BBMB	40	181.20
Okhla	Ranney Wells	6	27.20
Sonia Vihar	Ganga (UGC)	140	634.20
Ranney Wells/Tubewells		100	453.00
Total		**796**	**3,606.00**

Anon. (2007) Summer Action Plan, DJB, Govt. of NCT-Delhi

There is a clear demand and supply gap, 20 per cent by DJB's own admission and 25-34 per cent according to an ASSOCHAM report (2008).

What about the unmet demand?

A majority of Delhi's residents (about 73 per cent) depend on the Delhi Jal Board (DJB) pipelines for water. Another 5 per cent of the households surveyed were serviced by DJB water tankers on a regular basis. Around 12 per cent of households depend on motor pumps and tube-wells and another 10 per cent on hand-pumps (DHDR, 2006).

TABLE 1.4: DJB'S MODE OF WATER SUPPLY

Type of supply	Supply mode	Volume supplied in MLD (Million Liters/Day)
Domestic connections	1331820 connections	1,124
Commercial and Institutional connections	52623 connections	34
Industrial connections	10876 connections	13
Bulk supply to DGF and NDMC	Bulk supply	158
Public standposts	11533 standposts	221
Water tankers	493 vehicles	10

Estimations – PWC, GHV, TCE (2004) "Project preparation study – Delhi Water Supply and Sewarage Project" Report prepared for the Delhi Jal Board (DJB).

A perception (Knowledge, Attitude and Practice) survey about the state of river Yamuna, drinking water and health of the people was carried out in Delhi during first half of 2009 by PEACE Institute Charitable Trust, Delhi and Centre for Media Studies – environment, New Delhi. The study had a sample size of more than a thousand households covering areas at the entry (Palla), exit (Jaitpur) of the river, within 5 km of the river and rest of Delhi - largely urban slum and rural areas.

It was reported by the survey that the main source of drinking water, overall, is network supply (DJB) water (60.4per cent) followed by hand pump/boring (around 20per cent). It is interesting to note that at the exit and within 5 km of the river in National Capital Territory (NCT), more than 30 per cent have indicated hand pump/boring as the main source of drinking water.

TABLE 1.5: HOUSEHOLDS' SOURCE OF DRINKING WATER IN DELHI

Source of drinking water	Number of Household	Percentage of total
Tap	1,924,149	75.3
Handpump	476,999	18.7
Tubewell	82,519	3.2
Tank, Pond, Lake	17,409	0.7
Other	53,073	2.1
Total number of household	**2,554,149**	**100**

Census of India, 2001

It is reported and understood that people whose water needs are not being met by DJB depend on underground water. Even DJB draws about 480 mld (100 MGD) of ground water for its network supply. Thus, there is extensive dependence on ground water in Delhi. How much ground water is extracted can only be guessed as there are large numbers of unregistered private tube-wells, bore wells and hand pumps in the city. According to estimates, in 2004 there were between 200,000 and 360,000 private tubewells (bore wells) extracting an estimated 1,300 mld of water (Augustine, 2004). Thus, about 50 per cent of water demand in Delhi was being met through groundwater abstraction in 2004. (Maria, 2004)

The dependence on ground water in Delhi has been increasing. The Central Ground Water Board reported in 1979-80 an average annual withdrawal of about 237 million cubic meters of water in Delhi for different beneficial uses. Each day about 0.31 million cubic meter (mcm) of groundwater was used as a drinking supply in the city. (CBPCWP 1986)

1.5 Recharging Ground Water in Delhi

The Yamuna's flood plains have a key role in recharging the ground water. According to CGWB estimates, the river Yamuna in its 50 km stretch in NCT of Delhi has developed about 97 sq km of active flood plains. Of this about 16.5 sq km is under water and the remaining 80.5 sq. km. is either waterlogged or has very shallow water table. The thickness of alluvium in the flood plain varies from 20 m to 240 m. The ground water is fresh down to about 40 metres and the quality then deteriorates with depth. Aquifers with 20 to 30 m depth are capable of yielding 40 to more than 60 cubic metre of water per hour. (CGWB 1996)

1.6 Private Tankers and Bore Wells

There is a background reason for the proliferation of use of private supply of water by tankers in Delhi. Llorente & Zerah (2003) explain that cholera epidemics in the late 1980s led the users of shallow wells to avail of services of private tanker operators. These operators generally own deeper tube wells equipped with electric pumps set up on the outskirts of the city. In some cases private tankers allegedly carry water illegally obtained from the public network. Although water from these tankers is less prone to bacterial contamination than shallow wells located in the heart of dense residential areas without proper sanitation, the quality of the water they provide still remains unreliable.

"These networks are supplied with water electrically pumped from local deep tube well and can provide water to 50 to 700 households. Water is generally supplied without treatment for one or two hours a day. Connections are taken by the users for a deposit of Rs 1,400 and monthly charges of around Rs 200 for a volume supplied of around 0.5 cubic metre /day." (Maria 2006)

Based on an interview with Secretary General of Private Tanker Owners' Association, Shivani Daga (2003) reported that approximately 250 private water suppliers provide water in Delhi. They supply water to Vasant Vihar, Vasant Kunj, Greater Kailash and other South Delhi areas that suffer from acute water crisis. During periods of shortages, DJB hires 200-400 water tankers from private suppliers. Even in emergencies like flare up of epidemics, DJB hires as many as 100-150 tankers.

THE ECONOMICS OF PRIVATE WATER SUPPLY

It does not take much to venture into the business of private water supply. The cost of installing a simple bore well varies from Rs 30,000-40,000 to Rs 2.5 lakh. One can dig bore wells in any part of Delhi without much hassle. In order to bore a tube well or a bore well in a 'Notified Area' one has to acquire permission from the Central Ground Water Authority (CGWA). Given the laxity in enforcement of the laws, the private water suppliers are able to bore tube wells in notified as well as un-notified areas with equal ease. A private water supplier can own anywhere between two (2) and 25 tankers depending upon the size of his business. Thus, it is not surprising to find the water tanker owners minting money during hot summer months. (CCS - Daga, 2003)

Discussion and Conclusion

Discussion: Evolving Delhi and Deprived People

Two natural features - the Ridge and the River Yamuna -- made Delhi a favourite settlement for various rulers. While the former provided natural protection, the latter was a perennial source of water right at the gateway to the vast Indo-Gangetic plains.

Delhi traces its origins to the time of the epic Mahabharata, when it was known as Indraprastha. In modern times, Delhi has been the political capital of several dynasties – Slave, Khilji, Tughlaq, Sayyad and Lodi - between the 12th and early 16th centuries and later was the seat of power of the Mughals in the 17th century. In the last century, Delhi got a boost in importance in 1911, when the capital of the British Empire was shifted from Calcutta to Delhi. Post Independence, as India's capital city, Delhi is an attractive work destination for people from all over the country.

India's population growth rate is 21.3 per cent (1991-2001) while Delhi's population growth rate is nearly double at 46.3 per cent in the same period.

Delhi has been growing by approximately 1,000 persons every day for a number of years. Migration has roughly averaged 1.3 times the natural growth in Delhi (WaterAid 2005). As a result, Delhi has grown exponentially into a mega-metropolis from a mere 0.4 million in 1901 to 17.6 million now, or in other words grown 44 times its size.

But this growth of Delhi is no secret development or overnight happening. In a way, the Government itself has been responsible for these developments. Its culpability can be traced to the time of partition of the country in 1947, when a great influx poured into the city and were resettled in slum-like conditions without the provision of basic amenities. Later, during the Asian Games in 1982, a million strong labour force was brought into the city without making provisions for their stay. Over the years big clusters of slums and unauthorised colonies have developed under the Government's nose, without it taking much preventive action. Later in recent times many of these were removed in 2004 and 2006 without a suitable relocation plan.

Delhi Human Development Report (2006) commissioned by Government of National Capital Territory of Delhi estimates that 45 per cent of Delhi's population resides in slums, which include informal settlements (squatter settlements and illegal sub-divisions as also unauthorised colonies). In 2001, there were 1087 jhuggi and jhopdi clusters with an estimated population of over

3 million—up from 20,000 in 1977. In most slums, housing and living conditions are appallingly poor.

Delhi is the seat of the central government. The city has one of the largest municipalities in the country (1 per cent of the Capital's population works for the government, or in other words, there is one municipal employee per 100 persons in Delhi). It is very clear that the government has not been able to keep pace with the growing population and its basic needs of water, sanitation, electricity and housing. People have managed in sub-standard living conditions on their own steam, even as the government labels these settlements as jhuggi-jhopdi, slums, unauthorised colonies and resettlement colonies.

Indeed, it appears as though the label of "illegal settler" is sweet music to government agencies as it provides an excuse for lower level officials to extract graft. Politicians too are happy for such settlements are large vote banks since people living in them look up to the former to help them lead a more honourable and dignified life. Service providing agencies like DJB and MCD can get away with the excuse that 'illegal' settler cannot be provided services that are the due of legal settlers. It is a contestable point why there are different norms for people living in formal and informal colonies for provision of basic services (See Table 1.6).

TABLE 1.6: DISPARITIES IN BASIC SERVICE PROVISION

Basic services	Norm for formal housings	Norm for informal housing	Actual provision in informal settlements
Water	363 lpcd	40 lpcd – one (1) community stand post for 150 persons	30 lpcd
Sanitation	Individual toilets connected to city level sewage system	Community toilets; one seat for 25 persons	One seat for 111 persons Only 75 per cent with sewage cover
Solid waste management	Household level collection	Deposit at nearest garbage point	44 per cent gap for all city
Electricity	Individual metered connection 150 unit per individual per day	Street light and some individual metered connections through group contractor (12 units per individual per day)	30 per cent gap; complete coverage with un-metered connections 8 units per individual per day

Profiling Informal City of Delhi, WaterAid India & Delhi Slum Dwellers Federation, New Delhi, 2005

Conclusion

Due to untrammelled growth, Delhi today has a complex structure with almost three-fourth of its people residing in informal, sub-standard clusters that have limited basic amenities including water available to them. Due to this informal 'unauthorised' nature of living, people shy away from demanding facilities necessary for a dignified living and the service-providing agencies have ready excuse for not providing these services to them. Such un-provisioned living becomes a fertile ground for an increase in disease burden in the city.

Discussion: Water Demand-Supply Equation in Delhi

Water is a basic need of every human being. Besides meeting the drinking requirements, water is also needed to cook food and meet hygiene / sanitation needs.

The service coverage of water supply in Delhi is as high as 99 per cent but the city-state faces an unparalleled water crisis. During a recent survey, Delhi's residents identified water among the five priority areas requiring serious attention (DHDR 2006). According to ASSOCHAM (2008) the gap in demand and supply is to the tune of 25-34 per cent while DJB admits the gap to be around 20 per cent.

The situation has not improved in the last decade since the data of 1991 provides a similar picture of water supply. According to the Delhi Economic Survey (1999-2000) "in aggregate, 75.72 per cent of the households in Delhi had piped water supply, 20.06 per cent depended on hand-pumps / tube-wells and the remaining 4.22 per cent used wells, rivers and canals for drinking water in 1991".

The water supply network of Government of Delhi has always been lagging behind in fulfilling the demands of the residents of the city. During 7th to 10th Five-Year plans (1985-2007), the unfulfilled gap ranged between 33 per cent and 24 per cent. This gap would have been much higher had the per capita requirement for calculation purposes not been lowered from 70 gallon to 60 gallon in the 10th plan (2002).

TABLE 1.7: WATER REQUIREMENT V*IS-A-VIS* PRODUCTION

Five Year plan	Population in lakh	Requirement* of water in MGD	Production of water in MGD	Short fall (MGD)	Shortfall Percentage
7th (1985-90)	94	658	437**	221	33.59
8th (1992-97)	110	770	580	190	24.68
9th (1997-02)	138	966	650	316	32.71
10th(2002-07)	176	1,050	780	270	25.71

**Requirement was computed by the Department at 70 GPCD (gallon per capita per day) up to ninth Five Year Plan and at 60 GPCD during the Tenth Plan.*
*** Installed capacity. CAG (2008)*

TABLE 1.8: THIRSTING FOR MORE: THE SUPPLY- DEMAND GAP

Plan Period	Population on March 1 (in lakh)	Water requirement @ 70 gallon per day per person	Water treatment capacity in MGD	Supply-demand gap In MGD
1951-56	21.66	152	60	92
1956-61	26.59	186	90	96
1961-66	32.88	230	130	100
1969-74	46.19	323	175	148
1974-79	57.13	400	240	160

1980-85	73.64	515	337	178
1985-90	90.48	633	437	196
1990-91	94.21	659	469	190
1991-92	97.56	683	472	211
1992-93	101.04	707	472	235
1993-94	104.65	733	525	208
1994-95	108.38	759	575	184
1995-96	112.24	786	575	211
1996-97	117.36	821	577	244
1997-98	122.82	860	580	280
1998-99	128.56	900	591	309

Delhi Statistical Abstract, Delhi Statistical Handbook, Deptt. of Economics & Statistics, Govt. of NCT of Delhi.

This gap is further widened when we consider the quantity supplied by DJB and what actually reaches the consumers. Delhi Jal Board supplies just over 30 million cubic meters per day, but only 17 million cubic meters reach its consumers due to infrastructure problems, such as leaking pipes (approximately 40 per cent leaks out, according to ASSOCHAM, 2008).

Another study points out that 'the city's water demand is about 3,600 MLD, while it has a capacity to treat 2,880 MLD of raw water and it officially supplies 3,040 MLD of water. This includes 410 MLD of officially drawn groundwater, which then adds to the waste stream. But the water supplied does not reach a vast section of the population. The DJB admits that only 1,730 MLD water reaches its consumers.' (Sarkar, et al 2007)

According to a Performance Audit of Water Management in Delhi by CAG (2008) reporting a survey conducted among the registered RWA (113 responses), 40 per cent of those surveyed stated that they received water supply for less than two hours in a day and 63 per cent did not find supply of water sufficient. (CAG, 2008)

People abstract ground water out of compulsion. Since the need is not met by the DJB network, citizens tend to install bore wells, incurring considerable digging, electricity and maintenance costs. It can be safely assumed that all the houses built on private plots, commercial plots, multi- storey buildings, cooperative group housing societies, industries, have ground water abstraction facilities. Farmers in peri-urban areas too have tube wells.

