



Research Article

An assessment of water quality of river Yamuna at Waterworks station, Agra

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Abstract: The present study is an effort to know the water quality of river Yamuna. The water of river Yamuna is collected and treated before supplying to the city. As the Yamuna river comes to Agra passing through several cities, some of them are industrial which dump their waste into the river. Besides this city waste or sewage is also dumped. As the river Yamuna passes through Ghats due to which various organic, as well as inorganic waste, are also added to the Yamuna river which increases the pollution load. "During our study at Waterworks, Agra, It was observed that the pH, Hardness, Chloride, and Alkalinity are always higher than the IS Standards. In river Yamuna's water due to dumping problem many problems arise which increases the colour, pH as well as other physiochemical parameters. Due to which the colour becomes higher than the normal standard as by IS standards (Which is maximum 20 Hazon)". Due to such an increased pollution in Yamuna river water, the water treatment at Waterworks, Agra become difficult and the chlorine dosing (Which is used for disinfection) and Alum dosing (For sedimentation) becomes higher and dosing quantity changes according to the seasonal variation in Yamuna river water.

Keywords: Water pollution, Physiochemical parameters, Ghats, Water treatment, Sewage.

1. Introduction

Water is one of the most abundant and important remarkable substances. Water is the most valuable resource on earth and essential for life. Without water, no life can exist. It's the principal substance that separates our planet from all others and makes life possible. The availability of water impacts every part of our lives. Water is present in the air as water vapour and in the ground in the form of underground speed.

- i. Water is essential for all forms of life, but the distribution of water over the earth's surface is not uniform.
- ii. Each person needs to drink about 2½ quarts (80 ounces) of water every day.
- iii. Deserts have no permanent surface water. Oceans cover about 78% of the earth's surface.
- iv. All organisms are made up of nearly of water. A tree about 60% by weight and animals are about 50 to 65% water and the human body is about 75% water.
- v. A person can survive about a month without food, but only 5 to 7 days without water is possible.

- vi. The quality of life depends upon the quality of water available for various needs, safe and adequate water is not only necessary for public health, but also in important infrastructure for economic development.
- vii. Rivers of water are important in maintaining a healthy as well as a prosperous nation in a healthy environment is amply understood from very existence the civilization on this globe.
- viii. The water resources are used to meet day to day requirements of human settlements, for production hydel power and most importantly for agricultural and industrial needs.
- ix. All the above said activities are expected to have a significant impact on the water quality. Furthermore; these human interferences are bound to affect the living resources that are animals and plants occurring in these water.

2. Composition of Natural Water

The composition of water may include salts (mostly in the form of ions, molecules, and molecular complexes) organic substances, gases, disperse impurities, hydrobionts (plankton, benthos, neuston,

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and pagon), and bacteria and viruses. Natural water may also contain suspended clay, sand, gypsum and lime particles. Various organic substances, silicic acid, iron (III), hydroxides, fulvic acids, human etc. in the colloidal state and truly dissolve substances mainly mineral salts which enrich water with iron.

There is a direct relationship between the depth of underground water bedding and the degree of their mineralization. Underground water often has high hardness and elevated concentration of iron. The properties of water and quality of water can be determined in terms of physical indices (temperature, suspended matter, coloration, odour, flavor etc.), chemical (hardness, alkalinity, reactivity, Oxidation susceptibility, dry residue etc.), biological (hydrobionts) and bacteriological (total concentration of bacteria *E. coli* index etc.).

2.1 Temperature

Water of the underground is characterized by a rather constant temperature (8-12°C), with seasonal variations of temperature decreasing with an increase in the bedding depth. The temperature of water of surface sources varies substantially in the year and depends on the inflow of underground water and discharges of the wastewater used for cooling.

2.2 Turbidity

The presence of suspended particles of sand, clay, silt plankton, algae, which gets into the water due to the erosion of river banks with rainfall and thawing water on stirring up sediments etc. characterize the concentration of suspended matter as well as the indices of transparency and turbidity.

Turbidity of water (which is the inverse of transparency) is measured in turbidity meters by comparing, under the identical illumination conditions. Water turbidity of potable water should not exceed 1.5mg/l.

2.3 Alkalinity

It is determined as the sum of hydroxyl ions and anions of weak acids present in water it is distinguished between bicarbonate, carbonate and hydrate alkalinity.

2.4 Hardness

It is due to the presence of calcium and magnesium. It is distinguished between carbonate, non-carbonate and total hardness of water. Carbonate hardness is due to the presence of calcium and magnesium carbonates and bicarbonates. It can be eliminated easily by boiling. In boiling water, bicarbonate decomposes into gases carbon dioxide and insoluble calcium carbonate and magnesium hydroxide, which precipitate from the solution. Non-carbonate hardness is caused by sulphuric, hydrochloric, silicic and nitric salts of calcium and magnesium. The sum of carbonate and non-carbonate hardness defines the total hardness.

