WATER QUALITY STATUS OF RIVER YAMUNA: A CASE STUDY OF DELHI

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Abstract

The River Yamuna, in Delhi has degraded and polluted because of occurrence of increasing anthropogenic activities which majorly includes interference of excess amount of domestic wastewater. Delhi itself is known to be a major polluter as it discharges 79% of total pollutants in river. It is a major challenge in front of environmentalists to restore its water quality. A pilot study in summer season during May 2017-June 2017 was performed to analyze the present quality of water of river Yamuna in which number of pollutants were anlaysed which includes dissolve oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) etc. Samples were taken from three various stretch of river Yamuna in Delhi. This chapter deals with the brief description of the performed study.

Keywords:

Anthropogenic activities, Yamuna, pollutants, wastewater.

"Water is life, and clean water means health".

Introduction

Water is the most important and essential renewable natural resource for supporting life. Growing population with increasing infrastructural development efforts has an increasing stress on water resources. The uneven distribution over the time, their modification through human use and abuse are the major reasons for water crisis over the globe. All these result in intensifying the pressure on the environment. The world is already facing water crisis due to, population increase pollution, and climate change in United Nation report (2014) has predicted that about 3.4 billion people would face "water-scarce" conditions by 2025. For the current situation, correction measures can be taken to avoid the crisis from worsening. The freshwater resources are limited; hence, there is requirement for increasing awareness to be protected both in terms of quantity and quality. The water challenge affects not the water community, but also decision makers and every human being.

Distinctive Characteristics Of Water

1. Water occurs as a natural inorganic liquid on the planet earth. It is the single chemical on this planet that is naturally present in all the three states of matter i.e. solid, liquid and gaseous.
2. It has large surface tension about 73 dynes per cm at 293 k and its ability to wet surfaces are the reason of its capillary action, which transports water to the leaves of plants and trees.
3. The maximum density of water is at 277K.
4. Ice has the lower density than water therefore, it floats on the surface of water and freezing of aquatic systems get freezed downwards the surface.
5. Water has high heat capacity per unit weight, which means that it can absorbs relatively large quantity of heat without large change in the temperature.
6. Water has low compressibility about 5 per pa at ordinary temperatures and pressures.
7. The dielectric constant of water is high due to which it is an excellent solvent and refer as a universal solvent.
8. There are certain types of water defined as per their availability on a specific location which are described below**.**

Surface Water:

The water that is present on the surface of the earth is called surface water such as oceans, seas, lakes, rivers, or wetlands. There are many important properties of it which includes temperature,

salinity, turbidity, and levels of dissolved nutrients, such as oxygen and carbon dioxide. These factors affect climate patterns and the biodiversity in and around a water body.

- **Temperature** It is the average kinetic energy of the molecules in a substance. At the surface, it is warmest, and gets cooler at deeper levels. The deep oceans are extremely cold because of the dark zones. Temperature of surface water varies with season. So, when we look at temperature, we consider averages of the observed data. While there is an interesting information about the temperature is that sea water doesn't freeze at 0 degrees Celsius; the salt in the water allows it to get colder before it does. Also, warmer water tends to have less oxygen, which can make it harder for some species of marine life to survive.
- **Salinity** is the presence of salt in water water. It quanitifies the volume of dissolved potassium, sodium, and other salts in the water. Higher salinity leads to denser water, which has an impact on water currents around the world. Areas with high amount of evaporation are observed to have higher rates of salinity which makes it denser also because when the water evaporates, it leaves the residuals as salts.
- **Dissolved nutrients** are the portions of various chemical compounds that are totally dissolved into water which includes, phosphorous, nitrogen, oxygen, carbon dioxide etc. having different effects on the ecology of water. The availability of phosphorus and nitrogen increases the rate of plankton growth, which are important food source for marine ecosystems. Oxygen is also an important factor to be considered because the fishes and other marine life needs it for the survival.
- **Turbidity** is the measure of clarity in water which is visible to human eye. Low turbidity levels signify that the water is specifically clear. There are many things which can make water as less clear water including due to the presence of planktons, sediment levels, erosion rates, and pollution runoff from nearby urban areas and industries.

Groundwater:

The water which naturally gets recharge by rainwater that release through various sources such as streams, rivers or lakes and also it will help to recharge the water table. A portion of the present water can be used for vegetation; some of it gets evaporated and returns back to the atmosphere. The water that passes via the unsaturated zone and achieves the water table, which is an illusory surface where it is saturated beneath this level. The water that found beneath the ground surface is called the saturated zone water.