Alarms have been raised. "Ground water table in Delhi is low and depleting fast due to over exploitation," says a report (CPCB 2003). Another report (ASSOCHAM 2008) issues a stark warning: "At current consumption rates, New Delhi will run out of ground water by 2015"

Signs of doom are there for all to see. "Over-exploitation of groundwater sources has led to a sharp fall in water tables across Delhi and has become a major source of concern. Groundwater withdrawals have exceeded the rate of recharge, resulting in lowering groundwater tables and increased chemical concentration. Compared to 1960, water tables in Delhi have dropped between two (2) to 30 metres. Levels in Alipur and Kanjhawala blocks have declined by 2 to 6 metres, in the Najafgarh block by 10 metres and in Mehrauli by 20 metres." (DHDR 2006)

What are the government agencies doing about ground water recharge?

CGWB (Central ground Water Board) had identified as far back as in year 2000 that the Yamuna flood plains were the main source of ground water recharge. But instead of protecting and developing the recharge potential of the Yamuna flood plains, it is being encroached upon by government agencies themselves such as Delhi Metro Railway Corporation (DMRC) and the Delhi Development Authority (DDA). While Delhi Metro has built two depots, a number of commercial and residential quarters and number of stations right on the flood plains, the DDA has allowed development of structures like the Akshardham and the Commonwealth Games Village on it.

As per Section 8 of DJB Act, 1998, the Government may constitute a Water Consultative Council with the object to:
- advise the Board on policy matters and formulation of annual and five-years plans;
- give expert advice on administrative, financial and technical matters;
- advise the Board on matter pertaining to the interest of consumers and issues affecting the environment and;
- advise the Board on any matter on which the Board seeks its advice.

The Council as above was constituted in August 1998 but no meeting was ever held as of August 2007. This defeated the very purpose for which the Council was set up." (CAG, 2008)

It is one thing to identify and plan steps to improve the ground water levels in Delhi and another to actually implement them. Delhi Economic Survey (1999-2000) envisaged the widening and deepening of the Najafgarh drain between the Kakrola-Dhansa Regulator; preserving and developing old lakes; preserving and developing the forest area in Delhi; developing water bodies at Asola Wild Life Sanctuary and planting trees and harvesting of roof top rain water and waste water re-cycling in Delhi. But many of these plans remain on paper. Whatever little steps are taken have little impact even as the government remains focussed on engineering solutions.

Meanwhile, Delhi is thirsty for water. DJB has been always lagging behind in meeting its targets. Of course, some small measures were planned. For instance, it sought to recover the transition loss of 30 per cent due to unlined Western Yamuna Canal (WYC).

"To prevent this loss, a parallel channel is proposed to be constructed from Munak to Haiderpur. Under an agreement signed with the Haryana Government, the Delhi Government paid an advance of Rs 5 crore to the Haryana Irrigation Department in 1994-95 to execute the work. However, the Haryana Government has not yet started construction. Water availability will increase by 120 MGD on construction of this parallel channel." (DES 1999-2000)

The work after much delay started in 2003 to be completed in 27 months. But, at the time of writing this report, it is not complete as yet and the responsible agencies in Delhi and Haryana continue to squabble. Haryana Irrigation Department (HID) blames that last 600m could not be completed because DJB has not acquired the land. DJB confirms that it is in the process of acquiring land while counter blaming HID that it has not completed many portions in its jurisdiction, also. (Times of India, 14 July 2009)

DJB has been expecting extra 80 MGD from the new canal for water treatment plants - 40 MGD for Dwarka and 20 MGD each for Bawana and Okhla. This is a scale-down from earlier

expectations of 120 MGD. Even 80 MGD, if the estimations are correct, would be possible only if the work is completed.

To add to all this, HID has added a spanner in the whole scheme, turning DJB's plans into a kind of pipe dream. Reports suggest that the Capital will not get any extra water from the newly lined Munak Canal. To be precise, "not a drop out of any savings shall be given." (Times of India, 14 July 2009).

CLC already in use at Munak Headworks

A personal visit to assess the situation in the field reveals that this so called parallel canal is named as Carrier Lined Channel (CLC). Originating from Munak, some portions of this canal is already in use. The quality of work of lining of the channel gives one a feeling that by the time the work is completed, the lining in several parts may be requiring repairs!

Conclusion

Network water supply agency in Delhi, DJB, has been always lagging behind in meeting the demand. It is the result of delayed implementation of projects.

Forty (40) per cent distribution loss / leakage in the city is way above admissible average and reflects the inefficient functioning of DJB.

Inequity in supply is up to 20 times. Some people in the city get less than 25 lpcd while some others get more than 500 lpcd.

Ground water is depleting very fast. Every government agency agrees. But not much is being done about it. Instead some agencies like Delhi Metro and DDA are ensuring that the ground water disappears faster, with sealing the potential source of recharge of aquifers – the Yamuna flood plain.

Munak canal (CLC) still under construction!

Water Consultative Council to advice DJB on matters ranging from policy to consumer interest to environment was conceived in the DJB Act, 1998 and in fact, constituted in August 1998 but it did not meet even once in 10 years.

DJB dreamed of getting 120 MGD from Munak- Haiderpur Carrier Lined Channel (CLC) in 1994-95. The dream remains unfulfilled even after 15 years because of non-completion of the Channel and Haryana Irrigation Department now says, "not a drop out of savings shall be given".

Haryana Irrigation Department and DJB, the agencies responsible for providing water in Haryana and Delhi respectively, squabble over the non-completion of the project while people in Delhi wait endlessly!

Government agencies know that the ground water is contaminated and yet they do nothing to stop its usage (authorities, in fact, look the other way) because they know people will then ask for water which they do not have and hence cannot provide.

CHAPTER 2

Deteriorating Health of the Yamuna

Today river Yamuna figures very high on the list of the most polluted rivers in the world. The river is certainly a far cry from the early 1900s, when the Imperial Gazetteer of India, mentioned that the waters of Yamuna were distinguishable as “clear blue” compared to silt-ridden yellow of the Ganges.

Most of the pollution in the Yamuna is thought to occur during its journey through Delhi. There is a general presumption that water in the Himalayan segment and as it reaches Hathnikund Barrage is fine. But as we analysed the sources of pollution segment by segment, it’s clear that this presumption is mistaken and the river’s contamination begins fairly early in its journey. Although there’s no denying that the maximum amount of pollution does take place in Delhi.
To begin with let’s look at the main sources of pollution of the river

2.1 Sources of Pollution

There are several sources of pollution of rivers. Rising density of human population on the river banks and poor sanitation practices by residents is a major cause as are industrialization and discharge of effluents.

Abandoned Idols alongside a dead dog in a flow less river (30.11.2007)

In the case of the river Yamuna three main sources of pollution are untreated domestic wastewater; untreated industrial effluents and agricultural run offs. Undetected and untreated pesticide residues leave a toxic mark all across the river.

Untreated domestic wastewater falling into the river causes bacterial contamination. Other sources of bacterial contamination are open defecation near banks, dead body dumping and cattle washing. Untreated industrial effluents can be toxic and contain harmful heavy metals such as cadmium, aluminium and mercury. Agricultural run off to river carries chemical fertilisers and deadly pesticides including DDT, hexa chloro-hydrocarbons, and cyclodiene.

A significant source of pollution is religious activity and immersion of idols. To immerse puja left overs into flowing rivers is an age old practice. In recent times this practice has emerged as a major source of river pollution as often it is not just the puja left overs (flowers, *samagri*, dust, etc) but also polythene and household solid waste which are thus immersed. Idols of Ganesha, Durga and other deities made of Plaster of Paris and colored with toxic paints also find their way into the river and further pollute it. The pollution situation gets worse when such immersion takes place in a river like Yamuna, with little flow of its own in Delhi.

2.2 Segment by Segment Analysis of Pollution of River Yamuna

CPCB regularly monitors the entire 1376 km of river Yamuna under the National River Conservation Directorate (NRCD / MoEF) sponsored project and under National Water Quality Monitoring Programme (NWQMP). There are 21 sampling locations on river Yamuna. (CPCB 2007)

The CPCB reports that the water quality of river Yamuna has deteriorated at Paonta Sahib (Upstream of Tajewala), Kalanaur, Sonepat and Palla (upstream of Wazirabad). (CPCB 2008)

Contrary to popular belief that Yamuna is fairly clean until it reaches Delhi, there is now increasing evidence to show that the water at Hathnikund is no longer good for bathing, forget drinking. The FC/TC pollution level here is more than permissible limit for bathing at 500 MPN/100ml. (For detailed tables on water quality of the Yamuna river, with segment by segment break up refer to **Annexure 1**)

The Upper Segment

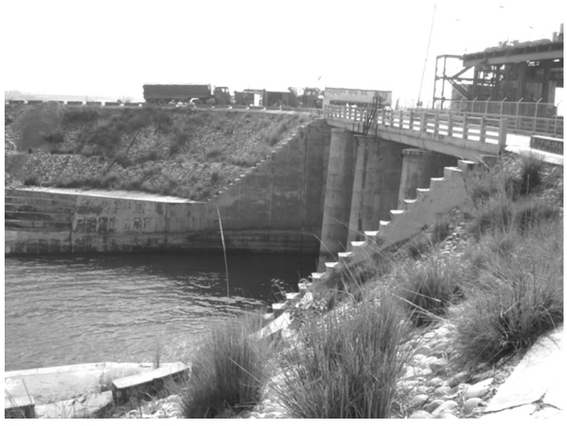
At Tajewala (now Hathnikund) in the upper segment, Yamuna's waters are diverted into two canals, the Western Yamuna Canal (WYC) and the Eastern Yamuna Canal (EYC) leading them into Haryana and Uttar Pradesh (UP). The WYC crosses Yamuna Nagar, Karnal and Panipat before reaching the Haiderpur treatment plant (which supplies part of Delhi's water), receiving wastewater from Yamuna Nagar and Panipat.

Hathnikund Barrage

Western Yamuna Canal

Drain 8 from Sonepat brings fresh water (back from the WYC) to the river Yamuna just few kilometres upstream of Wazirabad. The quality of water in WYC and the Yamuna upstream of Wazirabad is important for the mega-city of Delhi with its massive drinking water requirement.

At Yamuna Nagar and Jagadiri, industrial towns lying along WYC in Haryana, entire domestic and industrial effluents, treated, partially treated and untreated are dumped into the WYC. Unfortunately, there is no information in public domain about the quality of water downstream of Yamuna Nagar (CSE 2007). However, the Central Pollution Control Board (CPCB) notes that 'the Western Yamuna



Eastern Yamuna Canal

Canal (WYC) downstream of Yamuna Nagar at Damla is grossly polluted due to municipal and industrial wastewater disposal' (Status of water quality in India - 2007, July 2008). The situation at Damla worsens further with minimum DO touching zero and maximum BOD reaching 188 mg/l and Total Coliform 72,000,000 mpn/100 ml in 2008.

Deteriorating quality of water in WYC is illustrated by the following analysis (CSE 2007)

- DO level : According to MIS report of November 2005, the dissolved oxygen (DO) level at Tajewala and Kalanaur shows a decline from 1996 but even so they are much above the minimum level desired for bathing, i.e. 5 mg/l

Waste water from industries and other sources polluting Drain No 8 at Kundli (Haryana) upstream of Palla (6.8.2009)

Drain No. 8 (from WYC at Sonipat) meeting river Yamuna at Palla 6.8.2009

- BOD level : Though NRCD recorded BOD values in the river at Kalanaur at 1.30 mg/l during 2005 the levels almost reached 3 mg/l (maximum limit for bathing) during 2002 and 2004. Downstream along WYC, an analysis of HSPCB data revealed that the BOD is many times higher even at Dhanora escape along WYC, 22 km downstream of Yamuna Nagar. In March 2006, the BOD values were 39 mg/l
- Coliform : At Kalanaur, mean faecal coliform counts have increased from 431 to 12881 mpn / 100ml from 1995 to 2005

Pollution story at Yamuna Nagar does not end here. Here, the WYC is intercepted and the freshwater flow diverted into a lined canal – Augmentation Canal – and it flows away from the town. The water is only released into main WYC when the flow in Augmentation canal (AC) is more than 3,200 cusecs. As a result the WYC has no freshwater flow for most of the year. Thus, the canal accumulates domestic and industrial waste and remains polluted. When freshwater is released from the cross regulator at Yamuna Nagar, the accumulated waste is pushed downstream and let off finally into the Yamuna through Dhanora escape 22 km downstream of Yamuna Nagar. This causes a shock load (whenever water is released through the WYC) and leads to episodes of high pollution at water treatment plants in Delhi (CSE 2007).

Discussion: Upstream Wazirabad Status

There is a lot hidden behind the river monitoring statistics (annual, several years, from several stations). A river is a dynamic system and so is the water abstraction process and wastewater generation and its merging with the river. The impact of industries on rivers can never be fully gauged. At times, due to power failure or mechanical/technical fault, a STP (sewage treatment plant) may not be functioning properly. The first rains of the monsoon flush pollutants accumulated in the catchment area into the river. There are numerous instances when there is sudden shock load of pollution and WTP (water treatment plant) may not be capable of treating such polluted raw water.

According to sources in the Haryana State Pollution Control Board's (HSPCB) regional office in Yamuna Nagar, 'there have been sporadic episodes of heightened pollution, when the river has lost the ability to breathe and bear life' (CSE 2007). An example of such a situation would suffice here. In March 22, 2006, 12 km upstream of Kalanaur, sudden fish deaths were reported in the Yamuna. According to HSPCB's regional officer, Chand Saini, this pollution occurred because of Kaskara Nala – a wastewater drain upstream – discharged sugar mill and distillery effluents from Kamalpur in Saharanpur district in UP illegally into the Yamuna. Saini says that BOD level in the drain was then about 57 mg/l.

The alarming level of pollution at Yamuna Nagar is acknowledged by CPCB also in its 2007 report.

Population, industries, and developmental activities are increasing upstream of Wazirabad as is the case downstream. There is increasing abstraction of raw water from river and consequently more wastewater is generated.

The data capturing by CPCB's river monitoring unit also bears scrutiny. For instance, at Sonepat in February 1995 despite DO being 10, BOD is high at 5; in the same year at Palla during March, the DO was 9.30 while the BOD remained high 9.00. How can two related indicators show inconsistent results for the same tested water?