2.5 Reactivity of Water (pH)

The reactivity of water is expressed by the pH index, which is the negative logarithm of the concentration of hydrogen ions.

$$\text{pH} = -\log(\text{H}^+)$$

Therefore, pH is equal to 7 for neutral water, is less than 7 for acid ones, and more alkaline water. Natural water can be classified by the pH index in the following manner–

Acid	-	pH = 1-3
Weakly acid	-	pH = 4-6
Neutral	-	pH = 7
Weakly alkaline	-	pH = 8-10
Alkaline	-	pH = 11-14

2.6 Coloration

Color of water may be due to the presence of humic and tanning substances, protein and hydrocarbon-like compounds, fats, organic acids and other organic acids which can get into water as product of living activity and decay of various living organisms inhabiting water; further, coloration may be caused by iron compounds, wastewater of certain industrial processes or by bloom of water basing which observed on mass reproduction of algae. Depending on the species of algae, water may become bright greenish (protococcus algae), or emerald green (blue-green algae).

Coloration of surface water usually diminishes with an increase of hardness and that of hydro carbonate water with an increase of alkalinity, whereas soft water of a low alkalinity is usually strongly colored. Thus, with an increase of carbonate hardness (alkalinity) the concentration of humic substances which are responsible for coloration usually decrease.

2.7 Taste and Odour

It may be of natural or artificial origin. Water may have a salty, bitter, sweet or acid taste. A salty taste of water is mainly due to dissolve sodium chloride a bitter taste is due to magnesium sulphate; an acid due to carbon dioxide; an alkaline taste is imparted by the presence of potassium carbonate soda or sodium hydroxide and astringent flavor is due to calcium sulfate.

2.8 Chlorides and Sulphates

When present in substantial, concentration, chloride and sulfates make water aggressive relative to concrete. Water with the concentrations of sulfate ion more than 250mg/l may be destructive to concrete structures owing to the formation of gypsum (by the reaction between sulfates and the lime of cement), which results in an increase of the volume of concrete and in cracking.

The presence of chloride and sulfate in water in appreciable concentrations is indicative of an elevated solute residue which makes the water poorly suitable for feeding of steam boiler plants or as process water in

the manufacture of certain polymers, synthetic rubber, some grades etc.

High concentrations of sulfate in water can cause malfunctioning of the alimentary canal whereas magnesium and calcium sulphate and chlorides are responsible for the non-carbonate hardness of water.

WATER QUALITY STANDARDS (ISO)

S. No.	Constituents	Recommended Permissible Limit
1.	Total Solids	less than 500 ppm
2.	Hardness	less than 100 ppm
3.	Taste	no objectionable taste
4.	Color	10 to 20 (on photo scale)
5.	Odour	0-4
6.	Temperature	10°C to 15.6°C
7.	pH Value	6.5 to 8.0 ppm
8.	Dissolved oxygen	5.0 to 6.00 ppm
9.	Chloride	less than 250 ppm
10.	Nitrates	NH
11.	Iron and Manganese	less than 0.30 ppm
12.	Lead	less than 0.10 ppm
13.	Arsenic	less than 0.05 ppm
14.	Copper	less than 3.0 ppm
15.	Chlorine	0.01 to 0.2 ppm

International standards for drinking water

Parameter	Max. Permissible USPH Standard	Level, WHO Standard	Mg/L. European Standard
pH	6-8.5	6.5-9.2	6.5-8.5
Sp. conductance (Mho cm ⁻¹)	300		400
Arsenic	0-05	0.05	-
Ammonia	0-5	0.5	
BOD	5.0	6.0	
Boron	1.0		
Calcium	100	100	100
Cadmium	0.01	0.01	
Chromium (VI)	0.05	0.05	
Copper	0.1	1.5	
Chloride	250	500	25
Cyanide	0.05	0.05	
COD	4.0	10	5.0
Iron	0.3	1.0	
Lead	0.05	0.1	
Magnesium	30	150	-
Manganese	0.05	0.5	
Mercury	0.001	0.001	-
Nitrate & Nitrite	10	45	
Phenol	0.001	0.002	0.5
Poly nuclear aromatic Hydrocarbon (PAH)	0.002	0.2	0.002
Pesticides (total)	0.005	-	0.005
<i>E. coli</i>	100/100ml	10/100ml	
Total Hardness (CaCO ₃)	-	500	
Total dissolved solids	-	500	

2.9 Bacteria and Viruses

Most bacteria are colorless and transparent. It can be made visible by dying with aniline dyes.

