A REPORT ON Toxicity Load of Yamuna River in Delhi



Toxics Link for a toxics-free world

About Toxics Link

Toxics Link is an Indian environmental research and advocacy organization set up in 1996, engaged in disseminating information to help strengthen the campaign against toxics pollution, provide cleaner alternatives and bring together groups and people affected by this problem. Toxics Link's mission statement is 'Working together for environmental justice and freedom from toxics. We have taken upon ourselves to collect and share both information about the sources and the dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives for India and the rest of the world.'



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Content

Ack	knowle	edgement vi						
Abl	Abbreviationsvii							
Exe	Executive Summary viii							
1.	INTRODUCTION1							
	1.1	Yamuna River in Delhi1						
	1.2	Condition of the river in Delhi1						
	1.3	Literature review on pollution load of indian river2						
	1.3.1	Water Quality Status						
	1.3.2	Sediment Quality Status						
2.	SCO	PE & OBJECTIVES OF THE STUDY4						
	2.1	Scope of the study						
	2.2	Objectives						
3.	SAM	PLING & METHODOLOGY5						
	3.1	Sampling5						
	3.2	Methodology						
	3.3	Physicochemical Parameters						
	3.3.1	pH8						
	3.3.2	Turbidity9						
	3.3.3	Total Solids9						
	3.4	Heavy metals and their health implications9						
	3.4.1	Mercury						
	3.4.2	Arsenic						

	3.4.3 Lead11	
	3.4.4 Cadmium	
	3.4.5 Chromium	
4.	RESULTS & DISCUSSIONS	
	4.1 Water Quality of River Yamuna - Physicochemical Parameters	
	4.1.1 Surface Water Quality of River Yamuna14	
	4.1.2 Sediment Quality of River Yamuna16	
	4.2 Observations	
5.	CONCLUSIONS & RECOMMENDATIONS	
RE	ERENCES	
AN	NEXURES	1

Table

Table 1 :	Sampling locations	7
Table 2 :	Methods used to identify parameters	8
Table 3 :	Methods used to identify parameters	13
Table 4 :	Water quality in pre and post monsoon season – physical parameters	14
Table 5 :	Sediment quality in pre and post monsoon season of Yamuna River	16
Figure		
Figure 1 :	Phisical appearnce of river water befor and after Wazirabad	2
Figure 2 :	Sampling Locations	6
Figure 3 :	Location 1 - Near Jagatpur Village	6
Figure 4 :	Location 2 - Near Najaf Garagh Nala	6
Figure 5 :	Location 3 - Near Majnu Ka Tila	7
Figure 6 :	Location 4 - Near Vidhan Sabha Nala	7
Figure 7 :	Location 5 - Near ISBT	7
Figure 8 :	Location 6 - Yamuna Bazar	7
Figure 9 :	Seasonal variation in pH concentration in water	14
Figure 10 :	Seasonal variation in turbidity concentration in water	15
Figure 11 :	Seasonal variation in total solids concentration in water	16
Figure 12 :	Seasonal variation in lead concentration in sediments	17
Figure 13 :	Seasonal variation in cadmium concentration in sediments	18
Figure 14:	Seasonal variation in total chromium concentration in sediments	18
Figure 15 :	Seasonal variation in mercury concentration in sediments	19
Figure 16 :	Seasonal variation in arsenic concentration in sediments	19



Acknowledgements

We take this opportunity to thank all those who were instrumental in compiling and shaping this report.

Our sincere thanks to Swedish Society for Nature Conservation (SSNC) for providing funding support to carry out this study.

Thanks to all our colleagues at Toxics Link for their valuable inputs to the report.

Finally our sincere gratitude to SPECTRO Analytical Lab, Okhla, New Delhi for sampling and Delhi Test House (NABL accredited lab), A- 62/3, G.T. Karnal road, Industrial area, Opposite Hans Cinema, Azadpur, Delhi - 110033 in analyzing the samples in their lab.

Abbreviations

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AAS	:	Atomic Absorption Spectrometry
APHA	:	American Public Health Association
As	:	Arsenic
BOD	:	Biochemical Oxygen Demand
Cd	:	Cadmium
COD	:	Chemical Oxygen Demand
CPCB	:	Central Pollution Control Board
Cr	:	Chromium
Hg	:	Mercury
ICP-ES	:	Inductively Coupled Plasma- Emission Spectrometry
IS	:	Indian Standard
ISBT	:	Inter State Bus Terminal
Km	:	Kilometers
NCT	:	National Capital Territory
NTU	:	Nephelometric Turbidity Unit
Pb	:	Lead
pН	:	Negative logarithm of hydrogen ion concentration
PPM	:	Parts Per Million
µg/l	:	Micrograms/ Liter

Executive Summary

The River Yamuna originates from the Himalayan glacier. Yamuna geographically covers parts of the states of Uttaranchal, Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh and NCT–Delhi. The river crosses several states like Uttarakhand, Himachal Pradesh and Haryana then reaches Delhi. It enters Delhi near Wazirabad (Delhi) and covers a 48 km stretch in Delhi before entering into the state of Uttar Pradesh. Two other major cities Yamuna Nagar and Panipat of Haryana state are located close to the river prior to its entering Delhi.

River Yamuna covers 375 kms from its source of origin to Wazirabad in Delhi. Although there are two major industrial cities located close to the river discharging their waste waters into the river, however, in its physical appearance the water of Yamuna is of "reasonably good quality" till it reaches the Wazirabad barrage in Delhi. From Wazirabad, onwards the physical appearance of the river changes drastically due to the discharge of waste water from the drains.

Scope of the Study:

The primary focus of the present study is to detect the physiochemical parameters (pH, total solids and turbidity) and heavy metals (Pb, Cd, Hg, total Cr, As) content in Yamuna water sample collected from different locations in Delhi. Moreover the study also reveals the variations in heavy metals concentration of the river in pre & post monsoon season. Finally the study aims to suggest some policy and practice measures that could be taken up in Delhi and implemented not only in Yamuna River but also for other rivers of India.

Objectives:

- To detect the physico-chemical parameters and heavy metals in Yamuna water and sediment samples collected from Yamuna river in Delhi
- To study the variation of physico-chemical parameters and the heavy metals concentration of Yamuna River water in pre and post-monsoon season.
- To draw attention of the policymakers for suitable actions.

Observations:

The results indicates the level of contamination and seasonal changes in the water and sediment samples collected from different locations of River Yamuna:

- There were seasonal variations in pH concentration at all locations except location no. 1
- The pH level of all the samples were within the prescribed limit of Indian standard (6.5-6.8)
- All the samples witnessed high turbidity level in compare to the prescribed limit of Indian Standard (5 NTU).
- All locations indicated increased turbidity level post monsoon season except for location 5
- Total solids concentration of samples from location 1 and 2 were within the prescribed limit of Indian Standard (500 mg/l), while samples from other locations were found to be quite high. The highest total solids was observed at location no. 3 (955 mg/l) in pre monsoon season
- No heavy metals were observed in the water samples of the river
- Lead was detected in all the sediment samples with variations in pre and post monsoon season
- Cadmium was detected in all the pre monsoon samples however no cadmium was detected in post monsoon samples
- Chromium was detected in all the samples with variations in pre and post monsoon season
- Mercury was detected in all the samples collected in pre monsoon season, while only two samples collected in post monsoon show presence of mercury
- Arsenic was detected in all the samples with varied concentration.

Conclusions and Recommendations:

The test results show high level of heavy metals in the sediment of the river Yamuna. The results also indicate the high variation in concentration of the heavy metals before and after Wazirabad. Thus the detection of high level of heavy metals in the samples after Wazirabad may be due to the discharge of the waste water into the river from various canals and the drains. Further as the vegetables are being grown in the flood plain of Yamuna, the present studies raise the issue of contamination of these vegetables.