No flowing water (only standing pool) in river Yamuna at Panipat on 7 8 2009

CSE 2007 finds a dearth of data and little that exists cannot be trusted for taking decisions or formulating strategies. In all the towns surveyed along Yamuna there are stories of figures not tallying and agencies coming up with contradictory figures that lead policy planning astray and derailing river cleaning strategies.

Furthermore, 90 per cent of Yamuna water is diverted to WYC and EYC and there is hardly any fresh water to dilute the untreated or partially treated wastewater and industrial effluents flushed into the river by Haryana towns upstream of Wazirabad. A personal visit in August 2009 to Yamuna at Hathnikund, Yamuna Nagar, Panipat, Palla (upstream) revealed no flow in the river at all even at the height of the monsoon season.

TABLE 2.1: DESIGNATED BEST USE CLASSIFICATION BY CPCB

Designated-Best-Use	Class of water	Criteria
Drinking water source without conventional treatment but after disinfection	A	1. Total Coliforms Organism MPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (organised)	B	1. Total Coliforms Organism MPN/100ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less 2. pH between 6 to 9 3. Dissolved Oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 to 8.5 2. Dissolved Oxygen 4mg/l or more 3. Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25°C micro mhos/cm Max.2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/l

Conclusion

Pollution upstream of Wazirabad is increasing, as is acknowledged by latest monitoring reports of CPCB, detailed study by Centre for Science and Environment (CSE) and occasional shut down of WTPs in Delhi when it becomes impossible to treat the heavily polluted raw water.

Delhi's role in the Pollution of Yamuna

The Delhi stretch of Yamuna is largely defined as its 22 km course from Wazirabad to Okhla barrages. The health of Yamuna in Delhi is aptly summarised by (CSE 2007): "Yamuna in Delhi is barely 2 per cent of its entire length but according to CPCB it contributes over 70 per cent of total pollution load. 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. What that flows subsequently is only sewage and waste."

Within Delhi for most of the year, Nizamuddin and Okhla see DO levels falling to around zero. This is true even during monsoon (when the DO level did not reach 5 mg/l from Jan 2002-May 2006). BOD concentration measured during Jan 2002-May 2006 ranged between 50 mg/l and 59 mg/l at Okhla and 38-41 mg/l at Nizamuddin (far more than the acceptable 3 mg/l). Year 2006 was the worst. BOD levels in the river touched 119 mg/l and 144 mg/l in January and February at Okhla. This indicates a complete failure of pollution control measures. As for the coliform count, it has increased so much that it is difficult to count the zeros. The value observed at Nizamuddin in February 2005 was 1970 million MPN/100 ml which declined to 190 million MPN/100 ml in Feb 2006. At Okhla the count in May 2006 was 6.1 million MPN/100 ml (CSE 2007)

CPCB data corroborates this. Even way back in 2001-02, it reported that the Delhi segment (of the Yamuna) was the most polluted. The anaerobic condition in the river is frequently reflected by masses of gaseous sludge rising from the bottom and floating on the surface. (CPCB Annual Report 2001-2002)

Major sources of pollution of Yamuna in Delhi are untreated domestic wastewater and untreated industrial effluents reaching the river through a network of drains. There are 22 major drains in Delhi of which 17 drains join the Yamuna, three join Agra canal and one joins Gurgaon Canal.

According to the official statistics from March 2007, sewage treatment capacity of 512.4 MGD (2321 mld) existed, but treatment was possible of only 341.4 MGD (1546 mld) – in other words, the utilisation was 67%. The reasons outlined for low utilisation were 'low flow of sewage to STPs, trunk and peripheral sewer lines still to be connected to STPs', and so on. The sewage generation was estimated to be around 676 MGD (3062 mld). The calculation taken being 720 (water production) X 0.8) + 100 (Private ground water abstraction). Treatment was done only on around 341 MGD (1546 mld) of sewage. Thus untreated sewage to the tune of 335 MGD (1518 mld), or about 50 per cent, falls into the river Yamuna and is the major cause of river pollution. (Delhi Economic Survey, 2008)

The situation has clearly not improved even more than two years later. In a statement on 8 July 2009, MoS for Environment and Forests, Jairam Ramesh informed the Lok Sabha that "a treatment capacity of around 2325 mld is available in Delhi. However, due to silting and settlement of trunk sewers, treatment capacity of only 1570 mld is presently in use."

TABLE 2.2: SEWAGE TREATMENT IN DELHI AS ON 31 MARCH 2008

S. No	Name of STP	Capacity (MGD) As on 31.3.2001	Capacity (MGD) As on 31.3.2007	Actual treatment in MCD as on 31.3.2007
1.	Okhla	140	140	130
2.	Keshopur	72	72	50
3.	Coronation Pillar with oxidation ponds at Timarpur	46	46	23
4.	Rithala	40	80	40
5.	Kondli I, II, III, IV	45	45	50,30
6.	Yamuna VIhar I, II	10	20	7.3
7.	Vasant Kunj	5	5	4.50

8.	Ghitorni	5	5	0
9.	Pappankalan	20	20	7.00
10.	Narela	10	10	1
11.	Najafgarh	5	5	1
12.	Delhi Gate	2.2	2.2	2.4
13.	Sen Nursing Home	2.2.	2.2	2.4
14.	Rohini	-	15	0.5
15.	Nilothi	-	40	19
16.	Mehrauli	-	5	1.89
	Total	**402.4**	**512.40**	**341.39**

Coronation Pillar 40 + Oxidation Ponds 6. The capacity was same on 31 March 2008 also. (Delhi Economic Survey, 2008)

As for the industrial waste discharge in November 2004, the Baijal Committee quoted NEERI as saying that industrial wastewater generated in the city was around 180 mld (CSE 2007). With various directions from the Supreme Court, a network of Common Effluent Treatment Plants have been created.

TABLE 2.3: CETPs IN INDUSTRIAL AREAS BEING MAINTAINED BY DSIIDC AND MINI STPs BY SLUM & JJ DEPTT. (MARCH 2007)

S.NO.	Name of STP	Installed Capacity (MLD)	Treated Water Available Per Day (MLD)	Treated Water in MLD
DSIIDC				
1.	Mayapuri	12	8	
2.	Wazirpur	24	15	
3.	CETP GT Karnal Road	6	4	
4.	Jhilmil	16.8	3	
5.	Nangloi	12	3	
6.	Mongolpuri	24	1.5	
7.	Lawrence Road	12	3	
8.	SMA	12	1.5	
	Total	**118.8**	**39.00**	**8.6**
SLUM & JJ				
1.	Molar Band Mini STP	30 lakh ltr.	6	
2.	Bakkarwal Mini STP	30 lakh ltr.	4	
3.	Holambi Mini STP	20 lakhs ltr.	-	
4.	Tikri Khurd Mini STP (Narela)	20 lakhs ltr.	-	
	Total	**100 lakhs ltr.**	**10**	**2.4**

Delhi Economic Survey, 2008

2.3 Pollution of Yamuna in Delhi

Given that the waters of the Yamuna are visibly black with filth, and stinking badly, no tests are really needed to verify its quality or health. The river is a repelling sight full of foul smelling water with load of pollutants floating and gases oozing out. Centre for Science and Environment's director, Sunita Narain says that 'the river is dead it just needs an official cremation'. Other experts have not been less scathing in their comments.

According to an ASSOCHAM (2008) report, "coursing through the capital, the river becomes a noxious black thread. Clumps of raw sewage float on top. Methane gas gurgles on the surface. It is hardly safe for fish, let alone bathing or drinking".

Data on water consumption and consequent wastewater generated is always confusing due to unspecified use of ground water. Thus, different agencies point out different figures for wastewater generated in Delhi. For instance, estimations are ASSOCAM (2008) - 4303 mld, CPCB - 3,853 mld (2007) and DJB -2,934 mld (2007) as quoted by Sarkar et al (2007).

The waste water can be actually measured or estimated from water used. The flaw here is that there is no accurate data on water used. An example quoted by (CSE 2007) will suffice. "The most glaring example of underestimation is Delhi, where CPCB has assumed water supply to be 210 litres per capita day (lpcd) and on this basis calculated a wastewater flow of 2,582.64 mld. This is 1,100 mld short of figure of 3,684 mld provided by the same agency, when under SC directives it measured the wastewater flow of the drains flowing out of Delhi.'

However, there is no dispute about the sewage treatment capacity in Delhi. Delhi Economic survey (2007-08), Sarkar et al (2007) and MoS Jairam Ramesh's statement in the Lok Sabha as recently as on 08.07.2009 both confirm that together Delhi's 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 at present in use.

By the government's own admission about 50 per cent sewage waste water goes untreated into the river. As in the case of increasing water supply always lagging behind in meeting increasing demand due to targets not being met on time or faulty planning, waste water generation and treatment too suffers from the same problems. Never ever has there been a situation when the concerned government agency has been able to treat all the waste water, whatever the quantity or capacity for treatment.

TABLE 2.4: WASTE WATER AND TREATMENT CAPACITY IN DELHI IN MILLION LITRE PER DAY (MLD)

Year	Waste Water	STP Capacity#	Gap
1951	260*	190	70
1991	1,630	1,227	403
2001	2,650	1,823	827

Delhi Human Development Report 2006
 # Treatment capacity. Actual treatment has always been way lower.
** for year 1961*

CPCB is regularly monitoring these 18 drains in Delhi on a monthly basis, noting the discharge and pollution load in terms of BOD. The total discharge and pollution load in terms of BOD from these drains meeting Yamuna and Agra Canal and Gurgaon Canal since 2000 is tabulated in

Table 2.5. The total discharge of around 50 cum/sec may seem higher than most estimates quoted above because it includes the fresh water which is being released by Haryana state (app. 7 cu m/sec) into Yamuna through Najafgarh drain for its supply into irrigation canals downstream of the state.

The BOD load in 2000 appears to be more than 2007 because at that time the city had 20 per cent less sewage treatment capacity. Regarding increase in BOD load in 2007, CPCB's analysis (2007) is that 'either generation of BOD load in the city has increased or there is decrease in treatment efficiency of sewage treatment plants (STPs).'

TABLE 2.5: WASTEWATER DISCHARGE TRENDS OF DELHI

Year	Total flow cu m/sec	Total BOD Load in tonne/day	BOD load received by Yamuna t/d*
2000	46.30	311.05	283.98
2001	47.73	259.61	231.20
2004	42.65 – 2.8%	277 – 15%	NA
2005	42.65	277.00	229.00
2006	50.00	265.00 – 13%	NA
2007	50.00	265.00	215.00

CPCB Annual reports and Parivesh Highlights
**Rest is received by Agra and Gurgaon Canals*
NA – Not available

TABLE 2.6: DETAIL OF HEAVY METAL POLLUTION IN DRAINS / NALLAHS

S. No.	Metal	Standard as per EPA	Actually Measured from Drains
i)	Copper	9	28 to 770
ii)	Lead	2.5	40 to 454
iii)	Nickel	52	20 to 153
iv)	Zinc	120	138 to 12,600
v)	Mercury	0.77	17.4 to 462

Besides, presence of free ammonia was ranged between 1.64 to 6.73 mg/l against the prescribed standard of 0.02 mg/l and below. (CAG 2005)

The gross pollution of Yamuna by Delhi wastewater in term of heavy metals is indeed a matter of great concern.

There is an interesting sidelight to this stinking story of pollution of Yamuna. Delhi Pollution Control Committee (DPCC), which is supposed to be a watch dog on environment simply washes its hands off the pollution of Yamuna in Delhi by penalising DJB which is responsible for cleaning wastewater before it meets Yamuna and fails to do so consistently. DJB, on its part, is making the consumers to pay the penalty levied upon Delhi Jal Board (DJB) for non-treating of sewage water. It is charging three paisa per kilolitre water from the consumers. Strangely, the consumer is being forced to pay for the failure of Delhi Jal Board to treat sewage water. (Kumar 2009)

How good is the treated wastewater that meets the river, depends on the treatment technology used and quality parameters prescribed and actually achieved after treatment.

In Delhi all STPs are based on the aerobic principle (where oxygen is used to decompose organic matter). As much as 88 per cent of the treatment capacity created is based on the activated sludge process (ASP), which involves screening, oil and grease removal, settling, aeration (where the bacteria feeds on organic matter in the presence of oxygen) and secondary settling (98 per cent of STPs). Only two per cent systems are based on advanced processes. These include high load aeration and bio-filtration (for tertiary treatment) or attached growth process like tricking filters - fluidized aerobic bioreactor (FAB) or Submerged Aerobic Fixed Film (SAFF) process. The only oxidation pond in Delhi is in Timarpur. (CSE 2007)

As for the quality of treated sewage (CSE 2007) is concerned that the average coliform count in treated effluents runs into millions (46 million MPN/100ml). Beyond the conventional treatment, CSE finds that the policy-makers are not even beginning to look at the crucial pollutants like pathogens, nutrients (nitrogen and phosphorous) and micro pollutants (DDT, aldrin etc).

Sarkar (2007) too questions the qualities of sewage treatment plants. He feels that treatment only on the basis of three parameters - BOD, COD (Chemical Oxygen Demand) and TSS (Total Suspended Solids) is inadequate. The key issue is that the waste is full of pathogens deadly to our health. Only in some plants, such as those built using Yamuna Action Plan funds, do the National River Conservation Directorate's (NRCD) set coliform standards (1000 MPN/100 ml) apply. But in these plants, the disinfection units, which use ultraviolet radiation to kill coliform, are invariably out of order. Other plants, where CPCB standards apply, do not have a coliform standard, for no such design requirement is applicable to them. In other words, these expensive plants can be built, and still pollute.

CSE 2007 finds that 'by 2006, capital investment totalling Rs 1188-1491 crore under YAP I and its extension period has literally gone down the drain. And the pollution level in the river has gone up.'

TABLE 2.7: MONEY DOWN THE DRAIN?

Capital Investment to clean Yamuna in Delhi	Rs. Crore
YAP I spent in Delhi	19.94
YAP Extended in Delhi	166.62
17 STPs with a capacity 2330 mld	745.6 – 1048.5
15 Common Effluent Treatment Plants	256
Total	**1,188.16 – 1,491.06**

Now, DJB has come up with another sewage treatment proposal – an interceptor plan, estimated to cost around Rs 4,000-5,000 crore. CSE, which has been closely reviewing status of sewage treatment in Delhi is highly critical of the plan and feels that this money too, like prior efforts, would go down the drain.