There are three main forms of bacteria–

- Spheroidal (cocci) of a size of 1-2µm.
- Rod-like (bacilli) of a length of 1-4µm.

- Spiral form bacteria (*Spirillum*, *Spirochaeta*, *Vibrio*) of a length of 1-20µm.

By the mode of nutrition, all bacteria are divided into three groups:-

- Autotrophic – Those which acquire the vital energy by photosynthesis or chemosynthesis.
- Heterotrophic – These are saprophytic which feed on organic substances (yeast, mould, fungi etc.)
- Paratrophic – These are parasites which need live proteins of dead organic substances for nutrition.

Coagulation of water impurities can reduce the concentration of viruses in water by 40% and that of *Bacillus coli* by 85%. By an experimental data, with an increase of turbidity of drinking water from 0.15 to 1.0mg/l the frequency of virus hepatitis increase from 180 per 100,000 of the population.

3. Effects of Water Pollutants

The main effects of water pollutants are:-

- Compounds of mercury, arsenic, and lead are poisonous. Mercury, when dissolved in water, is absorbed by aquatic plants and enters the food chain through herbivorous fishes. These are eaten by a large number of fishes which are eaten by man as food. On reaching of the human body, it causes the disease called Minamata.
- Lead impairs metabolism and brings about congenital deformities, anemia, loss of appetite and defective gums. Cadmium damages kidneys and liver. Fine suspended particles or colloidal substances make water turbid.
- Presence of dyes and compounds of chromium and iron in the discharge changes color of water.
- Soap, detergents, and alkalis result in foam formation.
- Industrial effluents containing iron, free chlorine, phenol, manganese, oils, and hydrocarbons impair the taste of water. Chlorine, phenol, hydrogen sulphide, ammonia, algae, and microorganisms give an unpleasant odour to water.

4. Water Treatment

The treatment of water in order to make it suitable for drinking, domestic or industrial use includes a complex of physical, chemical and biological methods which change the initial composition of water. Water treatment involves not only purification and removal of various unwanted and harmful impurities but also improvement of the natural properties of water by adding certain deficient ingredients.

A particular method of water treatment is chosen upon preliminary examination of the composition and properties of water of the water sources to be useful and comparison of these data with the consumer's requirement and with health point of view.

The technology for the improvement of water quality at water purification on plants can be

characterized by a large diversity of the method and processes employed and by substantial differences in the design of process structure and equipment as well as in the reagents used for the intensification of various stages of water purification.

4.1 Process of Water Treatment

The process of water treatment is complete in several steps. They are as follows:

4.1.1 Collection of Raw Water

The raw water is collected from water pumping station, which is situated on the bank of the river. This water is supplied with the help of pumps and motors. This completes the requirement based on water level on the river, it is the primary process of treatment.

4.1.2 Aeration Process

After collection of raw water, it passes for aerator process. Aerator is a waterfall like technique in which the water comes to the underside in aerator and

flows on side result increased the rate of dissolved oxygen. In polluted water, the level of water dissolved oxygen decreases and sometimes become nil also so the aeration is an important process of oxygen treatment.

4.1.3 Coagulation

Coagulation of water impurities is the process of aggregation of colloidal and disperses as they stick together under the action of molecular attraction forces coagulation results in the formation of larger aggregates or flakes which are readily visible by the naked eye and separate from the liquid phase. Colloidal and fine disperse impurities in water possess a certain anticoagulation stability, which is due to the presence of hydrate shells of a double electric field around the particles. The anticoagulation stability of impurities can be disturbed by heating, freezing and the addition of electrolytes to water or by the application of a magnetic field. Coagulating hydrophilic and hydrophobic impurities most often solves the problem of improving the quality of water.

Parameters for water quality characterization and standards (Domestic water supply)