Recommendations

Generation of Data

There are number of studies on the pollution load of the river Yamuna however there is a need for generation of data periodically to monitor the pollution load of the river. There is also requirement for more research studies on the river bed and its impact on the flora and fauna along the river.

Sources Identification

Some of the sources of the contamination of the river are well known however there are number of small drains those are releasing the waste water to the river. So steps need to be taken to identify these sources.

Technology Adoption

Suitable technology need to be adopted at the sources to decontaminate the water entering into the river.

Remedial Measures

The study found that the river bed is highly contaminated with the heavy metals, so suitable measures need to be taken to decontaminate the river bed.

Public Awareness

Public awareness is an important aspect to save the river from pollution. So efforts should be taken to involve citizens in building the campaign for clean Yamuna. The process will help to improve monitoring and decision making process concerning the river.

1 Introduction

1.1 Yamuna River in Delhi

The River Yamuna originates from the Himalayan glacier. Being the largest tributary of River Ganga and with a total basin area of 366,223 km², Yamuna geographically covers parts of the states of Uttaranchal, Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh and NCT–Delhi. The river crosses several states like Uttarakhand, Himachal Pradesh and Haryana then reaches Delhi. It enters Delhi near Wazirabad (Delhi) and covers a 48 km stretch in Delhi before entering into the state of Uttar Pradesh. Two other major cities Yamuna Nagar and Panipat of Haryana state are located close to the river prior to its entering Delhi.

Though the river Yamuna has its origin in Himalayan glacier Yamunotri which is located at 6,387 meters of the uppermost parts of the lower Himalayas and is a perennial river, however during the non-monsoon period in Delhi the Yamuna cannot be designated as a perennial river because during this period it segregates into four independent segments due to the presence of three barrages from where almost the entire water is being diverted for various socio-economic activities thus resulting in the absence of the good quality fresh water in the river which is essential to maintain its assimilation capacity.

1.2 Condition of the river in Delhi

River Yamuna covers 375 kms from its source of origin to Wazirabad in Delhi. Although there are two major industrial cities located close to the river discharging their waste waters into the river, however, in its physical appearance the water of Yamuna is of "reasonably good quality" till it reaches the Wazirabad barrage in Delhi. From Wazirabad, onwards the physical appearance of the river changes drastically due to the discharge of waste water through 15 drains between Wazirabad barrage and Okhla barrage renders the river to be severely polluted (Fig 1). Some of these prominent drains and canals are Najafgarh Nalah; Majnu Ka Tila drains; Vidhansabha Nalah; ISBT drain and Yamuna Bazaar drains. As Delhi impounds water from the barrage constructed at Wazirabad, so virtually the river has no fresh water flow for nine months and the water that flows subsequently is only sewage and waste.



Before Wazirabad

After Wazirabad



Research studies available on Yamuna River indicate a rise in pollution load of the river over the years. One study has revealed that pollution measured in terms of Biochemical Oxygen Demand (BOD) level has increased 2.5 times between 1980 and 2005. The BOD level which was 117 tons per day (tpd) in 1980 increased to 276 tpd in 2005.¹ Further, the Yamuna water quality at Okhla and Nizamuddin bridges was described as the worst affected and was placed seventh on the list of rivers with highest BOD levels (observed as 93 mg/L, while the permissible level is 3 mg/L), BOD being one of the most important indicators of pollution (Central Pollution Control Board, 2007).

1.3 Literature review on pollution load of Indian rivers

Numerous studies have been conducted on the pollution load of the rivers in India. Some findings of the water quality status of rivers across the country are indicated below:

1.3.1 Water Quality Status

- In 1997, Konhauser et al. recorded 2.68 and 9.8 ug/l of lead and chromium respectively at Mahanadi water samples.²
- In 2001 Nayak et al. recorded 3.45 lead, 9.6 ug/l chromium in Mahanadi water samples.³
- In 2005 Gomti River, Singh et al. recorded 0.02 ppm of lead, 0.0005 mg/l of cadmium, and 0.007 ppm of chromium.⁴

¹Anil Kumar Misra, (2010), A River about to Die: Yamuna, J. Water Resource and Protection, 2010, 2, 489-500 (doi:10.4236/jwarp.2010.25056 Published Online May 2010)

⁴Singh, V. K., Singh, K.P., Mohan, D. (2005). Status of heavy metals in water and bed sediments of river Gomti-a tributary of the Ganga River, India. Environ Monit Assess. 105(1-3):43-67.

²Konhauser, K. O.; Powell, M. A.; Fyfe, W. S.; Longstaffe, F. J.; Tripathy, S., (1997). Trace element chemistry of major rivers in Orissa State, India. Environ. Geo., 29 (1-2), 132-141.

³Nayak, B. B., Panda, U. C., Panigrahy, P. K., Acharya, B. C. (2001). Dynamics of heavy metals in Dhamara Estuary of Orissa state in India. Chem. Environ. Res., 10 (3-4), 203-218.

- In 2006 Jain and Sharma, recorded 37 μg/l of lead, 15 μg/l of chromium at Hindan River.⁵
- In 2006 Prasad et al. recorded 72 µg/l of lead, 6.0 µg/l cadmium in Achankovil River water samples.⁶
- In 2009 Sundaray et al. recorded 1.67 μg/l of lead, 10.89 μg/l of chromium in Koel (Brahmani) River water samples.⁷
- In 2010 Aktar, et al. recorded 120 of lead, 5 μg/l of cadmium in River Ganga water samples. In the same year R. Reza, et al. recorded mercury <0.05 μg/l, lead 12.08 ug/l, cadmium 4 μg/l and chromium 3 μg/l at Brahmani river water samples.⁸
- The current study done in year 2012 at Subarnarekha River by Manoj Kumar et al. recorded 0.023 mg/l of lead in water sample.⁹

1.3.2 Sediment Quality Status

- In 2005 Singh, et al. recoded 64.5 ppm of lead, 5.0 ppm of cadmium and 15.5 ppm of chromium in the sediment samples collected from the River Gomti.
- In 2009 Chakrabarty et al. recorded 39.1 ppm of lead and 50.7 ppm of chromium in the sediment samples collected from the River Dikrong.¹⁰
- In 2010 Taghinia Hejabi et al. recorded 265.4 ppm of lead, 60.7 ppm of chromium in the sediment samples collected from the River Kabini.¹¹
- In 2012 Manoj Kumar et al. recorded only lead (0.023 ppm) in the sediment sample of Subarnarekha river.

⁵Jain, C. K.; Sharma, M. K., (2006). Heavy metal transport in the Hindon river basin, India. Environ. Monitor. Assess., 112 (1-3), 255-270

⁶Prasad, M. B. K.; Ramanathan, A. L.; Shrivastav, S. K.; Anshumali.; Rajinder, S., (2006). Metal fractionation studies in surfacial and core sediments in the Achankovil river basin in India. Environ. Monitor. Assess., 121 (1-3), 77-102

⁷Sundaray, S. K., (2009). Application of multivariate statistical techniques in hydro-geochemical studies-a case study: Brahmani-Koel River (India). Environ. Monitor. Assess., 164 (1-4), 297-310

⁸Aktar, M. W.; Paramasivam, M.; Ganguly, M.; Purkait, S.; Sengupta, D., (2010). Assessment and occurrence of various heavy metals in surface water of Ganga river around Kolkata: a study for toxicity and ecological impact. Environ. Monitor. Assess., 160 (1-4), 207-213

⁹*Kumar M., Kumar B, Padhy P K. 2012. Characterisation of metals in water and sediments of Subarnarekha river along the projects' sites in lower basin, India. Universal Journal of Environmental Research and Technology. 2 (5): 402-410*

¹⁰Chakravarty M., Patgiri A.D. (2009). Metal pollution assessment in sediments of the Dikrong river, N.E. India. J Hum Ecol, 27(1): 63-67

¹¹Taghinia, H. A., Basavarajappa, H.T. and Qaid Saeed, A. M. (2010). Heavy metal pollution in Kabini river sediments. Int. J. Environ. Res., 4(4):629-636

2 Scope & Objectives of the Study

2.1 Scope of the Study

The primary focus of the present study is to detect the physio-chemical parameters (pH, total solids and turbidity) and heavy metals (Pb, Cd, Hg, total Cr, As) content in Yamuna water sample collected from different locations in Delhi. Moreover the study also reveals the variations in heavy metals concentration of the river in pre & post monsoon season. Finally the study aims to suggest some policy and practice measures that could be taken up in Delhi and implemented not only in Yamuna River but also for other rivers of India.