Conclusion

STPs in Delhi are being created and remain under utilised. Around 50 per cent waste water joins Yamuna untreated nullifying the effort and money, spent on treatment of the rest.

The actual functioning of STPs and the treatment standards are such that even treated water remains grossly polluted in the context of coli forms, micro-nutrients and pesticides.

2.4 Yamuna Water Treatment in Delhi and its Quality

Until 1993, Wazirabad and Chandrawal, built during the British period, were the main WTP (water treatment plant) on the Yamuna for Delhi. At present, Delhi's water treatment plants -Wazirabad, Haiderpur, Chandrawal, Bhagirathi (part) – receive water from Yamuna or its waters routed through WYC (DJB 2007). Even the Sonia Vihar plants get water from the Yamuna when the Ganga Canal is shut down. (Treatment plants and their capacities are given in Table 1.3 of this report).

Water treatment is based on conventional treatment technology. For instance, the Okhla WTP uses Ozone technology because it is treating ranney well water. The process involves settling, coagulation, percolation, filtration and curing.

Alum-Ferric (alum) and/or Poly-Aluminum Chloride (PAC) are used in the treatment process for coagulation. For destruction of pathogens, reactive chemical agents, such as chlorine is used. According to Dr D. D. Basu (CPCB), heavy metals precipitate in the treatment process.

According to sources, raw water is first tested and used for treatment, if it is within the capacity of treatment plant to treat. The treated water is tested and is supplied only if it is potable. An RTI reply relating to Sonia Vihar WTP reveals that there is an in-house testing lab where water testing is done every hour as per WHO standards before releasing from plant and there has been no incidence of treated water being found to be contaminated during 2008-09.

Discussion: Drinking water quality in Delhi

According to official version of network water supplier, DJB, there is no possibility of contaminated water being supplied. But MCD (Municipal Corporation of Delhi) regularly tests drinking water at various points and generally finds a large number of samples unfit for consumption. In 2004, 16 per cent of water from various sources were deemed unfit (coli-form positive). Hand pumps, water from private water trolleys and stored water of DJB are more contaminated. In all, 95.6, 43.9, 24.4 percent samples were found unfit from hand pumps, water trolleys and DJB stored water respectively. It is alarming that one-fourth of the samples of DJB stored water were found unfit. (Sarkar et al 2007)

The situation remained equally grave in 2009. The Municipal Corporation of Delhi (MCD) has found 15 per cent of the Delhi's water to be unfit for drinking. Out of the 765 samples taken to test the purification level of drinking water, 90 samples came out to be unfit. In south Delhi, the contamination is highest with 50 per cent of the samples declared polluted. (Chandel 2009)

In a study on analysis of the microbiological flora of the water supplied for drinking purposes by Prof Sarman Singh (2000) of AIIMS found that Delhi water is biologically contaminated. The study reveals that even direct tap water was found contaminated in more than 50 per cent samples. The commonest isolates were from protozoan category - the free living amoeba (90.1 per cent) and aerobic bacteria (73.0 per cent).

Whenever an explanation is sought from any government agency or institution related with water supply or testing for contaminated water reaching consumers, a standard answer is given.

"The water supplied is of standard quality. It's during the distribution that things go wrong. The supply lines are not properly sealed." Other reasons given are that people use booster pumps to draw supplied water. When the pipe line is empty and booster pump is used, it creates a negative pressure in the pipe due to which surrounding pollutants get sucked into the pipe line and reach the consumer mixed with water, when supplied. It does not sound convincing that this could be the only reason for contaminated water reaching a consumer.

How serious is the government about water and its quality is reflected in the way it neglects WTPs. One example would suffice here. Chandrawal water treatment plant has been in dire need of renovation for about a quarter of a century now. Despite approval of the renovation work as early as in 1988, the actual award and execution of work has been delayed for about 20 years. Delay in carrying out necessary renovation and replacement of filters would affect cost-effectiveness and efficiency of operations of the plant. The concerned Executive Engineer (E&M) stated in September 2007 that delay in finalisation of renovation work has led to deterioration of the condition of the plant to such an extent that no repair was possible except for its complete replacement. EE further states that DJB was incurring substantial expenditure on maintenance of old filter media and the efficiency of the units had drastically reduced. To maintain the supply, extra labour was required. If the implementation was delayed further, the units might totally collapse leading to reduction in filtering capacity and, thus, the production. (CAG 2008)

The CAG (2008) report seriously questions the quality of chemicals used at WTPs. Although standard ensuring procedures are laid down where "the Department is required to get the samples of alum/PAC picked up at random and tested at the National Physical Laboratory (NPL), New Delhi once in a month in the presence of the officials of Director General Supplies and Disposal (DGS&D), firm's representatives and DJB".

Nevertheless, the standard procedure, was grossly overlooked and CAG Audit scrutiny revealed that only 13 samples were lifted during 2004-07 of which seven samples (54 *per cent*) did not conform to I.S. specification. DJB's callous attitude about using non-standard chemicals does not end here because "by the time the test results were received from NPL, the substandard alum/PAC had already been utilised during the course of treatment process of potable water. Thus, there was no mechanism which assured DJB about the purity and effectiveness of the chemicals before they were actually used in water treatment." Furthermore, the handling of the material by DJB is such that the substandard "material cannot be traced as it gets mixed with other supplies and consumed at the plant".

In such a situation, CAG rightly points out that "use of untested chemicals for treatment of water may seriously compromise the quality standards of water supplied to the residents of Delhi".

There are regular reports in national dailies about supply of contaminated water by DJB. Is this also a reflection on quality of water treatment?

At times, people complain of foul smell or dirty water in supplied tap water. This generally happens when excessive chlorine is used to get rid of heavy pollution load and the residual chlorine is more than the permissible limits. R. K. Garg, Member, DJB voiced this. He explained "The reason is industrial pollutants from Panipat mixing with the Yamuna water." (Times of India, 8.6 2009)

Suspected treated water quality is corroborated by CAG (2008) Audit examination which disclosed that the number of samples found unsatisfactory has "increased considerably during last four years from 0.73 per cent in 2002-03 to 2.85 per cent in 2005-06 and 1.88 per cent in 2006-07".

What is worrisome is that the Directorate of Quality Control of DJB does not seem to be taking these test reports very seriously. In 2006-07 it did not appear to have taken action in 90 per cent of the cases of unsatisfactory samples from treatment plants. (CAG, 2008)

Conclusion

DJB's words do not match its deeds. From the CAG reports, frequent newspaper reports on contaminated water supply, and finding of several researchers it is evident that the quality of network water supply is suspect.

2.5 Quality of Ground water

Ground water quality was a serious issue even 30 years ago. So much so that a question about cadmium pollution of ground water in UT of Delhi (now NCT of Delhi) was raised in Rajya Sabha (Starred Question No. 216) on Mach 26, 1980. This forced the CPCB (then known as Central Board for the Prevention and Control of Water Pollution) to undertake first monitoring and surveillance study to know the water quality status of the groundwater in Delhi (and adjoining areas of Haryana and Uttar Pradesh). In the investigation in 1981, 7 out of 150 samples contained cadmium more than the international drinking water standard (i.e. 0.01ppm).

The detailed report given in Table 2.8 indicates the problem in ground water quality on several other counts. Iron – 15 percent, Fluoride - 59 percent, Total Coliform - 60 percent and Faecal Coliform - 48 percent samples did not meet the maximum permissible limit standards. (CBPCWP 1986)

TABLE 2.8: MAXIMUM PERMISSIBLE LIMITS AND OBSERVED VALUES OF PARAMETERS IN THE GROUNDWATER OF DELHI AND AROUND

Maximum permissible		Frequency distribution of actual observed values	
Parameters	**limits for drinking waters (ug/l)**	**No. of samples out of 150 samples**	**Concentration (ug/1)**
Cadmium	10	143	<10
		6	10- 20
		1	20-30
Lead	100	147	<100
		3	100-300
Chromium 50	50	150	<50
Zinc	15,000	150	<15,000
Copper	1,500	150	<1,500

Iron	1,000	127	<1,000
		12	1,000-2,000
		6	2,000-3,000
		5	3,0000-5,000
Fluoride	1,000	61	<1,000
		43	1,000-2,000
		36	2,000-3,000
		10	>5,000
Total Coliform (MPN/100 ml)	1.0	60	<1
		40	1-10
		32	10-100
		18	>100
Fecal Coliform (MPN/100 ml)	1.0	78	<1
		35	1-10
		29	10-100
		8	>100

Central Ground Water Board in its report Development and Augmentation of Ground Water Resource in NCT of Delhi published in 1996 presented the ground water quality monitoring report of shallow aquifer zones being developed for drinking and irrigation purposes as follows:

Salinity: In the areas east of the ridge and in the Chattarpur basin, the ground water is characterized by low salinity - ground water being very fresh (EC:<1000 microsiemens/cm) in the Chattarpur basin and adjoining north-eastern areas, and the flood plains of river Yamuna. In the areas west of the ridge comprising blocks of Najafgarh, Kanjhawala, Alipur, City (part) and Mehrauli (part) the salinity of ground water generally increases towards southwest and northwest directions - being fairly high (EC:>3,000 microsiemens/cm) in areas around Dhansa, Roata in southwest, and Auchandi, Kutabgarh, Jaunti, Kanjhwala and Tikrikalan in the northwest. Besides small patches having highly saline ground water are located around Sanoth in Alipur block, Rithala in Kanjhawala block, Janakpuri in the City block and Saboli in Shahdara block.

Occurrence of high concentrations of NO_3 in ground water is one of the major problems of water supply in Delhi. As observed, NO_3 concentrations are more than 100 mg/l, (the permissible limit for drinking water) at several locations. In the IIT Delhi Campus, NO_3 content in ground water is as high as 560 mg/l. In NCERT Campus, it ranges between 106 to 940 mg/l. Tubewell from a location near Sulabh Sauchalaya in Naraina (City block) contains 850 mg/l of NO_3. In Shahbara block at Saboli, NO_3 content of 1600 mg/l is observed in ground water. A sample from piezometer constructed at Kutabgarh in Kanjhawala block contains 1000 mg/l of NO_3. Such high levels of NO_3 in shallow ground water could be due to its leaching from solid wastes, discharge from sewage water and excessive use of fertilizers. It is observed that ground water in the vicinity of the landfill in Yamuna flood plains have high NO_3 contents (upto 250 mg/l). Similar situations prevail in IIT and Naraina land fill areas also.

Fluoride concentrations in ground water in Delhi area are more than the permissible limit (1.5 mg/l) at several places. The point values of high fluorides in general are up to 5 mg/l however higher values up to 13.8 mg/l have also been found. (CGWB 1996)

For Mercury contamination, in one study, ground water was tested at 57 locations. Mercury was not traceable in all but one sample from Sarai Kale Khan, where it was 1.57 ug/l, which is slightly above the maximum permissible limits (0.001 mg/l or 1.0 ug/l) for drinking water. However, presence of mercury in ground water collected from Sarai Kale Khan may be attributable because of the fact that this location is the area reclaimed from old garbage landfill site. (CPCB 2003)

According to Maria (2004), along with salinity, fluoride concentration is a major constraint to safe groundwater use for water supply. Fluoride concentration exceeds the WHO norms of 1.5 mg/L in 30 per cent of the NCT of Delhi area. In addition to this, Delhi's groundwater resources are subject to various forms of pollution. Nitrate and pesticides are generated by agricultural activity in the rural areas in and around the NCT Delhi, heavy metals are accumulating due to urban run off infiltration, and bacteriological contaminations affects most shallow aquifers.

An assessment of microbial load of different types of water and the prevalence of emerging waterborne pathogens, with samples collected from the entire region of the city of Delhi revealed "all groundwater samples (100), whether collected from shallow or deep bore pumps, showed the presence of coliforms". The presence of coliforms of faecal origin in a majority of these samples showed that microbial contamination in groundwater was widespread and even deeper layers of groundwater may not be regarded as free from disease-causing micro-organisms. (Sharma, et al 2003).

Arsenic level in 49 ground water samples collected from different areas of Delhi was analysed. It was in the range of 0.0170 to 0.100 ppm - minimum concentration at Ranney Well no. 7 (0.0170 ppm) and maximum at Kotla Mubarak Pur (0.100 ppm). The current drinking water quality guideline by WHO for arsenic is 0.01 ppm. Thus, in all the areas arsenic level in ground water is more than permissible limit of WHO. (India Water Portal www.indiawaterportal.org)

Discussion – Ground water quality

Ground water abstraction in Delhi is diffused but quite extensive due to non-fulfilment of demand by DJB and certain areas not being connected to network due to their designation as unauthorised. Thus, the quality of ground water is not so much in the news or in focus. Nevertheless, several studies – by government agencies as well as independent researchers – reveal that the contamination of ground water is a very serious issue.

The questionable quality of groundwater is decades old and the situation is getting from bad to worse. In the investigation in 1981, CPCB found 5 per cent samples contained cadmium level more than the international drinking water standard (i.e. 0.01ppm). The report found problem in ground water quality on several other counts. Iron – 15 percent, Floride - 59 percent, Total Coliform - 60 percent and Fecal Coliform - 48 percent samples not meeting the maximum permissible limit standards.

A report of Central Ground Water Board in 1996 revealed the occurrence of high concentrations of NO_3 in ground water is one of the major problems of water in Delhi. Maria (2004) points out

Nitrate and pesticides are generated by agricultural activity in the rural areas in and around the NCT Delhi and Sarkar (2007) adds that partially treated waste water from septic tanks enter into the soil absorption systems, and causes high local levels of nitrates in soils. Rainfall washes the nitrate from the soil into streams and ground water.

Fluoride concentrations in ground water in Delhi area are more than the permissible limit (1.5 mg/l) at several places. The point values of high fluorides in general are up to 5 mg/l however higher values up to 13.8 mg/l have also been found (CGWB 1996). This is further substantiated by ASSOCAM (2008) report that 50 per cent of the area (in Delhi) is affected by fluoride pollution with levels of fluoride being 3-4 times higher than the desirable limit while Sarkar (2007) brackets National Capital Territory of Delhi among the states where 40-70 per cent districts are affected with Fluorosis.