Global Water Scenario

Globally, 783 million people, at present, absence access to a safe and reliable water source and about 20% of aquifers are depleted today which leads to pressure on freshwater recourses (United Nation Water Report, 2014). The fresh water which gets supplied are either stored in soil that is aquifers or in bedrock fractures which are present beneath the ground level i.e. ground water or in the lakes, rivers and streams present on the earth's surface is surface water (US EPA, 2015).

The Millennium Development Goal of drinking water target, calls for achieving, universal and impartial access to harmless and reasonable drinking water to all along with this improved water quality by reduced pollution, eliminated and minimized release of hazardous chemicals and materials, which will reduce the percentage of untreated wastewater and substantially increase recycling and reuse globally by 2030 (United Nations Sustainable Development, 2017).

Scenario Of Drinking Water In Delhi

New Delhi, now officially known as the National Capital Region of Delhi, is the capital of India and home to about 17 million people. It is one of the largest cities in India in times of area and has the maximum population density in country. As of 2012, New Delhi was housed to 6,343 slums with about1 million households. Whereas the census states that about 83% of used treated tap water as a main potable drinking water, and only half of the total slum households have any kind of water source in their premises, which indicates the deficient availability and overreliance on unreliable shared sources. The Delhi Jal Board is a public water utility centre and is accountable for manufacture and allocation of drinking water in the NCT of Delhi. Delhi Jal Board reports coverage of about 82% of households in Delhi through piped water supply and confirmed the average accessibility of 50 gallons per capita of filtered water every day. Water is supplied to about 17 million people in Delhi by using a water supply system comprised of 11,350 km pipelines and 105 underground reservoirs for rationalized distribution of supply. Delhi utilizes an average of 835 MGD raw water daily from a supply of about 906 MGD (as of

2014). It is projected that in 2021, Delhi will have a minimum water demand of at least1, 174 MGD. Although 2011 Census numbers reflect similar amounts of water supply to all housing categories including slums, this does not tell the whole condition. Availability of water in the premises of households living in planned colonies is reported at 78% compared to just 51% in slums. This suggests that water supply sources are being shared among households in the slums. Observations during the field study confirmed this, showing community level taps shared between 10 and 30 households. Water was observed to be available for 1 to 2 hours of water supply. It takes 35% of households more than one hour daily to fetch water, sometimes extending upto 3 hours. Most respondents spend 30-60 minutes daily. With the gap in water supply to slum households, tanker water supply is a critical lifeline for Delhi's urban poor. Almost half of these households (HHs) rely on tanker water as their potable water source (and another quarter on municipal water taps). A significant share of over 800 tankers are owned and hired by DJB to serve the urban poor. However, tanker water is quite costly for the water utility and there is also the risk of contamination, making it potentially unsuitable for potable purposes. Using a bore well or tube well is also quite common in slums, but for non-potable purposes; groundwater in Delhi is affected with above-permissible limits of geogenic contaminants like fluoride and nitrates. Paying for water is not unusual for slum households. Overall, most households (71%) reported paying for water and 63% of HHs reported paying an initial one-time payment for getting access to water. These payments covered bore-well construct costs, purchase of submersible pumps, or paying for legal and illegal last-mile connectivity to the piped network.

Groundwater Scenario of NCT Delhi It is important to consider groundwater as well, since many people depend on this for meeting their daily water requirements. While government extracts groundwater through tube wells for piped water supply in areas which are not adequately served by a WTP, households extract groundwater through personal bore wells. Additionally, a lot of groundwater is extracted for agriculture purposes in the outer realms of this region. According to the Central Ground Water Development Board (CGWB, 2011), the average level of exploitation of groundwater in Delhi is 137. For the present study, a case study was performed in order to observe the quality of water of river Yamuna in Delhi.