2.2 Objectives

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- To draw attention of the policymakers for suitable actions.

3

Sampling & Methodology

3.1 Sampling

Locations - In the present study, water and sediment samples were collected from 6 locations (Fig. 2) during two different seasons (pre monsoon season and post monsoon season). Sampling was done taking into consideration the pollution contributing sources to the river. For example, Location 1 represents relatively clean water and only agricultural activities could be the source of pollution in this location. Whereas in other locations (2, 3, 4, 5 and 6) domestic sewage, agricultural activities and industrial activities are possible contributing sources of pollution. These six location are at Jagatpur Village near Wazirabad (Location 1) which is also considered as control (Fig. 3) , Najafgarh Drain (Fig. 4), Majnu Ka Tila (Fig. 5), Vidhansabha Nalah, (Fig. 6), ISBT (Fig. 7), Yamuna Bazaar (Fig 8). The coordinates and other details of all water and sediment sampling locations are presented in table no. 1 and annexure 1.

Water Sampling - Surface water samples were collected from the identified locations, the samples were collected in plastic container (~ 1 L) and taken to the laboratory for further analysis.

Sediment Sampling - A grab sampler was used initially but it failed to collect depth samples at the identified locations hence the samples were collected close to the riverbed at the depth of ~ 10 cm in the plastic zip log bag, and taken to the laboratory for further analysis.

The samples were collected in pre and post monsoon seasons of year 2013. Total 24 numbers (12 for each water and sediment) of samples were collected from the study area (1 from each location in each season). Sampling was started from upstream of the river (Jagatpur village) to the downstream (Yamuna Bazar) (Fig.2).

The samples were sent to Delhi Test House (NABL accredited lab – ISO/ IEC 17025:2005), A- 62/3, G.T. Karnal Road, Industrial Area, Opposite Hans Cinema, Azadpur, Delhi - 110033 for conducting quantitative analysis of Physicochemical Parameters (pH, total solids, and turbidity) in water samples and heavy metals (Pb, Cd, Hg, total Cr, As) in water and sediment samples.

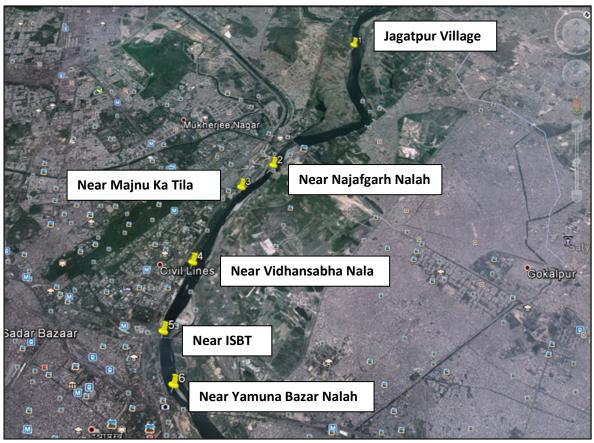


Figure 2 : Sampling Locations



Figure 3 : Location 1- Near Jagatpur Village



Figure 4 : Location 2 - Near Najafgarh Nala



Figure 5 : Location 3 – Near Majnu Ka Tila



Figure 7 : Location 5 – Near ISBT

Table 1	:	Sampling	locations
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Figure 6: Location 4–Near Vidhansabha Nala



Figure 8 : Location 6 – Near Yamuna Bazaar

Sn	Location	Landmark	Sample No.	Co-ordinates
1	Jagatpur	Near stone hips	1.1	280 44' N 770 13' E
2	Najafgarh Nalah	Near Pontoon Bridge	2.1	280 42' N 770 13' E
3	Majnu Ka Tila	Back Side of Gurudwara, Majnu Ka Tila	3.1	280 41' N 770 13' E
4	Vidhansabha Nala	Chandiram Akhada, Back side of Indraprastha Gas Station	4.1	280 40' N 770 13' E
5	ISBT	-	5.1	280 40' N 770 14' E
6	Yamuna Bazaar	Loha Pul, NIli Chhatri	6.1	280 39' N 770 14' E

3.2 Methodology

The collected samples were sent to the accredited laboratory for analysis. Standards Operating Procedures/methods were obtained to analyze the samples.

IS: 3025 (part 11): 1984	рН
IS : 3025 (part 10) : 1984	Turbidity (NTU)
IS: 3025 (Part 15): 1984	Total Solids
AAS/ ICP	Lead, nickel
AAS / ICP	Zinc, cadmium, mercury
APHA - 3500 - Cr - D	Hexavalent chromium

Table 2 : Methods used to iden	ntify parameters for water
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Note:

*APHA: American Public Health Association *AAS Atomic Absorption Spectrometry *ICP: Inductively Coupled Plasma-Emission Spectrometry (ICP–ES) *IS: Indian Standards

The protocol used for the analysis of heavy metals (Pb, Cd, Hg, As, Cd) in Sediment Samples is US-EPA-3051-A.¹² The digestion method used for heavy metals was Microwave Digestion of 7500cx ICP-MS from M/S Agilent Technologies.

3.3 Physicochemical Parameters

3.3.1 pH

pH of aqueous solution is defined as the negative logarithm of hydrogen ion activity. The basic principle of pH measurement is determination of the activity of the hydrogen ions by potentiometer, using a standard hydrogen electrode and a reference electrode. Its value is governed largely by the carbon dioxide/ bicarbonate/carbonate equilibrium. The effect of pH on the chemical and biological properties of water makes its determination very important. It is used in several calculations in analytical work and its adjustment is necessary in most of the analytical procedures. The pH of water determines the solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.). The pH determination is usually done by electrometric (pH meter with a combination of pH electrodes) method. This is considered to be one of the most accurate methods as it is free of interference. The pH of samples was measured on pH meter pre-standardized with buffers of pH 4.0, 7.0 and 9.2. Values for pH are reported in standard pH units.

¹²http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/3051a.pdf

3.3.2 Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. Fluids can contain suspended solid matter consisting of particles of many different sizes. While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand (the settable solids), very small particles will settle very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid. Turbidity (or haze) is also applied to transparent solids such as glass or plastic. In plastic production haze is defined as the percentage of light that is deflected more than 2.5 from the incoming light direction.¹³

3.3.3 Total Solids

A total solid is a measure of the suspended and dissolved solids in water. Suspended solids are those that can be retained on a water filter and are capable of settling out of the water column onto the stream bottom when stream velocities are low. They include silt, clay, plankton, organic wastes, and inorganic precipitates such as those from acid mine drainage. Dissolved solids are those that pass through a water filter. They include some organic materials, as well as salts, inorganic nutrients, and toxins.