In a study cited by india water portal, arsenic level in ground water from different areas of Delhi was analysed and alarmingly found to be more than permissible limit set by WHO. (http://www.indiawaterportal.org/tt/gwm/res/iaft04i2p135.pdf)

CPCB perhaps found ground water contamination with mercury at Sarai Kale Khan because this location is the area reclaimed from old garbage landfill site. (CPCB 2003). It would be important to watch for such contamination at other land fill sites also on a regular basis.

Microbial contamination in groundwater which was found to be 60 per cent samples having Total Coliform and 48 per cent samples Fecal Coliform (CPCB 1986) reached its nadir with 100 percent of ground water samples whether collected from shallow or deep bore pumps, showing the presence of coliforms. (Sharma et al 2003).

DJB extracts as much as 100 mld of ground water with tubewells and Ranney Wells. Okhla WTPs uses Ranney well water. It is reported that a very expensive Ozone treatment process is used, most likely due to the level and kind of pollution of ground water drawn from Ranney wells (personal communication, Dr D.D. Basu, CPCB).

Conclusion

Much of the groundwater in Delhi besides disappearing fast is unhealthy with virtually all kind of contaminants (more than the maximum permissible limit) –Nitrate, Arsenic, Fluoride and coliforms. There are even areas in Delhi with Cadmium, Mercury and other heavy metal contamination in ground water.

TOXIC VEGETABLES: THE FRUIT OF SICK RIVER YAMUNA

A common sight in Delhi is a number of vegetable vendors sitting on the bridges spanning Yamuna, unmindful of the traffic and bustle. People returning from work usually stop by to pick up turnips, radishes, cauliflowers and leafy greens from these vendors in the belief that these are good quality, freshly harvested vegetables right from the Yamuna flood plains. Little do they know that these vegetables are probably highly toxic, and potentially harmful?

Several research findings indicate that vegetables irrigated, washed or cooked with polluted water get contaminated with pathogenic organisms causing water-borne diseases.

According to MCD officials, the rise in typhoid cases in Delhi from 1997-2003 was due to eating of raw vegetables as salad. Waters of the river Yamuna, which is the dumping ground of Delhi's sewage system, are also used to irrigate crops of vegetables in trans-Yamuna and downstream areas. Common vegetables grown in these regions are consumed raw and contain all kinds of pathogens including Salmonella typhus, typhoid bacteria.

Preliminary data from a study on Geo-accumulation and Bio-accumulation of heavy metals and pesticides indicated that vegetables grown on sewage irrigated soil have traces of heavy metals and pesticides that are harmful for human consumption (CPCB 2003)

Vegetables grown in semi-urban areas that use industrial wastewater for irrigation have high levels of heavy metals such as lead, which is neurotoxic to brain, and cadmium, which can cause cancer, according to a recent study by Indian and UK scientists. The study was carried out from 2003-2007 in three areas of Varanasi-Dinapur (in the vicinity of the city's major sewage treatment plant), Shivpur (to the north east of the city, close to the Shivpur industrial area) and Lohta (to the west of the city close to several industrial areas).

The heavy metals sampled included zinc, lead, copper, cadmium, chromium, manganese and nickel. Of these, potentially the most toxic are cadmium and lead. These heavy metals are widely associated with many small-scale industries in Varanasi that include metal works, paper manufacturers and chemical and paint works. Vegetables such as spinach, radish, brinjal, cauliflower, tomato and cabbage were tested. (Toxics Link, 2007)

A study in Bangladesh traced the presence of arsenic in food chain. Rice from contaminated regions contained dangerous level of arsenic as compared to crops grown elsewhere. (Sarkar et al 2007)

Although there are no studies to correlate rising toxicity of vegetables with increasing incidences of cancer in Delhi, leading doctors in Delhi have already started warning their patients about the pitfalls of consuming raw vegetables. Gone are the days when it used to be suggested that vegetables and fruits should not be peeled as the nutrients lie closer to the skin. Prof Sarman Singh, Professor of Microbiology at the All India Institute of Medical Sciences (Personal communication, 1 May 2009) says that pathogens of waterborne diseases enter vegetables and mostly get deposited on the surface due to irrigation and / or washing with contaminated water. Food cooked with such water too gets contaminated. The leafy vegetables are most dangerous.

At leading Delhi-based nutritionist, Ishi Khosla's clinic, patients who come for weight loss programmes who were earlier advised to eat raw salads are now advised to have them steamed or to buy only from shops which are known to source organically produced uncontaminated vegetables.

It is thus presumed that with the river's health deteriorating, the poison from its toxic waters is entering the blood stream of Delhi's residents through contaminated vegetables!

CHAPTER 3

Increasing Health Burden Of Delhi's Residents

In the public health domain, the right to health is now recognized as a basic human right. Access to safe drinking water, sanitation and a clean air are all now in the public discourse as the right of every citizen.

In Delhi, the burden of ill-health among its estimated 17.6 million population has been noticeably increasing. How closely linked is the rising disease burden of India's capital city with the river Yamuna's growing pollution is the key question.

There have been some global studies correlating the health of dependent communities with the health of the river. For instance, the findings of a 2002 public health project correlating the health of people in the Wairarapa with the health of river Ruamahanga in New Zealand (www.wairarapa.dhb.org.nz) are relevant. In this study, a Health Impact Assessment was done on the local population based near the river and measured against the average health of the rest of New Zealand population. As compared to the rest of the country, the predominantly Maori settlers near the river were found to fare poorly on the health parameters measured. In the study, the definition of health encompassed the physical, social, emotional and spiritual dimensions.

While the growing degradation of river Yamuna certainly has spiritual connotations for the residents of Delhi – after all it is considered one of the most sacred rivers of the country, in this study, we have not looked at these parameters, as these are hard to quantify,

The direct physical linkages on people's health however can be easily established by the growth in the incidents of waterborne diseases in the Capital city. In the previous section, the worsening quality of the river has been clearly established. In this section, despite the paucity of data, there is clear evidence that water borne diseases and water related diseases are on the rise in Delhi.

First, a brief look at the major waterborne diseases and the hazards they pose.

3.1 Waterborne Diseases

The major pathogens responsible for water-borne diseases (both diarrhoea and non-diarrhoea) are bacterial like E. coli, Shigella and V. cholera and viruses like Hepatitis A, Hepatitis E, Polio virus and Rota virus.

These pathogens are the result of contaminated water, improper sanitation and poor hygiene. Some water-borne diseases like viral hepatitis A & E and typhoid fever may not cause diarrhoea. A number of parasitic diseases (hook worm and other worm infestations) may not necessarily be water-borne, but they are included, as their presence in human body is essentially linked to poor sanitation and hygienic practice. But sanitation and hygiene cannot be separated from water as the former are generally the result of deficiency of water.

Some common waterborne diseases are described in the following section.

Diarrhoea

Diarrhoea is not a disease. It is a symptom of gastrointestinal infection that may be caused by bacteria or parasitic organisms most of which can be spread by contaminated water, food or soil.. The three most deadly diarrhoeal diseases are cholera, bacillary dysentery and gastroenteritis. Others include amoebic dysentery, giardiadis, salmonella, camplyo-bacteriosis and cryptosporidiosis.

Water contaminated with human faeces from municipal sewage, septic tanks and latrines is of special concern. Animal faeces also contain microorganisms that can cause diarrhoea. Water can contaminate food during irrigation, and fish and seafood from polluted water may also contribute to the disease.

Diarrhoea occurs world-wide and causes 4 per cent of all deaths and 5 per cent of health loss to disability. It kills around 2.2 million people globally each year, mostly children in developing countries (WHO 2009/undated).

The gravity of waterborne diseases is summed up by a NCMH (2005) report, which estimates that though India accounts for 16.5 per cent of the global population, it contributes a third of the diarrhoeal diseases.

A community level study conducted jointly by WHO and UNICEF, and published in Planning Commission's India Assessment Report, 2002, indicates that every child below 5 years has 2-3 episodes of diarrhoea every year. Sarkar (2007) calculated that over hundred million cases of diarrhoea occur every year, but only a small percentage of diarrhoeal diseases are reported.

Bacillary Dysentery - Shigellosis

Three major species of Shigella are responsible for bacillary dysentery: S. sonnei, S. flexneri and S. dysenteriae. A fourth species, S boydii, is responsible for scattered disease focus. The infection results in severe dysentery with blood and mucus in the stools.

Shigellosis is transmitted from humans-to-humans by the faecal-oral route via contaminated food and water or through person-to-person contact. Transmission by house flies has also been documented as a cause. Infection is common among travellers and military troops deployed in camps with less than optimal hygiene conditions.

Shigellosis is endemic throughout the world. The overwhelming majority occurs in developing countries and involves children less than five years of age. Recent estimates fix the Shigella global disease burden at 90 million episodes and 108 000 deaths per year. In addition, about half a million cases of shigellosis are reported each year among military personnel and travellers from industrialised countries (WHO 2009/undated).

Cholera

Cholera is reported to be caused by Vibrio cholerae O1 or O139. The bacteria affects gastrointestinal tract (acute gastroenteritis). The initial symptoms of cholera are an increase in peristalses followed by loose, watery and mucus-flecked "rice-water" stools that may cause a patient to lose as much as 10–15 litres of liquid per day. Case fatality rates vary according to facilities and preparedness. As many as 60 per cent of untreated patients may die as a result of severe dehydration and loss of electrolytes, but well established diarrhoeal disease control programmes can reduce fatalities

to less than 1 per cent. Non-toxigenic strains of *V. cholerae* can cause self-limiting gastroenteritis, wound infections and bacteraemia. (WHO 2008)

Cholera is typically transmitted by the faecal–oral route, and the infection is predominantly contracted by the ingestion of faecally contaminated water and food. The high numbers required to cause infection make person-to-person contact an unlikely route of transmission. Contamination of water due to poor sanitation is largely responsible for transmission. (WHO 2008)

2005 data from WHO reveals that the Indian subcontinent reported 46 per cent of all cases notified from Asia with India notifying a total of 3155 cases and 6 deaths. (NICD 2008)

According to the data compiled by CBHI, the cholera situation in India has improved steadily. While in 1991 there were 7088 cases (150 deaths) the same declined to 2635 cases (3 deaths) in the year 2007. (NICD 2008)

Typhoid fever

Typhoid fever is caused by *Salmonella typhi*, the typhoid bacillus. At present, there are 107 different strains of the bacteria.(NICD 2009).

Typhoid fever is transmitted by food and water contaminated by the faeces and urine of patients and carriers. Polluted water is the most common source of typhoid. In addition, shellfish taken from sewage-contaminated beds, vegetables fertilized by night soil and eaten raw, contaminated milk and milk products have been shown as a source of infection.

Typhoid was known to occur during the rainy season (July-September) but now occurs throughout the year. The bacteria do not multiply in water and may perish within 48 hours. But it may survive for up to 70 days in soil irrigated with sewage under moist conditions in winter and for over a month under drier summer conditions. Also it can multiply in contaminated food and milk. Vegetables irrigated or washed with contaminated water can be health hazards. India has the highest incidence of typhoid, around three million cases each year (NICD 2009/undated).

Rotavirus

Rotaviruses are very small (70 nm) RNA viruses that belong to the family Reoviridae. Rotavirus is currently by far the most common cause of severe diarrhoea in infants and young children worldwide and of diarrhoeal deaths in developing countries, with a distinct winter seasonality in temperate climates and year-round exposure in tropical countries. Symptoms include watery diarrhoea, nausea, vomiting, abdominal pain and dehydration.

Like cholera, rotavirus (RV) originated from the Ganga delta in West Bengal and Bangladesh in the early seventies. Within a decade, its prevalence and incidence increased across India. India accounts for the highest diversity of rotaviruses strains. It is the cause of the alarming levels of morbidity and mortality among children below five years of age.

Worldwide, RV has been estimated to account for almost 40 per cent of all cases of severe infant diarrhoea, which translates into 527,000 deaths each year mostly in children under age 2. Mortality is still the greatest in south and south-eastern Asia and sub-Saharan Africa, with almost 100,000 deaths each year in India alone and more than 200 000 in African countries (WHO 2009/ undated).

Rotavirus statistics are horrifying. According to Sarkar (2007) extrapolated data shows that around 11 million people in India suffer from rotavirus infection. Of the approximately 600,000 annual deaths due to **rotavirus** worldwide, more than 150,000 occur in India while Scott Wittel of the Programme for Appropriate Technology in Health (PATH), estimates that over 1,25,000 Indian children die each year from rotavirus diarrhoea.

Viral Hepatitis (Jaundice)

Infectious Viral Hepatitis A and E are essentially water-borne diseases. Water contaminated by faecal matters from infected persons is the major source of infection. Hence the doctors limit their intervention up to a level of conservative treatment. Therefore, diagnosis remains as jaundice, the main clinical feature of viral hepatitis. Due to paucity of diagnostic facility and resource constraint, getting the exact figure of Hepatitis A and Hepatitis E is not possible. (Sarkar 2007). Jaundice itself is not a disease, but rather a sign of one of many possible underlying pathological processes that occurs at some point along the normal physiological pathway of the metabolism of bilirubin (Wikipedia 2009/undated).

Hepatitis A: Hepatitis A (formerly known as infectious hepatitis) is an acute, usually self-limiting infection of the liver caused by Hepatitis A Virus (HAV). This infection is very common in India. Antibodies against HAV develop in response to infection and sero-prevalence can be used as a marker of viral transmission in a community. Sero-epidemiological studies carried out in India, Bangladesh, Bhutan and Nepal demonstrated that 85-95 per cent of children have been infected and are immune to HAV infection by ten years of age. (Sarkar 2007)

Hepatitis E: It is a viral hepatitis (liver inflammation) caused by infection with a virus called hepatitis E virus (HEV). Infection with this virus was first documented in 1955 during an outbreak in New Delhi, India.

Hepatitis E is prevalent in most developing countries, and common in any country with a hot climate. It is widespread in Southeast Asia, northern and central Africa, India, and Central America. It is spread mainly through fecal contamination of water supplies or food; person-to-person transmission is uncommon. Outbreaks of epidemic Hepatitis E most commonly occur after heavy rainfalls and monsoons because of their disruption of water supplies. Major outbreaks have occurred in New Delhi, India (30,000 cases in 1955-1956), Burma (20,000 cases in 1976-1977), Kashmir, India (52,000 cases in 1978), Kanpur, India (79,000 cases in 1991), and China (100,000 cases between 1986 and 1988) (Wikipedia 2009/undated).