Area Of Study:

The River Yamuna gets originated from the Yamunotri glacier, which is 6387 m above the mean sea level (msl), situated at the Banderpoonch peak in the Uttarkashi district of Uttaranchal. The catchment of the river spreads to states of Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan and Madhya Pradesh and the total union territory of Delhi. The river flows 1367 km from origin to its convergence with River Ganga at Allahabad. The main tributaries which join the river across its pathway includes the Hindon, Chambal, Sind, Betwa and Ken. The annual flow of this river is about 10,000 cumecs and the annual usage is about 4400 cumecs out of which irrigation accounts for 96% of this. Based on various geological and ecological traits, this river is divided into five sections—Himalayan, Upper, Delhi, Eutrophicated and Dilute among which the Delhi stretch is the most polluted. Himalayan segment is the 172 km long stretch which starts from origin to the Tajewala Barrage. The upper segment starts from Tajewala barrage where river flows to 224 km through Haryana upto Wazirabad barrage. The Delhi segment is of 22 km where the river pass through in Delhi from Wazirabad barrage and reaches to Okhla barrage. Starting from Okhla barrage to its convergence with Chambal with the distance of 490 km downstream, is known to be eutrophicated segment. Ahead of this point to its union with the Ganga river at Allahabad it is considered as the diluted segment. The ground levels in the basin fluctuate from 6320 m above the mean sea level near to the Yamnotri glacier to 100 m above means sea level at its union with River Ganga at Allahabad. The mean annual rainfall is about 1200 mm in the basin, which is received maximum during the period of monsoon i.e., June to September. The superior hilly region collects highest amount of annual rainfall up to 1600 mm whereas the minimum annual rainfall is about 400 mm which occur in western parts of basin. The river receives both kind of treated and untreated effluents discharging from various towns, industries and cities which are located on its banks. The commonly industrial towns situated at its banks are Yamuna nagar, Delhi, Mathura, and Agra. Figure 1 depicts the sampling sites preferred to perform the analysis. The quality of river water in India is classified into five categories which are (Saurabh, Saxena, Chaudhary, & Mishra, n.d.):

Class A: Fit for drinking purpose after proper disinfection by adding chlorine or bleaching powder.
Class B: Fit for the purpose of bathing.
Class C: Fit for drinking purpose only after filtration.
Class D: Fit only for aquatic life including fishes and wildlife

Class E: River water is appropriate only for purpose of irrigation, industrial cooling etc. and Yamuna River belongs to class E.