The concentration of dissolved solids in stream water is important because it determines the flow of water in and out of the cells of aquatic organisms. Also, some dissolved inorganic elements such as nitrogen, phosphorus, and sulfur are nutrients essential for life. Low concentrations of total solids can result in limited growth of aquatic organisms due to nutrient deficiencies. Elevated levels of total solids, however, can lead to eutrophication of the stream or increased turbidity. Both eutrophication and increased turbidity result in a decrease in stream water quality. Elevated concentrations of total solids may indicate the presence of agricultural activities, dredging, or mining upstream from your sample site.¹⁴

3.4 Heavy metals and their health implications

Heavy metals are typical pollutants in urban environments. These elements are of particular concern due to their persistence in the environment and their toxicity to humans.^{15,16} The non-biodegradability of heavy metals leads to their accumulation in the environment and thus they are also known as 'chemical time bombs'.¹⁷ Sediments, particularly surface sediments,

¹³http://en.wikipedia.org/wiki/Turbidity

¹⁴http://www.cotf.edu/ete/modules/waterq3/WQassess4g.html

¹⁵ Agency for Toxic Substances and Disease Registry (ATSDR), 2000, Toxicological Profile for Chromium, U.S. Department of Health and Human Services, Public Health Service, ATSDR, September 2000

¹⁶M. Biasioli, R. Barberis, F.Ajmone-Marsan, "The influence of a large city on some soil properties and metals content," Science of the Total Environment 2006, vol. 356, pp. 154-164.

¹⁷A.A. Odewande, A.F. Abimbola, "Contamination indices and heavy metal concentrations in urban soil of Ibadan metropolis, southwestern Nigeria," Environ Geochem Health 2008, vol. 30, pp. 243–254.

can act as metal pools that release metals to the overlaying water via natural or anthropogenic processes, causing potential adverse health effects to the ecosystems.^{18,19},

The main threats to human health from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic. These metals have been extensively studied and their effects on human health regularly reviewed by international bodies such as the WHO. Although several adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues, and is even increasing in some parts of the world, in particular in less developed countries, though emissions have declined in most developed countries over the last 100 years.²⁰

These heavy metals are not readily degradable in the environment and accumulate in the animal and human bodies to a very high toxic levels leading to undesirable effects. The increased population and the progress in agriculture and industry, in the recent years, have further complicated this situation.³ The discharge of untreated or partially treated industrial waste waters containing heavy metals into the water bodies, especially rivers, prevail in aquatic bodies and get bio-accumulated along the food chain. Bio-magnification of these heavy metals along the food chains occur leading to various health hazards to both humans and other living organisms.

Heavy Metals affect the structural, biological functioning of biomolecules.²¹ They are also known to interfere with synthesis & metabolism of the hormones.^{22,23,24}

Trace metals enter in river from variety of sources; it be can be either natural or anthropogenic. Usually in unaffected environments, the concentration of most of the metals is very low and is mostly derived from the mineralogy and the weathering. Main anthropogenic sources of heavy metal contamination are mining, disposal of untreated and partially treated effluents contain toxic metals, as well as metal chelates from different industries and indiscriminate use of heavy metal-containing fertilizer and pesticides in agricultural fields.²⁵

¹⁸G. Shi, Z. Xu, S. Chen, J. Zhang, L. Wang, , Bi, C., J. Teng, "Potentially toxic metal contamination of urban soils and roadside dust in Shanghai, China," Environmental Pollution 2008, vol. 156, pp. 251-260.

¹⁹R. J. Howarth, M. A. Nombela, "Metals in the sediments of Ensenada de San Simon (inner Ria de Vigo)," Galicia, NW Spain, Applied Geochemistry 2003, vol. 18, pp. 973–996, doi:10.1016/S0883-2927 (02)00203-2.

²⁰R. Reza; G. Singh. Heavy metal contamination and its indexing approach for river water. (2010) Int. J. Environ. Sci. Tech., 7(4), 785-792

²¹Giguere, A., Campbell, P. G. C., Hare, L., Mc Donald, D. G., & Rasmussen, J. B. (2004). Influence of lake chemistry and fish age on cadmium, copper and zinc concentrations in various organs of indigenous yellow perch (Percaflavescens). Canadian Journal of Fisheries and Aquatic Sciences, 61, 702–1716.

²²*McCormick, Sd., O'Dea, M. F., Moeckel, A. M., Lerner, D. T. and Bjornsson, B. T. (2005). Endocrine disruption of parr-smolt transformation and seawater tolerance of Atlantic Salmon by 4-nolyphenol and 17β estradiol. General and Comparative Endocrinology, 142,* 280–288. http://dx.doi.org/10.1016/j.ygcen.2005.01.015

²³Manjappa, S., & Puttaioh, E. T. (2005). Evaluation of trace metals in the sediments of river Bhadra near Bhadravathi town, Karnataka, India. Journal of Industrial Pollution Control, 21(2), 271–276.

²⁴Gupta, A., Rai, D.K., Pandey, R.S., & Sharma, B. (2009). Analysis of some heavy metals in the riverine water, sediments and fish from river ganges at Allahbad. Environmental Monitoring and Assessment, 157, 449-458. http://dx.doi.org/10.1007/s10661-008-0547-64

²⁵Riddell, D. J., Culp, J. M., & Baird, D. J. (2005). Behavioural response to sublethal cadmium within an experiment aquatic food web. Environmental Toxicology and Chemistry, 24, 431–441. http://dx.doi.org/10.1897/04-026R.1

3.4.1 Mercury:

The use of mercury in industrial processes significantly increased following the industrial revolution of the 19th century. Mercury is or has been used for the cathode in the electrolytic production of chlorine and caustic soda, in electrical appliances (lamps, arc rectifiers, mercury cells), in industrial and control instruments (switches, thermometers, barometers), in laboratory apparatus and as a raw material for various mercury compounds. The latter are used as fungicides, antiseptics, preservatives, pharmaceuticals, electrodes and reagents. Mercury has also been widely used in dental amalgams. Methylation of inorganic mercury is an important process in water and occurs in both fresh water and seawater (IPCS, 1989).

The two main effects of mercury poisoning are neurological and renal disturbances. The former is characteristic of poisoning by methyl- and ethyl-mercury (II) salts, in which liver and renal damage are of relatively little significance, the latter of poisoning by inorganic mercury.

Mercury poisoning deteriorates the nervous system, can impair hearing, speech, vision and gait, involuntary muscle movements, corrodes skin and mucous membranes, and causes chewing and swallowing to become difficult. Exposure to mercury can be particularly hazardous for pregnant women and small children.²⁶ In children, a syndrome characterized by red and painful extremities called acrodynia has been reported to result from chronic mercury exposure.

3.4.2 Arsenic :

The potential for arsenic in drinking water to cause effects in utero and for early life exposures to affect child development, child health, and adult disease has been a topic of increasing attention in recent years.²⁷ Arsenic ingestion causes characteristic pigmentation changes in the skin of the trunk and limbs and nodular keratosis on the palms and soles. In most populations with arsenic water problems, lesions are the first sign to indicate the problem.¹⁷

3.4.3 Lead:

Lead is used in the production of lead acid batteries, solder, alloys, cable sheathing, pigments, rust inhibitors, ammunition, glazes and plastic stabilizers, paint pigments, etc. From a drinking-water perspective, the almost universal use of lead compounds in plumbing fittings and as solder in water distribution systems is important. Lead pipes may be used in older distribution systems and plumbing.¹⁷ Lead is a cumulative general poison, with infants, children up to 6 years of age, the fetus and pregnant women being the most susceptible to

²⁶ J. K. Vodela, S. D. Lenz, J. A. Renden, W. H. Mcelhenney, and B. W. Kemppainen. Drinking water contaminants (Arsenic, Cadmium, Lead, Benzene, and Trichloroethylene). 2. Effects on reproductive performance, egg quality, and embryo toxicity in broiler breeders.