Mortality rates are generally low, for Hepatitis E is a “self-limiting” disease, in that it usually goes away by itself and the patient recovers and is fatal in about 2 per cent of all cases (Wikipedia 2009/undated). However, it carries high fatality rate in pregnant women (Singh et al, 2001)

3.2 Water Related Diseases

Water is a natural resource found as surface water in rivers and lakes or underground. It interacts with the surrounding environment, such as soil and rocks and air. Thus, water may contain many chemicals naturally such as ammonia, nitrate, arsenic, fluoride or iodine and metals like iron and manganese. Also, they may be added to water by anthropogenic activities, when all the wastewater produced by human beings after domestic use and industrial effluents merge with surface or ground water, largely in untreated form. Agricultural run-off of several herbicides like Alachlor, pesticides such as carbofuran and fertilizers like urea too may find their way to surface or ground water. But not all of them are toxic. WHO Guidelines for Drinking Water (2008) has

reviewed most of such possible contaminants of drinking water and has not set guideline value for many of them because the available information does not indicate hazardous impact on health at the level it can be found in drinking water. It has set guideline values for several such chemicals and metals where there is evidence of possible health hazards. For instance, herbicide Alachlor (Guideline value 0.02 mg/litre) which has been detected in water and can be carcinogenic or Cadmium (Guideline value 0.003 mg/litre) which can be toxic in high doses and affect kidney.

Brief information on the health impact of Arsenic, fluoride and some heavy metals is provided below.

Arsenic: (High Levels Impacts on Health)
Sarkar (2007) reports that there are about 250 arsenic-bearing minerals in nature but the most abundant form is in association with iron and sulphur as arsenopyrite. The metal mixes in water with dissolution of minerals and ores present in subsoil rocks. It is one of the most toxic elements in the world - its lethal dose being less than 5 milligram per kilogram of body weight. In other words, any normal human being with an average body weight of 60 kg will die by consuming just 300 milligram of arsenic due to acute toxicity. Generally chronic arsenic poisoning occurs due to consumption of contaminated water.

The list of impact on heath due to arsenic poisoning is very long. Long-term exposure to elevated level of arsenic in water may cause serious health hazards like rhinopharyngitis, pulmonary insufficiency, interstitial fibrosis, hyperkeratosis of palm and soles, melanosis, noncirrhotic portal fibrosis, myocardial damage with ECG changes, hypertension, peripheral vascular disease, sensorimotor polyneuropathy, retrobulbar neuritis, encephalopathy, bilateral optic atrophy, deafness, bowens disease, haemangioen-dothelioma of liver, leukemia, malignancy of stomach, urinary bladder, oesophagous, kidney, bone and lungs (India Water Portal 2009/undated)

Fluoride: (High level Impacts on Health)
Fluorosis is a crippling disease caused by regular intake of water contaminated with fluoride. This disease affects children as well as adults and exists in three forms - Dental Fluorosis, Skeletal Fluorosis and Non Skeletal Fluorosis.

The disease shows its signs in children who are above the age of 8 years and presents as white patches/flecks in the front teeth. If the intake of contaminated water is continuous, skeletal involvement occurs, followed by that of the nervous system. Changes induced in teeth as well as bones are irreversible and they do not resolve on removing the cause or by any other treatment, once they have manifested. Delhi has been identified as one of the states with high level of fluoride in water (GNCTD 2009/undated).

Excess of fluoride results in fluorisis. According to GNCTD (2009/undated) in Delhi against the permissible limit of 1.00 ppm, the level of fluoride in drinking water ranges from 1.1-32.46 ppm. The incidence of disease may be high especially in those areas where the source of drinking water is hand pump, tube wells or open wells. A UNICEF (1999) reports indicate that Delhi is among 17 states in India facing the fluoride contamination problem.

Heavy metals – (High level Impact on Health – Guideline Values from WHO 2008)
Cadmium: Cadmium (Guideline value 0.003 mg/litre) is released to the environment in wastewater, and diffused pollution is caused by contamination from fertilizers and local air pollution.

Contamination in drinking-water may also be caused by impurities in the zinc of galvanized pipes and solders and some metal fittings. The kidney is the main target organ for cadmium toxicity.

Lead: Lead (Guideline value 0.01 mg/litre). Owing to the decreasing use of lead containing additives in petrol and of lead-containing solder in the food processing industry, concentrations in air and food are declining, and intake from drinking-water constitutes a greater proportion of total intake. Lead is rarely present in tap water as a result of its dissolution from natural sources; rather, its presence is primarily from household plumbing systems containing lead in pipes, solder, fittings or the service connections to homes. The amount of lead dissolved from the plumbing system depends on several factors, including pH, temperature, water hardness and standing time of the water, with soft, acidic water being the most plumbo-solvent.

Lead is a general toxicant that accumulates in the skeleton. Infants, children up to 6 years of age and pregnant women are most susceptible to its adverse health effects. There is evidence from studies in humans that adverse neurotoxic effects other than cancer may occur at very low concentrations of lead and that a guideline value derived on this basis would also be protective for carcinogenic effects.

Manganese: Manganese (Guideline value 0.4 mg/litre) is one of the most abundant metals in the Earth's crust, usually occurring with iron. Manganese is an essential element for humans and other animals and occurs naturally in many food sources. Manganese is naturally occurring in many surface water and groundwater sources, particularly in anaerobic or low oxidation conditions, and this is the most important source for drinking-water. The greatest exposure to manganese is usually from food.

Adverse effects can result from both deficiency and overexposure. There have been epidemiological studies that report adverse neurological effects following extended exposure to very high levels in drinking-water.

Mercury: Mercury (Guideline value 0.006 mg/litre for inorganic mercury) is used in the electrolytic production of chlorine, in electrical appliances, in dental amalgams and as a raw material for various mercury compounds. Methylation of inorganic mercury has been shown to occur in fresh water and in seawater, although almost all mercury in uncontaminated drinking-water is thought to be in the form of Hg2+. Thus, it is unlikely that there is any direct risk of the intake of organic mercury compounds, especially of alkyl mercurials, as a result of the ingestion of drinking water. However, there is a possibility that methyl-mercury will be converted into inorganic mercury. Food is the main source of mercury in non-occupationally exposed populations; the mean dietary intake of mercury in various countries ranges from 2 to 20mg/day per person. The toxic effects of inorganic mercury compounds are seen mainly in the kidney in both humans and laboratory animals following short- and long-term exposure.

Nickel: Nickel (Guideline value 0.07 mg/litre) is used mainly in the production of stainless steel and nickel alloys. Food is the dominant source of nickel exposure in the non-smoking, non-occupationally exposed population; water is generally a minor contributor to the total daily oral intake. However, where there is heavy pollution, and areas in which nickel naturally occurs in groundwater or where there is use of certain types of kettles, non-resistant material in wells or of water that has come into contact with nickel- or chromium-plated taps, the nickel contribution from water may be significant. Allergic contact dermatitis is the most prevalent effect of nickel in the general population.

Discussion

The compilation of statistics of diseases by CBHI classifies one disease head as 'Acute Diarrhoeal Disease', though diarrhoea is not a disease but symptom of some waterborne infection. This is because in most of the diarrhoea cases the actual bacterial or viral infection is not identified.

Many reports club diseases resulting from improper sanitation and poor hygiene with waterborne diseases. It may be pointed out that improper sanitation and poor hygiene is largely the result of either improper use or lack of sufficient water supply / availability.

Many of the waterborne diseases can be a result of contaminated food as well. This has resulted in a tussle between DJB and MCD with each passing the buck on the other, but the fact of the matter is that vegetables irrigated, washed or cooked with contaminated water can get contaminated and become health hazards.

Reliability of coliform parameter in water treatment is doubtful in many situations. According to WHO Guidelines for Drinking Water (2008) some bacteria and viruses are highly resistant to conventional disinfection. For example, bacteria, Vibrio cholerae O1 and non-O1 have been detected in the absence of E. coli. Thus, according to WHO this organism (or, alternatively, thermo-tolerant coliforms) is not a reliable index for V. cholerae in drinking-water. Similarly, enteroviruses, one of the most common causes of human infections causing diseases ranging from a mild febrile illness to myocarditis, meningoencephalitis, poliomyelitis, herpangina, hand-foot-and mouth disease and neonatal multi-organ failure have been shown to occur in substantial numbers in raw water sources and treated drinking-water supplies. Likewise, the presence of HAV and HEV in treated drinking-water has been confirmed and they constitute substantial health risks. These too have higher resistance to disinfection. Thus, E. coli (or, alternatively, thermotolerant coliforms) is not a reliable index of their presence/absence in drinking-water supplies.

This has been confirmed by an extensive research done by Professor Sarman Singh of AIIMS (2000). He reports, "The presumptive coliform test is highly inadequate in the Indian context; that only gas forming lactose fermenters are tested in this protocol, while many pathogenic bacteria are non-lactosefermenting and non-gas forming. According to the presumptive test, if no lactose fermenting and gas forming growth is demonstrated after 24 hours the test is considered finished and thus we can miss a whole body of pathogenic bacteria including Salmonella typhi, Shigella and Vibrio."

Prof Sarman also points at the inadequacy of coli-form tests and suggests that "free living amoebae can be used as a cheap and sensitive model for testing the biological contamination of drinking water particularly in resource poor countries. Since these are harmless under normal conditions and can survive on simple culture plates for years, these amoebas can also be used for epidemiological mapping of the source of water contamination."

Conclusion

Delhi in India has the dubious distinction of documenting for the first time the outbreak of a new infection in 1955-56, identified as hepatitis E virus (HEV) and infected more than 30000 people.

Water Treatment Plants (WTP) in Delhi claim that all is well with the drinking water supply. The treatment is generally conventional and complete disinfection is assumed with absences of Coliform. Yet, WHO (2008) finds that several bacteria and viruses that are highly resistant to disinfection are prevalent in treated drinking water and thus, *E. coli* (or, alternatively, thermo-tolerant coli-forms) is not a reliable index of safety of water.

3.3 Trends in Waterborne Diseases

Central Bureau of Health Intelligence (CBHI) Government of India publishes an annual report of the state of health in the country. It brought out the first publication 'Health Statistics of India: 1951-1953'. This was followed by subsequent issues covering the Health Statistics up to the year 1975. The name of the report changed several times in between. During 2000-2005 it was being published as Health Information of India and now, Health Status Indicators of which 2007 report is available.

This compilation is done on the basis of reports provided by state governments. Reports from year 2000 onwards till 2007 are available online but the information is sketchy and compiled differently in different annual reports.

National Trends

The communicable diseases section of Health Status Indicators report of India, 2007 (provisional) short listed eight diseases that had an incidence of higher than one lakh cases. Waterborne diseases, Acute Diarrhoeal Disease (9.5 million) and Typhoid (Enteric Fever – 0.69 million) fall at second and fifth position respectively in this list. Since the data is provisional, final numbers may be higher. (CBHI 2007)

Morbidity trend from 2000 to 2006 for Acute Diarrhoeal Disease shows steady increase from 8.7 million in 2000 to 10.21 million in 2006, except for 2005 when cases were still higher at 10.97 million. (CBHI 2007)

Morbidity trend from 2000 to 2006 for Typhoid shows steady increase from 0.47 million in 2000 to 0.79 million in 2006. (CBHI 2007) This was 0.27 million in 1997 (Sarkar 2007).

CBHI (2007) report (provisional) has short listed 13 diseases that caused around 100 or more deaths. Acute Diarrhoeal Disease (2328) and Typhoid (393) fall at fourth and eighth position respectively in this list.

Delhi Trends

As for Delhi, the available institutional statistics of communicable diseases indicate that during the last 7-8 years, Acute Diarrhoea Diseases and Typhoid (Enteric Fever) cases are increasing and 2007 has been extremely bad.

Diarrhoea cases increased from 0.13 million in 2002 to 0.24 million in 2007 but returned to 0.13 million in 2008. In the case of Typhoid the case increased from 9750 in 2000 to 20864 in 2008 (in between, it peaked to 25969 cases in 2007)!

HAV (Hepatitis A Virus) appears to be rising sharply between 2006 - 2008 and case-death ratio should be a matter of concern (around 2 per 100 cases in 2007). HAV cases which were 2850 in 2006 almost doubled to 5425 in 2008.

TABLE 3.1: ACUTE DIARRHOEA DISEASES IN DELHI

Year	Cases	Deaths
2002	127,860*	118*
2006	104,643 (94,398)*	62 (85)*
2007	236,378	188
2008	129,506	86

*Directorate of Health Services, Govt. NCT Delhi, Delhi. * Central Bureau of Health Intelligence (CBHI), Government of India, New Delhi*

TABLE 3.2: TYPHOID (ENTERIC FEVER) IN DELHI

Year	Cases	Deaths
2000	9,750*	44
2006	13,412 (13,774)*	7 (18)*
2007	25,969	60
2008	20,864	32

*Directorate of Health Services, Govt. NCT Delhi, Delhi. * Central Bureau of Health Intelligence (CBHI), Government of India, New Delhi*

TABLE 3.3: VIRAL HEPATITIS (A) IN DELHI

Year	Cases	Deaths
2006	2,850	16
2007	4,485	84
2008	5,425	53

Directorate of Health Services, Govt. NCT Delhi, Delhi.

Cholera in Delhi

As for the cholera, Delhi is one of endemic focus besides Maharashtra, Tamil Nadu, Karnataka, Gujarat and West Bengal. These states account for 97 per cent of reported incidences in the country. The independent figures for Delhi are unavailable, but the annual cases and deaths in India due to Cholera in 1991 were 7088 and 150 respectively which now have reduced to 2635 and three (3) respectively during the year 2007. Cholera in Delhi is essentially linked to the quantity of water supply in the slum areas during summer and damage to water supply and sewerage system during various developmental work. (Sarkar 2007)

Reports like - 'After jaundice, it's cholera' (21 Jul 2004, 0024 hrs IST, TNN) are revealing. "About 945 cholera cases were reported in Delhi till June this year (2004). The figure is more than three times the number of cases (307) reported for the same period last year," - are common in national media. (Times of India, 2009)

Pattern of Morbidity of Waterborne Diseases in Delhi

Chapter 2 brings out the inequities in water supply and extent of coverage of DJB with piped supply of treated water. It has also been brought out that Yamuna surface water and recharged ground water by it are major sources of water for Delhi.