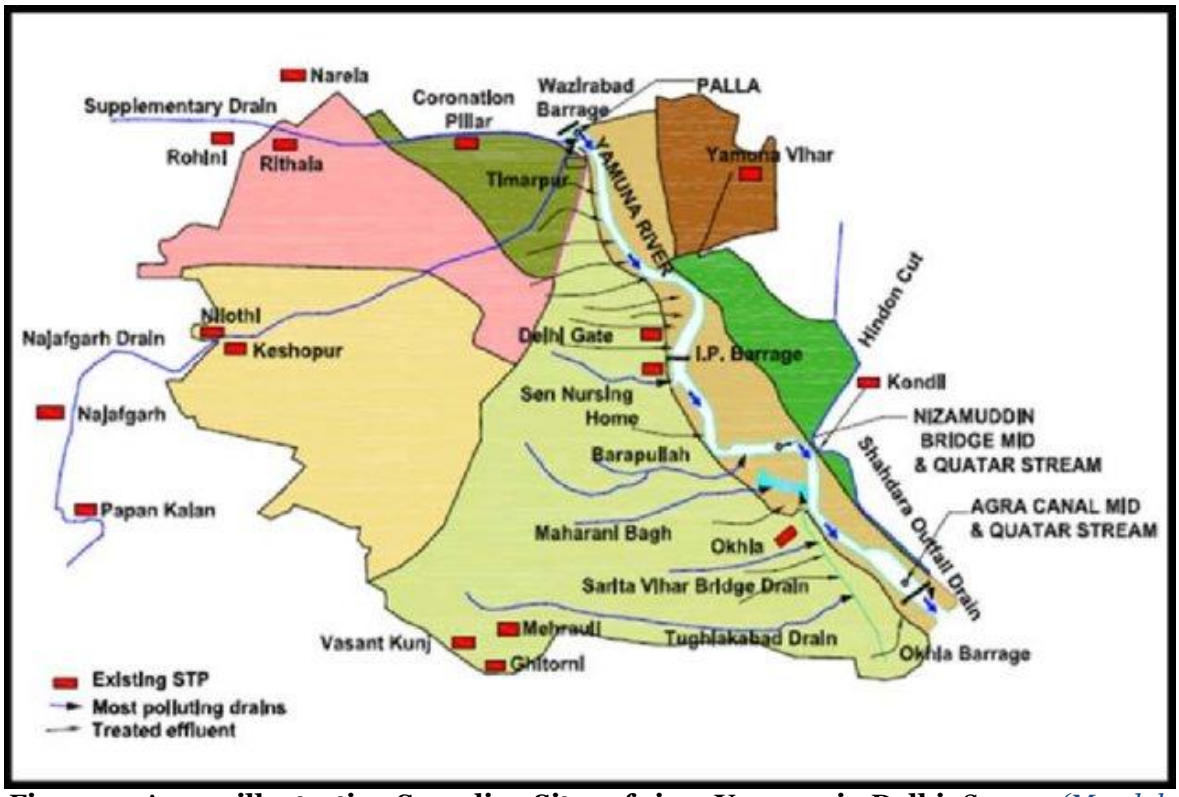

Figure 1 : A map illustrating Sampling Sites of river Yamuna in Delhi. *Source: (Mandal, Upadhyay, & Hasan, 2010)*

The following sampling sites on River Yamuna were chosen for the study

1. Wazirabad Barrage: This is the first site chosen for the study on River Yamuna. The river enters in Delhi at this site and an important intake water works for the city's water supply is located here.
2. Okhla Barrage: Through Barapulla drain, a part of the city's waste gets dumped into the River Yamuna at this site.
3. River Hindon, drains certain of the industrial towns of western Uttar Pradesh. This site also presents a notion of the aggregate effects of pollution of the river in its flow in the Delhi.

Results And Discussion:

The results obtained after performing the water quality analysis are summarized in table 1 and are discussed below.

1. **pH:** pH is a measure of how acidic/basic water is. The range goes from 0 - 14, pH with 7 is neutral. pH below than 7 signify acidity, whereas a pH more than 7 signifies a base. pH is a measure of the amount of free hydrogen and hydroxyl ions in the water. The highest pH observed in Okhla water sample i.e 8.5. And pH 8 is observed in both the water samples of Hindon river and Wazirabad.

S.No.	AREA	Standard Value	Hindon River	Wazirabad	Okhla
1.	pH	6-8.5	8	8	8.5
2.	DO (mg/L)	1-6	1.62	2	1.9
3.	BOD (mg/L)	30	6.9	7.5	6.5
4.	COD (mg/L)	250	130.56	134.68	188
5.	Total Hardness (mg/L)	600	3921	118	80
6.	Calcium Hardness (mg/L)	250	308	98	72

7.	Calcium Content (mg/L)	25-200	123.4	39.2	28.8
8.	Chloride Content (mg/L)	250-1000	205.46	337.48	0
9.	TDS (Surface Water) (mg/L)	50-3000	276	254	624
10.	TDS (Drinking Water) (mg/L)	50-2000	826	874	150
11.	TSS (Surface Water) (mg/L)	100	96	6	18
12.	TSS (Drinking water) (mg/L)	250	24	1140	4
13.	Chlorine (mg/L)	1	0	0	0
14.	Coliforms		Present	Present	Present