²⁷Allan H. Smith and Craig M. Steinmaus, 2009, Health Effects of Arsenic and Chromium in Drinking Water: Recent Human Findings, Annu Rev Public Health.; 30: 107–122.

adverse health effects. Its effects on the central nervous system can be particularly serious. Overt signs of acute intoxication, including dullness, restlessness, irritability, poor attention span, headaches, muscle tremor, abdominal cramps, kidney damage, hallucinations, loss of memory and encephalopathy.

3.4.4 Cadmium:

Cadmium metal is used mainly as an anticorrosive, electroplated onto steel. Cadmium sulfide and selenide are commonly used as pigments in plastics. Cadmium compounds are used in electric batteries, electronic components and nuclear reactors. Fertilizers produced from phosphate ores constitute a major source of diffuse cadmium pollution. The solubility of cadmium in water is influenced to a large degree by its acidity; suspended or sediment-bound cadmium may dissolve when there is an increase in acidity.

With chronic oral exposure, the kidney appears to be the most sensitive organ. Cadmium affects the resorption function of the proximal tubules, the first symptom being an increase in the urinary excretion of low-molecular-weight proteins, known as tubular proteinuria.²⁸ (Krajne et al., 1987). Possible effects include aminoaciduria, glucosuria and phosphaturia. Disturbances in renal handling of phosphorus and calcium may cause resorption of minerals from bone, which can result in the development of kidney stones and osteomalacia.

3.4.5 Chromium:

Chromium and its salts are used in the leather tanning industry, the manufacture of catalysts, pigments and paints, fungicides, the ceramic and glass industry, and in photography, and for chrome alloy and chromium metal production, chrome plating and corrosion control.

Chromium-3 is a nutritionally essential element in humans and is often added to vitamins as a dietary supplement. Chromium-3 has relatively low toxicity and would be a concern in drinking water only at very high levels of contamination; Chromium-6 is more toxic and poses potential health risks. People who use water containing total chromium in excess of the maximum contaminant level (MCL) over many years could experience allergic dermatitis. Ingestion of high concentrations of Cr (VI), for example, 29 mg/kg (body mass), often results in lung function and blood system problems; death may be the result of pulmonary or cardiac arrest. Ingestion of Cr (VI) often produces gastrointestinal burns and hemorrhage, liver damage, and kidney damage that may lead to death. Other symptoms are diarrhea, ulcers, abdominal pain, indigestion, and vomiting (ATSDR, 2000).¹⁵

²⁸ http://www.who.int/water_sanitation_health/dwq/chemicals/0304_80/en/index8.html

4 Results & Discussions

The sampling was done in the month of May and September 2013 for water and sediments sampling. Different analytical methods have been adopted and are listed below.

Parameters	Methods
pH	IS : 3025 (part 11) : 1984
Conductivity	APHA – 2510 B
Total hardness	APHA – 2340 C
Turbidity (NTU)	IS : 3025 (part 10) : 1984
COD	APHA – 5220 (COD) C
Lead, nickel	AAS/ ICP
Zinc , cadmium , mercury	AAS / ICP
HEX – Chromium	APHA – 3500 – Cr – D

Table 3 : Methods used to identify parameters

*APHA – American Public health association. *AAS / ICP –Atomic Absorption Spectrometry / Inductively Coupled Plasma Emission Spectrometry (ICP–ES) *IS –Indian Standards Detailed parameter for testing placed in Annex 1

4.1 Water Quality of River Yamuna - Physicochemical Parameters

Physical parameters are represented in table 4 and heavy metals are represented in table 5 as given below:

SN	рН		Turbidity (NTU)		Total Solids mg/lit	
	Pre	Post	Pre	Post	Pre	Post
1	6.9	6.9	14	16	240	222
2	7.18	7.22	12	32	405	1136
3	6.78	7.14	19	28	955	1052
4	7.05	7.16	26	34	882	902
5	6.93	7.02	29	28	782	760
6	7.35	7.22	17	26	855	790
Minimum	6.78	6.90	12	16	240	222
Maximum	7.35	7.22	29	34	955	1136
Average	7.03	7.11	20	27	687	810
Drinking Water Specification (IS: 10500)	6.5 - 8.5		5 NTU		500 mg/lit	

Table 4 : Water quality in pre and post monsoon season – physical parameters

4.1.1 Surface Water Quality of River Yamuna

The observed data was compared with Indian Standards (IS: 10500). The detailed comparative analysis is presented below.

pH Concentration:

The pH concentration varied from 6.78 to 7.35 in pre monsoon season and 6.90 to 7.22 in post monsoon season. This is found to be within the desirable limit as per Indian standards (6.5 to 8.5) for both seasons

During the study the lowest pH was recorded at location 3 and location 1 in pre and post monsoon season respectively and the highest pH was recorded at location 6 in both seasons. The average pH was 7.03 and 7.11 in and pre and post monsoon respectively. The pH value remained unchanged at location 1 (6.9), increased at locations 2, 3, 4 and 5 and decreased at location

6. Location 2-5 indicated an increasing trend for pH values (Fig. 9).

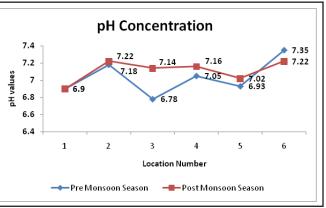


Figure 9 : Seasonal variation in pH concentration in water

Turbidity Concentration:

Turbidity is mainly due to the dispersion of suspended particles. Abnormal value of turbidity is usually due to discharge of water due to floating sediments carried by the river from catchment areas.

The observed turbidity concentration in the present study varied from 12.0 to 29 mg/l and 16.0 to 34.0 mg/l in pre and post monsoon season respectively. The average concentration of turbidity was observed to be 20.0 mg/l and 27.0 mg/l in pre and post monsoon season respectively.

All locations showed higher turbidity concentration as compared to the Indian standard (5 NTU) in both seasons. There is slight variation observed at location 1 and 5, but the turbidity level at other four locations was found gradual increase (Fig. 10).

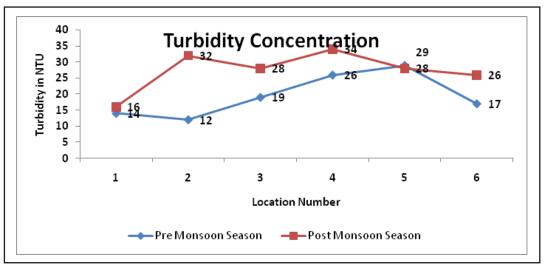


Figure 10 : Seasonal variation in turbidity concentration in water

Total Solids Concentration:

A total solid is the measure of total dissolved solids and total suspended solids. The observed total solids level in the present study varied from 240 to 955 mg/lit and 222 to 1136 mg/lit in pre and post monsoon season respectively. Average concentrations of total solids were 687 and 810 mg/l in pre and post monsoon season respectively.

In pre monsoon season location 1 and 2 and in post monsoon season location 1 were within the limit of Indian standards (500 mg/l) while other four locations in pre monsoon season and five in post monsoon season were higher.

At all location except 1, there was increase in total solid levels. An increase of total solid levels in post monsoon season indicates the pollution load in post monsoon season (Fig. 11).