Piped water supply is supposed to be treated and safe. Nevertheless, several studies reveal that areas with safe supply too are highly impacted by water borne diseases.

An MCD report in 2004 shows 30.26 per cent cholera cases in Delhi were found in unauthorized colonies, 19.58 cent in urbanized villages, 23.08 per cent in JJ clusters, 4.16 per cent in notified colonies, 22.92 per cent in regular colonies. This clearly brings out the paradox that morbidity in regular colonies is almost equal to that in JJ clusters. (Sarkar 2007)

A recent KAP survey on river Yamuna revealed that the main source of drinking water, overall, is DJB water (60.4 per cent) followed by hand pump/boring (around 20 per cent). It is rather surprising that there is almost same level of occurrence (around 25 per cent) of waterborne diseases in all segments of the city. More surprising is, that there is slightly more occurrences in 'entry' area (28.8 per cent) of the river where people use piped water and ground water the quality of which is supposed to be better in comparison of other areas. (PEACE Institute et al 2009)

Increasing Healthcare Infrastructure and Budget in Delhi

Healthcare facilities in Delhi are extended by both government as well as non-government organisations through a network of 188 health centres, viz dispensaries, primary health centres, poly clinics, 26 hospitals, nine autonomous bodies, private nursing homes and clinics. (CAG 2008)

According to Government of NCT, Delhi, there are 1256 primary healthcare centres and 715 secondary healthcare institutions in Delhi. The total number of beds available for admitted patients in Delhi are 36,555 which works out to 2.15 beds per thousand population. This is far better than the national average of 0.7 bed per thousand population. (GNCTD 2008)

The budget allocation for health during the Xth Plan period steadily increased. In 2002-03 the allocation was Rs 330.43 crore (7.50 per cent of total plan) increased in 2006-07 to Rs 720.50 crore (14.17 per cent of total plan). (GNCTD 2008)

TABLE 3.4 PRIMARY HEALTHCARE INFRASTRUCTURE

Type of Dispensary	GNCTD	MCD	NDMC	CGHS	Others*	Total
Allopathy	197	52	12	120	121	500
Ayurveda	24	116	12			152
Unani	10	21	-			31
Homeopathy	82	23	13			118
Mobile HS	69	16	-			85
School HS	20	-	-			20
MCW Centres	-	197	17			214
Polyclinics & Others		136				136
Total	**402**	**561**	**54**	**120**	**121**	**1256**

Healthcare Facilities in Delhi (http://des.delhigovt.nic.in/Publications/HB2008/c12.pdf), http://des.delhigovt.nic.in/Publications/HB2008/c12.pdf Accessed on 04.02.2009

TABLE 3.5: SECONDARY HEALTHCARE FACILITIES IN DELHI

Agency	No. of Institutions	Number of Beds
Delhi Government	37	6765
MCD	63	4046
NMDC	04	220
Govt. of India	25	10064
Other Autonomous bodies	05	240
Registered Nursing Homes	581	15220
Total	**715**	**36555**

Healthcare Facilities in Delhi (http://des.delhigovt.nic.in/Publications/HB2008/c12.pdf), http://des.delhigovt.nic.in/Publications/HB2008/c12.pdf Accessed on 04.02.2009

TABLE 3.6: BUDGET EXPENDITURE ON HEALTH BY GNCTD

Year	Total Plan	Allocation to Health	%
Xth Plan Period	**23000**	**2381.50**	**10.35**
2002-03	4405.89	330.43	7.50
2003-04	4609.21	389.42	8.45
2004-05	4260.53	469.89	11.03
2005-06	4280.87	543.33	12.69
2006-07	5083.70	720.50	14.17

Discussion

Non-availability and quality of data

CBHI has been compiling health-related statistics since 1951. But such data is available digitally from 2000 only, so we sought time series information through an RTI request to CBHI asking for annual statistics on Diarrhoea, Dysentery, Cholera, Typhoid, Hepatitis A, Hepatitis E and Rotavirus for Delhi since 1951.

CBHI passed on the buck to Directorate of Health Services (DHS), Govt. of NCT, Delhi (GNCTD). However, the DHS could provide us only with a compilation of 'Monthly statement showing institutional cases and deaths due to principal communicable diseases' from 2006 onwards.

From this, it is presumed that no dependable time-series data exists for the city. Prof Ajay Mahal, Harvard School of Public Health, USA (2005) in a paper entitled 'Choosing Investments in Health' did an extensive review of the available literature. He found that "for almost all diseases/conditions identified (including diarrhoea), and more particularly the National Health Programmes in which government investment was substantial, namely, malaria and other vector-borne diseases, TB, leprosy, reproductive health and childhood conditions, there is a paucity of high-quality epidemiological information and validated data for arriving at any baseline estimations on prevalence or incidence."

Prof. Mahal goes so far as to question the quality of available data. As he points out, "The non-availability of good quality data has been a major handicap in arriving at reliable estimations of the disease burden, affecting our ability to formulate appropriate policies and provide adequate budget."

This statement is further substantiated if you compare the diarrhoea and typhoid statistics for Delhi provided by two different government sources – CBHI and DHS and notice how they differ from each other.

Under Reporting

Health Status Indicators Report by CBHI (2007) at the very outset states that the statistics on morbidity and mortality are under reported as complete data from private health practitioners/ institutions does not reach the government recording system.

WHO and CBHI statistics on communicable disease morbidity and mortality are poles apart (see the diarrhoea and rotavirus estimation in India). Sarkar (2007) explains that while the government data reveals only gross underestimation of mortality and morbidity, some estimated data by international agencies expose alarming figures. These estimations are usually done by pooling of the data of multi-centric population-based survey.

Sarkar's analysis of this is: "Compared to the country's one billion population, three to four thousands of cholera cases seems to be negligible. But the fact remains that large number of cases are under-reported, particularly from private practitioners and private hospitals. Majority of the victims are poor and resort to quacks, who cannot diagnose the disease as cholera and treat them as any other acute gastro-intestinal disorders. Moreover, due to improvement in the communication system, any cholera epidemic during flood or any other natural disaster gets immediate attention. Hence, the report of cholera associated morbidity and mortality during

natural disasters declined. But local outbreaks due to a sudden collapse of water and sanitation conditions or continuous transmission of infection due to the perennial problem of water and sanitation are often unreported, unless it gets media attention and public outrage."

Inadequacy of Government Healthcare

According to GNCTD (2008) there are 715 secondary healthcare institutions in Delhi. The total number of beds available for indoor patients in Delhi is 36,555 which work out to 2.15 beds per thousand populations. This is far better than the national average of 0.7 beds per thousand populations, but far below the WHO norm of 5 beds per thousand populations, or in other words, 85,500 beds for 17.1 million Delhiites. GNCTD admits that super-speciality beds currently available in Delhi are just 6,000 only while the requirement is for 18,000.

NCMH (2005) reasons that government healthcare delivery has a lot of limitations with issues like access, quality, affordability, which prompts people to opt for local private treatment. It attributes the failure to 'poor governance and the dysfunctional role of the state; lack of a strategic vision; and weak management.'

Increasing Allocation for Healthcare by GNCTD

The budget allocation on health during Xth Plan period steadily increased during its five year term period. In 2002-03 the allocation was Rs 330.43 crore (7.50 per cent of the total plan) and by 2006-07 had increased to Rs 720.50 crore (14.17 per cent of the total plan) (GNCTD 2008). This allocation is reported to be the highest by any state government in the country. As a result, Delhi's per capita expenditure on health is more than three times the national per capita expenditure on health. (DHDR, 2006).

Role of Private Sector in Healthcare

Private practitioners, dispensaries, Primary Healthcare Centres and Hospitals play a critical role in providing healthcare services in Delhi.

Out of the 715 secondary healthcare institutions in Delhi, 581 are private, corporate, NGOs' or charitable hospitals, providing around 40 per cent of the beds in Delhi.

Of course, there are private practitioners in every nook and corner of the city, more so in regular colonies.

DHDR (2006) quotes a recent survey by the Voluntary Health Association of India which found that 29 per cent of households use public medical facilities and 71 per cent use private medical facilities.

A Baseline Survey in Trans-Yamuna Area (North East and East districts) of Delhi for Preparation of Healthy City was conducted from September 2000 to June 2001. The sample size was very large - 20,000 households (More than 1 Lakh people) with all types of settlements covered (Villages, Jhuggi-Jhopadis, Resettlement Colonies, Old Urban Colonies, New Urban Colonies and DDA colonies). The survey found that 80 per cent of the households use private facilities for usual health problems. (ICMR, 2003)

Quality of Healthcare delivered by Government Sector versus Private Sector

DHDR (2006) in a survey found that almost 44 per cent of the respondents rated private healthcare services as 'good' or 'very good' in contrast to the 21 per cent who felt similarly

about government health services. Only 9 per cent rated health services in the private sector to be poor or very poor as against 30 per cent who felt similarly about government health services. There was a mixed response towards assessing progress in the provisioning of health services by the government and by the private sector. While 45 per cent of respondents felt that there had not been any change or improvement in health services provided by the government, close to 30 per cent felt that private health services had improved over the past three years. Among the respondents, 13 per cent were of the opinion that provisioning of health services by government had deteriorated over the past three years. On the other hand, only 7 per cent felt similarly about healthcare provisioning by the private sector.

Cost of unsafe drinking water

In 1993, the World Bank formally introduced a new indicator of population health, the Disability-Adjusted Life Year (DALY). One DALY represents one single year lost in ill-health and is used to estimate the gap between the current health of a population and an ideal situation where everyone in that population would live into old age in full health.

Sarkar (2007) quoting World Health Report 1999 says that 8.2 per cent of DALYs lost in India is contributed by diarrhoeal diseases. The same report also states that 30.1 per cent of the global DALYs lost due to diarrhoea is contributed by India alone.

According to NCMH (2005), healthcare services requires substantial amounts of money. It impoverishes an estimated 3.3 per cent of India's population every year to the extent that poorest 10 per cent among them have to sell their assets or borrow in order to afford healthcare services.

Norden (2004), a UNICEF representative, estimates that India loses Rs. 36,000 million in terms of medical costs, man-days and loss of health every year.

Domestic water filtration is a usual practice in most middle and upper class homes. Collectively, filtration costs, electricity and maintenance expenses add up to an astronomical amount. Many rich people use big bottles of filtered water for domestic use. Outside the home, one is compelled to buy bottled water. Zerah (2000) a water economist estimated that in Delhi an average household spent Rs. 105 to boil water or Rs. 113 to filter water for consumption (per person), every year. Since then, costs have escalated. For example, the annual service charges for a filtration machine for a standard company are more than Rs 1000.

Despite the enormous spending on water and waste management, waterborne diseases continue to be rampant with the consequence that government as well as private spending on healthcare keeps rising. Sarkar (2007) quotes a Planning Commission report of 2002 and describes that Rs 734,760 million has been spent during 1951-2000 in an attempt to provide water supply and sewage disposal to the citizens of India. Correlating this to waterborne diseases, he says. "Except for cholera, it has made no difference to the incidence of waterborne diseases in the country."

In India, rural people spend at least Rs 100 rupees annually for the treatment of water / sanitation related diseases. According to the Government of India, this adds up to Rs. 67,000 million annually, which is just Rs. 520 million less than the annual budget of the Union Health Ministry. (Sarkar 2007)

Both the central as well as state governments spend large amounts on healthcare and in increasing, improving and maintaining health infrastructure and Healthcare programmes and activities. Yet, no perceivable improvements in health outcomes can be seen.

Climate change and Waterborne Diseases in North India

In a press conference on World Health Day, a WHO representative in India warned that waterborne diseases would "see a rise in northern region of the country". (Financial Express 2008).

Conclusion

The available data on waterborne diseases appears to be a case of gross underreporting. Several experts have questioned the veracity of the data. Meanwhile, independent surveys show that a majority of people in Delhi prefer private practitioners and institutions for their healthcare needs since the quality of government infrastructure and service is poor. Despite this fact, Government of NCT, Delhi's expenditure on healthcare is steadily rising. And the available statistics indicate that there is an increasing trend in several waterborne diseases. The logical corollary is that as the quality of water in Delhi is deteriorating, the disease burden is rising. It must be noted that unsafe water and consequent disease burden is not only a strain on government healthcare infrastructure and budget (and indirectly on tax payers), it also causes social agony, loss of man-days, and has an economic impact for the poor as well as affect the GDP of the country.

Increasing human population in Delhi is indeed a factor in the reported rise in incidences of diseases. But the fact that water availability through the river in the city is not expandable and is continuously getting more polluted will only make matters worse.

Analysis and Suggestions

The clear linkage between increasing Water Contamination and Waterborne Diseases

Analysis

It is a fact of life that Delhi is prone to waterborne diseases, many of which are increasing. It is logical that waterborne diseases are the result of use of unsafe water besides improper sanitation and hygiene. Authors of DHDR (2006) too agree that many of the communicable diseases of which waterborne diseases form a part, are traceable to deteriorating quality of water, increasing problems of poor sanitation and inadequate drainage. Since Yamuna is the main source of raw water, which is treated before supply and reportedly made safe for use, and yet there is increasing morbidity for certain diseases e.g. diarrhoea and typhoid in Delhi, indicates the increasing level of pollution of Yamuna.

High morbidity of waterborne diseases in regular colonies is invariably attributed to 'use of booster pumps, which creates a negative pressure during non-supply hours, sucking contaminated water or sewage through cracked, corroded old pipelines or leaked joints and valves' and thus contaminating the safe water supplied. Authorities hide inadequacies of conventional water treatment process and testing parameters which cannot rule out several waterborne diseases' bacteria and virus (WHO 2008).

WHO Guidelines for Drinking Water (2008) has reviewed all the possible contaminants of drinking water including, microbial, chemical, heavy metal, pesticide, insecticide, fertiliser, several of which have been found to cause waterborne and water related diseases largely because of contaminated water. The other way round, the fact sheets of several waterborne diseases indicate contaminated water as a major causative source.

Nothing would be better example of relation of waterborne diseases and pollution of Yamuna drinking water when sewage water mixing with Yamuna raw water resulted in an outbreak of a new infection in Delhi in 1955-56 which was for the first time documented as hepatitis E virus (HEV) and infected more than 30000 people.