Table 1: Water quality parameters studied and their respective values

2. **D.O:** Dissolved oxygen is referring to as amount of the oxygen that is dissolved in a body of water such as river. DO is an essential indicator of the health of the water body. Wastewater containing organic pollutants depletes the DO level. The highest DO value is seen in Wazirabad water sample (2mg/l) indicating high sewage contamination. The lowest is in Hindon river water sample (1.6mg/l).
3. **BOD:** Biochemical oxygen demand (BOD) is the amount of dissolved oxygen required by aerobic organisms in order to break down the present organic matter in a particular water sample at a specific temperature over a particular time period. The highest BOD value was observed in Wazirabad water sample (7.57mg/l) which indicates high sewage contamination. The lowest is in Okhla water sample (6.54mg/l).
4. **COD :** COD is defined as the amount of oxygen in mg/L, consumed under specific condition in the oxidation of organic and oxidizable inorganic matter, after correction for chloride interference .it indicates the amount of oxygen required to oxidize the carbonaceous matter using strong oxidizing agents. The highest COD value was seen in Hindon river sample 130.56mg/L and the lowest was seen Wazirabad 134.68 mg/L. All the COD values are within the permissible limit.
5. **TOTAL HARDNESS:** Total hardness is the amount of calcium and magnesium ions assembled in water sample. The water hardness ranges from zero to hundreds of milligrams per liter (or parts per million) naturally. Waters having total hardness of 0 to 60 mg/L are termed as soft water; when ranges from 60 to 120 mg/L is termed as moderately hard; and range within 120 to 180 mg/L is known as hard water; and values above180 mg/L are considered to be very hard. The maximum value of total hardness was observed in the water sample of Hindon River i.e. 392mg/l and the lowest was observed in Okhla water sample i.e. 80mg/l and all the values are under standard limits.
6. **CALCIUM HARDNESS:** Calcium hardness leads to water hardness, the relative amounts of calcium hardness, carbonate and non- carbonates hardness present in the water are the factors while determining the softening process. The calcium content may range from zero to several hundred ppm. The highest value of total hardness observed in the water sample of Hindon River (308mg/l) and the lowest was observed in Okhla water sample (72mg/l).
7. **CALCIUM:** The highest value of Calcium content was observed in the sample of Hindon River i.e. 123.4464mg/l. And the lowest value was seen in Okhla i.e. 39.2784mg/l.
8. **CHLORIDE (DRINKING WATER):** The highest value observed in the water of Wazirabad i.e 337.48mg/l an the lowest was observed in Okhla i.e 0 mg/l.
9. **TOTAL DISSOVLED SOLIDS in Surface Water:** TDS are the amounts of total solids present in water which are able to pass through a filter with approximately a pore size of 0.45 micrometers. TDS quantifies the amount of dissolved material present in water. This dissolved material includes carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. The maximum TDS value was observed in the Ohkla water sample i.e. 624mg/l and minimum value is observed in sample of Wazirabad i.e. 254mg/l.
10. **TOTAL DISSOVLED SOLIDS in DRINKING WATER:** The highest value of TDS observed in the water sample of Wazirabad i.e. 874mg/l and the lowest was seen in Okhla i.e.150mg/l.
11. **TOTAL SUSPENDED SOLIDS in SURFACE WATER:** TSS are the solids present in the water which can be easily trapped by a filter. TSS include a broad range of material like silt, decayed plant and animal matter, industrial effluents, and sewage waste. High concentrations of suspended solids

can cause many problems for stream health and aquatic life. The highest value of TSS was seen in Hindon River i.e. 96mg/l and the lowest value was observed in Warzirabad i.e., 6mg/l.

12. **TOTAL SUSPENDED SOLIDS in DRINKING WATER:** The highest value of TSS was seen in Wazirabad i.e. 1140mg/l and the lowest value was observed in Okhla 4mg/l.
13. **COLIFORM TEST:** The coliform test was observed as negative in all the given samples. Hence the coliform bacteria were present in the observing samples.
14. **CHLORINE TEST:** The chlorine content was seen in the water sample of Hindon river i.e. 0.1 mg/l. And in the other two water samples from Wazirabad and the Okhla the chlorine content was Zero.

Conclusion

Environment is made up of natural factors like air, water, and land. Each and every anthropogenic activity is supported directly/indirectly by these natural factors. India being a developing country with huge amount of population explosion is confronting a serious challenge of natural resource inadequacy, particularly, water in terms of expanding population and economic growth. Maximum freshwater bodies are now a days polluted which decreases the water potability. Life depends on water and it exists in various form naturally like ocean, river, lake, clouds, rain, snow, and fog etc. Due to increase in population growth, innovation in agriculture, development and industrialization has rendered surface water pollution as a major problem and has reduced drinking water availability. Numerous parts of the world come to terms with such water scarcity. Nearly all of wastewaters are discarded directly into the rivers, lakes, and estuaries without proper or no treatment. Lakes are vital feature of the Earth's land which are not only the source of precious water, but provides treasured habitats to plants and animals, modest hydrological cycles, impacted microclimate, augment the appealing beauty of the landscape and encompass many amusing opportunities to humankind. For problems, viewpoints on pollution, restoration and management of Ulsoor Lake Falls under Bangalore city is very crucial to know their significance but so far, there was no efficient environmental analysis is held out.

All the observed values of the selected samples were under permissible limit. The coliform test was observed as negative in all the given samples. Hence the coliform bacteria were present which makes it totally unfit for consumption by living beings. It has been noticed that for the protection of basic needs of various human activities, we should not depend on natural environmental resources as they are one-time origin, they may not be recycled. Hence when natural environmental factors like air, water and land get disturbed beyond their limitations of self-sustainable capacity it wills difficulty to various human activities.

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