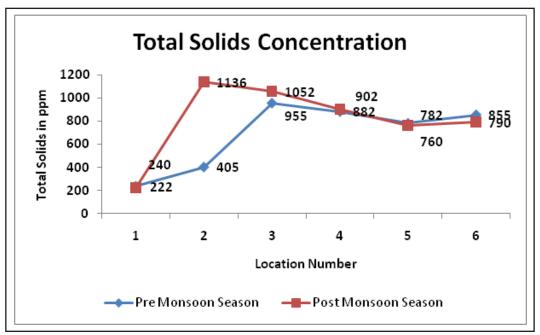


Figure 11 : Seasonal variation in total solids concentration in water

Heavy Metals Concentration:

Four heavy metals were analyzed in surface water sample in pre and post monsoon season. All heavy metals were found below detectable level in both seasons (table 4).

4.1.2 Sediment Quality of River Yamuna

The following section details out the status of sediments found in River Yamuna:

Heavy Metals Concentration:

Heavy Metal analysis of sediments collected from river Yamuna is represented in table 5:

SN	Lead		Lead Cadmium		Total Cr		Mercury		Arsenic	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	7.1	15.4	0.2	< 0.01	7.2	28.9	0.94	< 0.01	1.21	8.2
2	19.58	27.9	0.38	< 0.01	21.49	195.8	1.02	3.2	4.92	7.3
3	14.2	14.8	0.36	< 0.01	49.44	66.7	0.98	< 0.01	2.49	7
4	15.51	55.7	0.28	< 0.01	57.37	796.7	0.95	4.7	4.07	11.4
5	16.78	11.9	0.31	< 0.01	28.06	29.4	0.94	< 0.01	3.17	5.3
6	23.9	17.8	0.35	< 0.01	90.23	124.7	0.81	< 0.01	3.96	7.2
min	7.10	11.90	0.20	0.00	7.20	28.90	0.81	3.20	1.21	5.30
max	23.90	55.70	0.38	0.00	90.23	796.70	1.02	4.70	4.92	11.40
avg	16.18	23.92	0.31	0.00	42.30	207.03	0.94	3.95	3.30	7.73

Table 5 : Sediment quality in pre and post monsoon season of Yamuna River

* All values are in ppm

As location 1 was considered as a control location for the study, the other data was compared with this. Sediment sample of pre monsoon season contained lead, cadmium, chromium (total) and arsenic and levels were found to be higher than other 5 locations. There was not much difference in mercury level at the remaining 5 locations when compared with control location. In post monsoon season, lead levels were observed to have risen at locations 1, 2, and 4. Cadmium was not detected at any location. Increased levels of Chromium (total) and arsenic were found in post monsoon season. The chromium levels were very high in comparison to chromium level of control location.

Lead Concentration:

Lead concentration in pre monsoon season varied from 7.1 ppm to 23.9 ppm and 15.4 ppm to 55.7 ppm in post monsoon season. The average lead concentration in pre and post monsoon season was 16.18 ppm and 23.92 ppm respectively. Only four locations found increase of lead concentration on post monsoon season i.e., location 1 to location 4, out of these location 4 had shown huge variation. The lead concentration of location 4 in pre monsoon season was 15.51 ppm which was 55.7 ppm in post monsoon season, which clearly indicates that the activities carried out at the location contributing to the pollution in that season (Fig. 12).

Cadmium Concentration:

The cadmium concentration in pre monsoon season varied from 0.2 ppm to 0.38 ppm and the data observed in post monsoon season was below detectable level (Fig. 13).

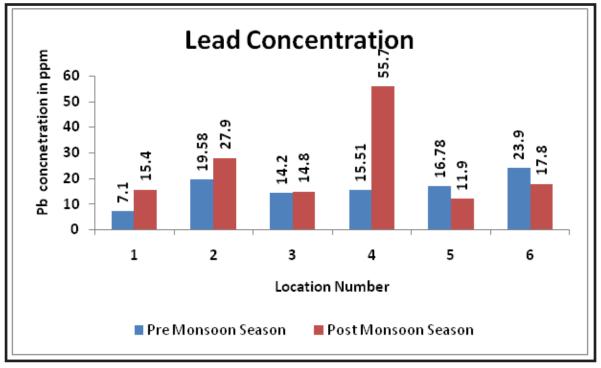


Figure 12 : Seasonal variation in lead concentration in sediments

Chromium Concentration:

In the present study the concentration of total chromium were observed in between 7.2 and 90.23 ppm in pre monsoon and 28.9 and 796.7 ppm in post monsoon season. The

average total chromium concentration observed in pre and post monsoon season was 40.30 ppm and 207.03 ppm respectively. in chromium Increase level has been observed at all locations, the highest level being in location initiating seasonal 4 variation (Fig. 14).

Mercury Concentration:

Mercury concentration in pre monsoon season varied from 0.81 ppm to

1.02 ppm but in post monsoon mercury was detected in only two locations i.e., location 2 (3.2 ppm) and 4 (4.7 ppm). The average mercury concentration observed in pre and post monsoon season was 0.94 ppm and 3.95 ppm respectively. Location 4 showed increase of mercury concentration in post monsoon season 4.7 from 0.95 ppm recorded in pre monsoon season,

which clearly indicated the seasonal variation (Fig. 15).

Arsenic Concentration:

In the present study the concentration of arsenic were observed in between 1.21 and 4.92 ppm in pre monsoon and 5.3 and 11.4 ppm in post monsoon season. The arsenic average concentration observed in pre and post monsoon season was 3.30 ppm and 7.73 ppm respectively. At all locations increase of arsenic level has been 18

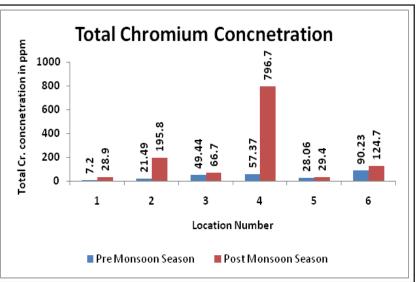


Figure 14 : Seasonal variation in total chromium concentration in sediments

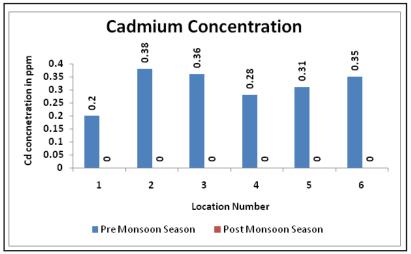


Figure 13 : Seasonal variation in cadmium concentration in sediments

observed but the highest level was observed in location 4, which indicates seasonal variation. This variation might occur because of surface runoff in rainy season, industrial and domestic pollution (Fig. 16).

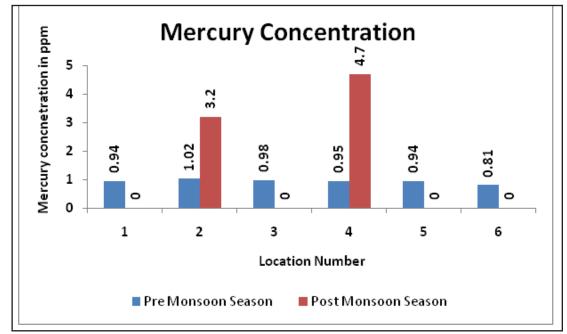


Figure 15 : Seasonal variation in mercury concentration in sediments

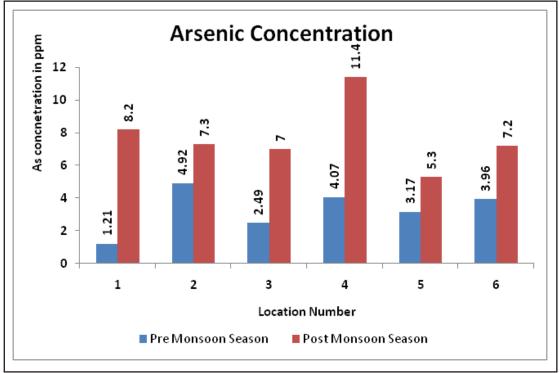


Figure 16 : Seasonal variation in arsenic concentration in sediments

4.2 Observations

The results indicate the level of contamination and seasonal changes in the water and sediment samples collected from different locations of River Yamuna:

- There were seasonal variations in pH concentration at all locations except location no 1.
- The pH level of all the samples were within the prescribed limit of Indian standard
- All the samples witnessed high turbidity level in compare to the prescribed limit of Indian Standard (5 NTU).
- All locations indicated increased turbidity level post monsoon season except for location 5
- Total solids concentration of samples from location 1 and 2 were within the prescribed limit of Indian Standard (500 mg/l), while samples from other locations were found to be quite high. The highest total solids was observed at location 3 (955 mg/l) in pre monsoon season.
- No heavy metals were observed in the water samples of the river
- Lead was detected in all the sediment samples with variations in pre and post monsoon season
- Cadmium was detected in all the pre monsoon samples however no cadmium was detected in post monsoon samples
- Chromium was detected in all the samples with variations in pre and post monsoon season.
- Mercury was detected in all the samples collected in pre monsoon season, while only two samples collected in post monsoon show presence of mercury.
- Arsenic was detected in all the samples with varied concentration.

5 Conclusions & Recommendations

The test results show high level of heavy metals in the sediment of the river Yamuna. The results also indicate the high variation in concentration of the heavy metals before and after Wazirabad. Thus the detection of high level of heavy metals in the samples after Wazirabad may be due to the discharge of the waste water into the river from various canals and the drains. Further as the vegetables are being grown in the flood plain of Yamuna, and the present studies raise the issue of contamination of these vegetables.

Recommendations:

Generation of Data

There are number of studies on the pollution load of the river Yamuna however there is a need for generation of data periodically to monitor the pollution load of the river. There is also requirement for more research studies on the river bed and its impact on the flora and fauna along the river.

Source Identification

Some of the sources of the contamination of the river are well known however there small drains are releasing the waste water to the river. So steps need to be taken to indentify these sources.

Technology Adoption

Suitable technology need to be adopted at the sources to decontaminate the water entering into the river.

Remedial Measures

The study found that the river bed is highly contaminated with the heavy metals, so suitable remedial measures are needed to be taken to decontaminate the river bed.

Public Awareness

Public awareness is an important aspect to save the river from pollution. So efforts should be taken to involve citizens in building the campaign for clean Yamuna. The process will help to improve monitoring and decision making process concerning the river.

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- 30 Omitted by Rule 2(i)(iii) of the Environment (Protection) Third Amendment Rules, 1993, vide G.S.R. 801(E) dated31.12.1993
- 31 Inserted by rule 2(k) (ix), ibid.

SN	Location	Landmark	Sampling No.	Co-ordinates
1	Jagatpur	Near stone hips	1.1	28° 44' 19.63" N 77° 13' 46.59" E
2	Najafgarh Nalah	Near Pontoon Bridge	2.1	28° 42' 13.82" N 77° 13' 57.17" E
3	Majnu Ka Tila	Back Side of Gurudwara, Majnu Ka Tila	3.1	28° 41' 48.99" N 77° 13' 46.13" E
4	Vidhansabha Nala	Chandiram Akhada, Back side of Indraprastha Gas Station	3.1	28° 41' 48.99" N 77° 13' 52.00" E
5	ISBT	-	5.1	28° 40' 08.59" N 77° 14' 04.55" E
6	Yamuna Bazaar	Loha Pul, NIli Chhatri	6.1	28° 39' 48.04" N 77° 14' 29.63" E

1. Water Sampling Location for River Yamuna

2. Sediment Sampling Location for River Yamuna

SN	Location	Landmark	Sampling No	Co-ordinates
1	Jagatpur	Jagatpur Band	1.1	28°44'19.37"N 77°13'46.95"E
2	Najafgarh Nalah	Near Pontoon Bridge	2.1	28° 42' 13.82" N 77° 13' 57.17" E
3	Majnu Ka Tila	Back Side of Gurudwara, Majnu Ka Tila	3.1	28° 41' 48.99" N 77° 13' 46.13" E
4	Vidhansabha Nala	Chandiram Akhada, Back side of Indraprastha Gas Station	4.1	28° 40' 50.09" N 77° 13' 51.24" E
5	ISBT	-	5.1	28° 40' 08.59" N 77° 14' 04.55" E
6	Yamuna Bazaar	Loha Pul, NIli Chhatri	6.1	28° 39' 47.68" N 77° 14' 29.14" E

Water Quality Standards

Drinking Water Specification: IS: 10500, 1992 (Reaffirmed 1993)²⁹

	Parameter	IS: 10500 Requirement (Desirable limit)	Undesirable effect outside the desirable limit	IS: 10500 Permissible limit in the absence of alternate source
Essent				
1.	рН	6.5 - 8.5	Beyond this range the water will effect the mucous membrane and / or water supply system	No relaxation
2.	Colour (Hazen Units), Maximum	5	Above 5, consumer acceptance decreases	25
3.	Odour	Unobjectionable		
4.	Taste	Agreeable		
5.	Turbidity, NTU, Max	5	Above 5, consumer acceptance decreases	10
Follow	ving Results are	expressed in mg/1	:	
6.	Total hardness CaCO ₃ , Max	as 300	Encrustation in water supply structure and adverse effects on domestic use	600
7.	Iron as Fe, Max	0.30	Beyond this limit taste / appearance are affected, has adverse effect on domestic uses and water supply structures, and promotes iron bacteria.	1.0
8.	Chlorides as Cl, Max	250	Beyond this limit taste, corrosion and palatability are effected	1000
9.	Residual, Free Chlorine, Min			

²⁹http://hppcb.gov.in/eiasorang/spec.pdf

Desi	rable Characteris	tics		
10.	Dissolved solids, Max	500	Beyond this palatability decreases and may cause gastro intentional irritation	2000
11.	Calcium as Ca, Max	75	Encrustation in water supply structure and adverse effects on domestic use	200
12.	Magnesium as Mg, Max	30	100	
13.	Copper as Cu, Max	0.05	Astringent taste, discoloration and corrosion of pipes, fitting and utensils will be caused beyond this	1.5
14.	Manganese as Mn, Max	0.1	Beyond this limit aste/appearance are affected, has adverse effect on domestic uses and water supply structures	0.3
15.	Sulphate as SO ₄ Max	200	Beyond this causes gastro intentional irritation when magnesium or sodium are present	400
16.	Nitrates as NO ₃	45	Beyond this methanemoglobinemia takes place	100
17.	Fluoride, Max	1.0	Fluoride may be kept as low as possible. High fluoride may cause fluorosis	1.5
18.	Phenolic compounds as C_6H_5OH , Max	0.001	Beyond this, it may cause objectionable taste and odour	0.002
19.	Mercury as Hg, Max	0.001	Beyond this, the water becomes toxic	No relaxation
20.	Cadmium as Cd, Max	0.01	Beyond this, the water becomes toxic	No relaxation
21.	Selenium as Se, Max	0.01	Beyond this, the water becomes toxic	No relaxation

22.	Arsenic as	0.05	Beyond this, the water	No relaxation
23.	Max Cyanide as	0.05	becomes toxic Beyond this, the water	No relaxation
24.	CN,Max Lead as Pb,	0.05	becomes toxic Beyond this, the water	No relaxation
25.	Max Zinc as Zn, Max	5	becomes toxic Beyond this limit it can cause astringent taste and an opalescence in water	15
26.	Anionic detergents as MBAS, Max	0.2	Beyond this limit it can cause a light froth in water	1.0
27.	Chromium as Cr_6^+ , Max	0.05	May be carcinogenic above this limit	No relaxation
28.	Polynucle aran omatic hydrocarbons as PAH, Max		May be carcinogenic	
29.	Mineral Oil, Max	0.01	Beyond this limit undesirable taste and odour after chlorination take place	0.03
30.	Pesticides, Max		Absent	Toxic 0.001
31.	Radioactive materials a) α emitters Bq/1, Max b) β emitters Pci/1, Max			0.1
32.	Alkalinity, Max	200	Beyond this limit taste becomes unpleasant	600
33.	Aluminum as Al, Max	0.03	Cumulative effect is reported to cause dementia	0.2
34.	Boron, Max	1	5	