Sarkar (2007) in his book reports of a typhoid outbreak in the campus of All India Institute of Medical Sciences (AIIMS), New Delhi in May 2000. The outbreak was essentially due to contaminated water, as water was not treated with chlorine. As a control measure, the water was chlorinated and the outbreak was controlled. He also quotes an NICD investigation of 10 hepatitis outbreaks in India since 1989-1996 and all of them were due to contaminated pipe waters.

In an article distributed by IANS news agency (2006), the municipality authority admits that waterborne diseases such as cholera are the result of poor drinking water quality in Delhi. In the context of increased number of cases of cholera in 2006, N.K. Yadav, deputy municipal health officer of Delhi said, "Waterborne diseases may be common in summer, but the poor drinking water quality is a major reason for the number of cases. We are working in collaboration with the Delhi Jal Board to deal with the situation."

In a recent article in Tribune, Chandel (2009) reported that the Municipal Corporation of Delhi (MCD) has found 15 per cent of the Delhi's water to be unfit for drinking. Water contamination has been detected from various zones of the city like Central Delhi, Civil Lines, Karol Bagh and South Delhi. Out of 765 samples taken to test the purification level of drinking water, 90 samples were declared unfit. In South Delhi, the level of contamination is highest with 50 per cent of the samples declared polluted. A total of 50 samples were tested, 25 of which were found unsuitable for drinking. The contamination level was 10 per cent in Delhi in 2008. This establishes increasing level of contaminated water reaching consumers.

A perception (KAP) survey carried out by CMS and PEACE demolishes the general perception that water quality being good at 'entry' point of the Yamuna in Delhi, there should be fewer cases of waterborne diseases there. On the contrary, about half of the respondents in that area reported that occurrence of waterborne diseases had increased over the last generation. As for the reason of diseases, more than 70 per cent felt that the polluted water was the main reason for such diseases (similar per cent of doctors too give the same reason to patients) while the other major cause perceived is environment pollution. Major percentage of people (72.4 per cent) as per the survey feel there is a link between the river Yamuna and waterborne diseases.

Despite the lack of some hard hitting statistics, such as 25-year data on health indices of the city, from the available data, there is enough evidence to show the clear linkage between the deteriorating quality of the Yamuna and the rising health burden of the people of Delhi.

Suggestions

a) Pathogens reach the river through several drains bringing industrial effluents and city's sewage. It is thus urgent that steps are taken to deal with them either through efficient STPs and CETPs or diverting at least some of the most polluting of them away from the river.
b) It is well known that rivers with adequate flow in them have a self rejuvenational potential. It is thus urgent that in tune with recommendations already made by experts (not covered in this report) and the Courts, a minimum of 10 cumecs (cubic metre per second) flow in the river all along its length is ensured round the year.
c) It is important that pollution monitoring information on the river is made public and available online (preferably on CPCB website) on a regular basis.
d) In view of the fact that health burden monitoring and reporting leaves a lot to be desired, the concerned state department may review the situation and launch a special drive to improve the situation.
e) Time series data on human health burden requires to be made available as a matter of policy for researchers as well as policy makers.
f) The critical role of flood plain in ground water recharge and in the city's water budget is all too evident. It is thus necessary that the remaining flood plains in the city are not compromised through constructions and concretisation in any manner.
g) A follow up study (this study neither had the resources nor the time) that may be able to track the flow of pathogens from the polluted river into food items (grains and vegetables grown in the flood plains) and further into humans is urgently called for to establish firm links (that on subjective grounds are otherwise indisputable) between the increasingly sick river and similarly rising trends of human health burden in the city.

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Annexure 1

Water quality of the Yamuna River

WATER QUALITY OF THE YAMUNA RIVER – PARAMETER TEMPERATURE C^0

Segment	Place	value	1978-81	1983-98	1999-02	2003	2005	2006	2008
Upper	Hathnikund/ Tajewala	Min	NA	9.5	NA	13	NA	4	10
		Max		33		25		23	26
		Av		22.4		20		16.1	18.9
	Yamunanagar/Kalanaur	Min				14		&.1	12
		Max				31		2&	27
		Av				23		19	22.7
	Sonepat	Min				14		4.5	6
		Max				31		22	27
		Av				23		16.4	20.2
	Palla/U/s Wazirabad	Min				14		13.5	11
		Max				32		27	29
		Av				24		19.8	22.3
Delhi	Nizamuddin	Min	NA	13.9	NA	14	NA	11	13
		Max		34		30		27	31
		Av		25		26		20.5	24.1
	D/s Okhla/Agra Canal	Min				13			11
		Max				32			30
		Av				25			2.6

WATER QUALITY OF THE YAMUNA RIVER – PARAMETER pH

Segment	Place	value	1978-81	1983-98	1999-02	2003	2005	2006	2008
Upper	Hathnikund/ Tajewala	Min	NA	NA	7.03	6.8	NA	7.64	7.4
		Max			8.48	8.4		8.6	8.4
		Av			7.67	7.7		7.88	7.9
	Yamunanagar/Kalanaur	Min				6.6		7.61	7.4
		Max				8.4		7.81	8.3
		Av				7.9		7.71	7.8
	Sonepat	Min				7.2		7.65	7.1
		Max				8.3		8.00	8.4
		Av				7.8		7.82	7.8
	Palla/U/s Wazirabad	Min				7.4		7.29	7.6

		Max				8.6		8.06	8.3
		Av				8.0		7.60	7.9
Delhi	Nizamuddin	Min	NA	NA	6.81	6.8	NA	7.14	7.3
		Max			7.64	8.0		7.44	8
		Av			7.16	7.4		7.27	7.6
	D/s Okhla/Agra Canal	Min				7.0		NA	7.3
		Max				7.9			8
		Av				7.5			7.7

WATER QUALITY OF THE YAMUNA RIVER – PARAMETER DISSOLVED OXYGEN (DO) MG/L

Segment	Place	Value	1978-81	1983-98	1999-02	2003	2005	2006	2008
Upper	Hathnikund/ Tajewala	Min		5.8	6.2	6.7		7.8	7.6
		Max		18	9.9	12.7		9.7	10.6
		Av	9	9.7	7.9	9.5	8.9	8.6	9.6
	Yamunanagar/Kalanaur	Min				6.1		8.1	6
		Max				10.7		9.1	8.6
		Av	8			8.6	9	8.5	7.6
	Sonepat	Min				5.2		5.6	4.5
		Max				9.2		8.6	9.1
		Av	8			7.2	6.8	7.1	7.2
	Palla/U/s Wazirabad	Min				5.6		5.3	6.2
		Max				12.3		8.7	10.5
		Av	8			8.1	8.2	7.1	8.1
Delhi	Nizamuddin	Min		0	0	1.3		NA	0
		Max		14.3	4.7	4.6			4.4
		Av	2	3.2	0.8	2.8	0.3		0.5
	D/s Okhla/Agra Canal	Min				0.3		NA	0
		Max				3.9			.4
		Av	3			1.6	0.6		0.2

WATER QUALITY OF THE YAMUNA RIVER – PARAMETER BIOCHEMICAL OXYGEN DEMAND (BOD) MG/L

Segment	Place	Value	1978-81*	1983-98	1999-02	2003	2005	2006	2008
Upper	Hathnikund/ Tajewala	Min	1.4 to 2.6	0.2	1	1.0		1	1
		Max		5	6	3.0		2	3
		Av		1.1	2	1.4	2	1.5	1.4

	Yamunanagar/Kalanaur	Min				1.0		1	1
		Max				2.0		3	4
		Av				1.3	1.3	2	1.9
	Sonepat	Min				1.0		3	1
		Max				3.0		5	5
		Av				1.9	2	4	2.7
	Palla/U/s Wazirabad	Min				1.0		2	1
		Max				2.0		5	3
		Av				1.3	2	3.5	1.5
Delhi	Nizamuddin	Min	6.2 to 11	1	4	4.0		25	2
		Max		62	36	36.0		44	55
		Av		17	18	22.1	24.3	36	25.7
	D/s Okhla/Agra Canal	Min				5.0		NA	2
		Max				23.0			32
		Av				12.8	14.3		12.8

**Water quality in Upper segment – class B. Water quality in Delhi segment – Class D*

WATER QUALITY OF THE YAMUNA RIVER – PARAMETER TOTAL COLIFORM MPN (MOST PROBABLE NUMBER)/100 ML

Segment	Place	Value	1978-81	1983-98	1999-02	2003	2005	2006	2008
Upper	Hathnikund/ Tajewala	Min	NA	20	630	130	NA	10000	120000
		Max		250000	3820000	1750000		120000	1580000
		Av		135	256911	252875		67250	39554
	Yamunanagar/ Kalanaur	Min				4100		64000	112000
		Max				20100000		700000	2200000
		Av				1971373		259000	873455
	Sonepat	Min				7200		55000	155000
		Max				21800000		1000000	6600000
		Av				2328645		329000	1220000
	Palla/U/s Wazirabad	Min				400		64000	19000
		Max				4350000		190000	570000
		Av				427425		112250	146727
Delhi Segment	Nizamuddin	Min	NA	150	130000	500000	NA	5700000	2300000
		Max		999999	6100000	890000000		110000000	17900000
		Av		206393	4672084	102508333		36225000	8918182
	D/s Okhla/ Agra Canal	Min				101000		NA	160000
		Max				262000000			27000000
		Av				37522583			6512000

Maximum permissible value of t.c. in bathing water is 500 mpn/100 ml while a water source should not exceed 5000 mpn/100 ml for it to be fit for drinking after conventional treatment.

WATER QUALITY OF THE YAMUNA RIVER – PARAMETER FAECAL COLIFORM MPN/100 ML

Segment	Place	Value	1978-81	1983-98	1999-02	2003	2005	2006	2008
Upper	Hathnikund/ Tajewala	Min	NA	0	100	40		240	180
		Max		4000	41000	8000		2700	91000
		Av		352	2896	1985	3458	1113	25360
	Yamunanagar/ Kalanaur	Min				160		830	1440
		Max				17200		9000	169000
		Av				3959	17180	3145	66476
	Sonepat	Min				270		920	600
		Max				119000		11000	760000
		Av				14875	29678	3948	152033
	Palla/U/s Wazirabad	Min				120		1900	500
		Max				7000		6800	60000
		Av				1943	7892	4025	18600
Delhi	Nizamuddin	Min	NA	0	5000	40000		480000	170000
		Max		266125	1570000	199000000		4000000	1990000
		Av		135089	270042	18036333	17554444	1772500	1064545
	D/s Okhla/Agra Canal	Min				20000			189000
		Max				97000000			2900000
		Av				15295083	18245833		709900

Annexure 2

Right To Information (RTI) Requests And Responses

Following agencies were approached with Right To Information (RTI) requests for information which could not be accessed otherwise.

Municipal Corporation of Delhi

Question: *Please provide copy of the report of Workshop on Waterborne diseases held at IHC, New Delhi in 2008*

Response : Received the copy of the report

Ministry of Environment & Forests (MoEF)

Question : *Please provide report of the project Impact assessment of Ganga Action Plan on Public Health implemented by NEERI.*

Response : Received a progress report for September 1990-April 1991. Full report was not available.

Council for Science and Industry Research (CSIR) / Nagpur Environmental Engineering Research Institute (NEERI)

NEERI conducted river Yamuna pollution monitoring way back in late 1950s. In fact an outbreak of jaundice in 1956 at Delhi paved the way for the establishment of this R&D institution.

Question : *Please provide us copies of the following NEERI Reports*

- Rheological Survey of the Yamuna river between Wazirabad and Okhla in Delhi (1958-59)
- Significance and value of biological indices of water pollution (1958-59)
- Sewage farming (1959-60)
- Oxidation Ditch (1962-63)
- Estimation of BOD per capita in Indian sewage (1963-64)
- Dairy Waste (1963-64)
- Control of algae at the Wazirabad reservoir by copper sulphate and its effect on fishes (1964-65)
- Removal of virus pollution from naturally and artificially polluted water (1964-65)
- Preventive maintenance of water distribution system (1974-75)
- Quantitative Biological assessment of pollution biotic index (1978-79)
- Correlation of Salmonella and indicator bacteria in naturally polluted water (1980-81)
- Epidemiological and engineering investigation of the incidence and prevalence of human enteric parasites in the city of Jaipur, Rajasthan (1981-82)
- Impact assessment of Ganga Action Plan on Public Health (1989-90)

Response : None of the reports were made available by NEERI.

Ministry of Health & Family Welfare (MoH&FW) / Central Bureau of Health Intelligence (CBHI)

Question : *Please provide Diarrhoea, Dysentery, Cholera, Typhoid, Hepatitis A, Hepatitis E and Rotavirus annual statistics in Delhi since 1951?*

Response : MoH&FW and CBHI passed on the question to Directorate of Health Services, NCTD. Received entirely unsatisfactory response by way of last three year consolidated data from NCTD while we had requested information from 1950s onward and only on certain waterborne diseases.

Delhi Jal Board

Question : *Please provide the following information*.

a) How much Yamuna water is treated and supplied on an average per day as drinking water by the DJB?
b) Which are the WTPs that treat purely Yamuna water? What are their capacities and how much on average is treated?
c) Which are the WTPs that treat mixed water (Yamuna and other sources)? How much is share of Yamuna water in such plants? What are their capacities and how much on average is treated?
d) How many instances (give dates) were there in the year 2008 - 09 (April 08 - March 09) when the raw water from river Yamuna was found to be unfit for treatment and hence not treated?
e) How does DJB ensure before supply that the treated water is potable and free from any disease carrying substance?
f) How many water testing labs are maintained? Where are DJB water testing labs situated? What is average time lag between dispatch of sample and receipt of report?
g) What actions are taken when water quality is not found to be potable?
h) Inform the potability criteria used by DJB for the water supply? Specify standard, if range any, used by DJB for determining the potability of supplied water.

Response: Received incomplete information. Only Sonia Vihar Water Treatment Plant responded with the information.

Delhi Jal Board (DJB)

Question : *Please provide copies of the treated water testing reports done by NEERI.*

Response : Received reports from 2004-08. Several reports or pages of certain reports were found missing. After approaching the First Appellate Authority, the missing pages are being provided by the DJB. (Still to be received by the time of the finalisation of this report).