General Standards for Discharge of Environmental Pollutants

Part A: Effluents

SN	Parameter	Inland surface water	Public sewers	Standards Land of irrigation	Marine/Coastal areas
1.	Colour and odour	Of Annexure 4	-	See 6 of Annexure 5	See 6 of Annexure 5
2.	Suspended solids Mg/1, max.	100	600	200	For processing wastewater, 100 For cooling water effluent,10 per cent above total suspended mater of influent
3.	Particle size of suspended solids	Shall pass 850 micron IS sieve	_		Floatable solids, solids max. 3 mm Settleable solids max. 856 microns
4.	pH value	5.5 to 9.0	5.5 to9.0	5.5 to 9.0	5.5 to 9.0
5.	Temperature	Shall not exceed 5°C above the receiving wate temperature	- 21	_	Shall not exceed 5° C above the receiving water temperature
6.	Oil and grease, Mg / 1 max.	, 10	20	10	20
7.	Total residual chlorine, g/1 max	1.0	-	-	1.0
8.	Ammonical Nitrogen (as N), mg/l, max.	50	50	_	50

9.	Total nitrogen (as N), mg/l, max.	100	-	-	100
10.	Free ammonia (as NH ₃), mg/l, max	5.0	-	-	5.0
11.	Biochemical oxygen demand (3 days at 27°C), mg/l, max	30	350	100	100
12.	Chemical oxygen demand, mg/l, max	250	-	-	250
13.	Arsenic (as As) mg/l, max	0.2	0.2	0.2	0.2
14.	Mercury (as Hg), mg/l, max	0.01	0.01	-	0.01
15.	Lead (as Pb), mg/l, max	0.1	0.1	_	2.0
16.	Cadmium (as Cd), mg/l, max	2.0	1.0	-	2.0
17.	Hexavalent chromium (as Cr+6), mg/l, max	0.1	2.0	-	1.0
18.	Total chromium (as Cr), mg/l, max	2.0	2.0	_	2.0

19.	Copper (as Cu), mg/l, max	3.0	3.0	_	30	
20.	Zinc (as Zn), mg/l, max	5.0	15	_	15	
21.	Selenium (as Se), mg/l, max	0.05	0.05	_	0.05	
22.	Nickel (as Ni), mg/l, max	3.0	3.0	_	50	
23.	Cyanide (as CN), mg/l, max	0.2	2.0	0.2	0.2	
24.	Fluoride (as F), mg/l, max	2.0	15	_	15	
25.	Dissolved phosphates (as P), mg/l, max	5.0	_	_	_	
26.	Sulphide (as S), mg/l, max	2.0	_	_	5.0	
27.	Phenolic compounds (as C ₆ H ₅ OH), mg/l, max	1.0	5.0	_	5.0	
28.	Radioactive materials					

	α emitters micro cure mg/l, max	10–7	10-7	10-8	10–7
	β emitters micro cure mg/l, max	10–6	10–6	10–7	10–6
29.	Bio-assay test	90 % survival of fish after 96 hours in 100 % effluent	90 % survival of fish after 96 hours in 100 %	90 % survival of fish of fish after 96 hours in 100 % effluent	90 % survival of fish after 96 hours in 100 % effluent Effluent
30.	Manganese (as Mn) mg/l	2 mg/l	2 mg/l	2 mg/l	2 mg/l
31.	Iron (as Fe)	3 mg/l	3 mg/l	3 mg/l	3
32.	Vanadium (as V)	0.2 mg/l	0.2 mg/l	-	0.2 mg/l
33.	Nitrate Nitrogen	10 mg/l	_	_	20 mg/l

Note: * These standards shall be applicable for industries, operations or processes other than those industries. Operations or processes for which standards have been specified in Schedule of the Environment Protection Rules 1989.

(For the purposes of Parts – A, B and C)

The State Boards shall following guide-lines in enforcing the standards specified under the schedule VI:

- (1) The waste waters and gases are to be treated with the best available technology (BAT) in order to achieve the prescribed standards.
- (2) The industries need to be encouraged for recycling and reuse, of waste materials as far as practicable in order to minimize the discharge of wastes into the environments.
- (3) The industries are to be encouraged for recovery of biogas, energy and reusable materials.
- (4) While permitting the discharge of effluent and emission into the environment, State Boards have to take into account the assimilative capacities of the receiving bodies, especially water bodies so that quality of the intended use of the receiving waters is not affected. Where such quality is likely to be effected discharges should not be allowed into water bodies.
- (5) The Central and State Boards shall put emphasis on the implementation of clean technologies by the industries in order to increase fuel efficiency and reduce the generation of environmental pollutants.
- (6) All efforts should be made to remove colour and unpleasant odour as far as practicable.
- (7) The standards mentioned in the Schedule shall also apply to all other effluents discharged such as industrial mining, and mineral processing activities and sewage.
- (8) The limit given for the total concentration of mercury in the final effluent of caustic soda industry is for the combined effluent from (a) Cell house, (b) Brine Plant, (c) Chlorine handling, (d) hydrogen handling and (e) hydro choleric acid plant.
- (9) 1[(a)...,(f)]
- (10) All effluents discharge including from the industries such as cotton textile, composite woollen mills, synthetic rubber, small pulp & paper, natural rubber, petro-chemicals, tanneries, point dyes, slaughter houses, food & fruit processing and diary industries into surface waters shall conform to be BOD limit specified above, namely 30 mg/l. For discharge an effluent having a BOD more than 30 mg/l, the standards shall conform to those given, above for other receiving bodies, namely, sewers, coastal waters, and land for irrigation.

- $(11) [***....]^{30}$
- (12) In case of fertilizer industry the limits in respect of chromium and fluoride shall be complied with at the outlet of chromium and fluoride removal units respectively.
- (13) In case of pesticides:
- (a) The limits should be complied with at the end of the treatment plant before dilution.
- (b) Bio-assay test should be carried out with the available species of fish in the receiving water, the COD limits to be specified in the consent conditions should be correlated with the BOD limits.
- (c) In case metabolites and isomers of the Pesticides in the given list are found in significant concentration, standards should be prescribed for these also in the same concentration as the individual pesticides.
- (d) Industries are required to analyze pesticides in waste water by advanced analytical methods such as GLC/HPLC.
- (14) ³¹The chemical oxygen demands (COD) concentration in a treated effluent, if observed to be persistently greater than 250 mg/l before disposal to any receiving body (public sewer, land for irrigation, inland surface water and marine coastal areas), such industrial units are required to identify chemicals causing the same. In case these are found to be toxic as defined in the Schedule I of the Hazardous Rules 1989 the State Board in such cases shall direct the industries to install tertiary treatment stipulating time limit.
- (15) Standards specified in Part A of Schedule VI for discharge of effluent into the public sewer shall be applicable only if such sewer leads to a secondary treatment including biological treatment system, otherwise the discharge into sewers shall be treated as discharge into inland surface waters].

 ³⁰Omitted by Rule 2(i)(iii) of the Environment (Protection) Third Amendment Rules, 1993, vide G.S.R. 801(E) dated31.12.1993
 ³¹Inserted by rule 2(k) (ix), ibid.