Parameters	USPH standard	ISI Standard (IS 2296-1963)	Raw Yamuna water
Colour	Colourless	-	Yellowish
Odour	Odourless	-	Foul odour
Taste	Tasteless	-	Salty
Inorganic chemicals			
pH	6.0-8.5	6.0-9.0	4.5-7.5
Specific Conductance	300 mho/cm	-	350 mho/cm
Dissolved Oxygen	500	-	300
Suspended Solids	5.0	-	9.0
Chloride	250	1000	450
Sulphate	250	1000	550
Cyanide	0.05	0.01	0.06
Nitrate and Nitrite	0.10	-	0.18
Fluoride	1.5	3.0	1.7
Phosphate	0.01	-	0.03
Sulphide	0.01mg/l ppb)	-	0.02mg/l ppb)
Ammonia	0.5	-	0.6
Boron	1.0	-	1.3
Calcium	100	-	180
Magnesium	30	-	45
Arsenic	0.05	0.2	0.08
Barium	1.0	-	1.2
Cadmium	0.01	-	0.01
Chromium (VI)	0.05	0.05	0.05
Copper	1.0	-	1.0
Iron (filterable)	0.3	-	0.5
Lead	0.05	0.01	0.09
Manganese (filterable)	0.05	-	0.04
Mercury	0.001	-	0.002
Selenium	0.01	-	0.06
Silver	0.05	-	0.55
Uranium	5.0	-	8.0
Zinc	5.5	-	9.5
Carbon CHCl ₃ exact	0.15	-	1.15
Methylene blue active	0.5	-	0.9
Surfactants	200	-	400
Gross beta	1000pc/l	-	1200pc/l
Radium – 226	3pc/l	-	3pc/l
Strontium	10pc/l	-	12pc/l
Bacteriological parameters			
Coliform cells/1000ml	100	-	350
Total bacterial count/100ml	1x10 ⁶	-	1x10 ⁷

Hydrophilic impurities in natural water are mostly represented by organic substances such as –OH, –COOH, etc. on their surfaces. When being in thermal Brownian motion, hydrophilic particles diffuse together with hydrate shells. Particles of sludge, clay, fine, sand and the like are hydrophobic impurities in water. They are almost free from hydrate shells, but have a double electric layer and carry substantial electric charges. When these charges are eliminated or diminished, hydrophobic impurities lose their anticoagulation stability and coagulate readily. Hydrophobic particles usually have a crystalline structure and an appreciable surface area and can absorb ions present in water.

On being added to water, a coagulant (such as aluminium sulphate and iron vitriol, etc.) initially dissociates into ions of a metal and strong acid anions. Ions of trivalent metals are exchanged with monovalent cations of the diffusion layer of hydrophobic impurity particles so that the anticoagulation stability of these particles decreased and the thickness of their diffusion layer becomes smaller. With the use of aluminium sulphate as a coagulant, the process of hydrolysis can result depending on the conditions, in the formation colloids of low soluble aluminium salt bases.

4.1.4 Flash Mixing

Pre-chlorination and alum solution add coagulant water come to the flash mixing chamber. The flash mixing chamber consists of three flash mixers for mixing, which mix water very well with the help of rotating motors and after mixing thoroughly to water clariflocculator. Every chamber connects with a clariflocculator.

4.1.5 Clarifying (Clariflocculator)

It is a big round chamber and consists of many chambers with a rotate pillar and a rotating cycle grill. Clariflocculator settles 75% impurities in the sedimentation, which results of a flock formation process. The impurities of 25% flow outside in the way of the overflow.

4.1.6 Filtration

Clariflocculators settle 75%, but 25% rest in the water. These impurities treated by the process of filtration. In this technique, a unit of filter filters water, but when filter blocked by impurities, its filtration process decreases eventually and stops. In this condition, we can press the filter with the water pressure in the way of underside resulting impurity layer disturbed and overflow on filter after this extra stream flows these impurities with self.

4.1.7 Post-Chlorination

After filtration, the turbidity of the water is determined standard normal values and ails impurities absent after this process, but the most important process “Disinfection” is complete in the post-chlorination. The river water contains many bacteria, viruses, protozoan, algae etc. that can produce many types of dreadful

disease so disinfection is very must. After post chlorination, the pure water collects in the CW receiver (clear water receiver) and supply to the zonal pumping station (ZPS).

4.1.8 Superchlorination

It is the last stage and step of water treatment of purification. After post chlorination, the water sullies to the zonal pumping system, but the chlorine demand decreased by varying the amount and the result of pipeline break and leakage of after may produce infection. So, the zonal pumping system is treated with super chlorination and then supply to public placed. The residual limit of chlorine always required 228; it is the standard value for purity.

5. Conclusion

The present study is an effort to know the water quality of river Yamuna. The water of river Yamuna is collected and treated before supplying to the city. As the Yamuna River comes to Agra passing through several cities, some of them are industrial which dump their waste into the river. Besides this city waste or sewage is also dumped. As the river Yamuna passes through Ghats due to which various organic, as well as inorganic waste, are also added to the Yamuna River which increases the pollution load.

“During our study at Waterworks, Agra, It was observed that the pH, Hardness, Chloride, and Alkalinity are always higher than the IS Standards. In river Yamuna’s water due to dumping problem many problems arise which increases the colour, pH as well as other physiochemical parameters. Due to which the colour becomes higher than the normal standard as by IS standards (Which is maximum 20 Hazon).”

Due to such an increased pollution in Yamuna river water, the water treatment at Waterworks, Agra become difficult and the chlorine dosing (Which is used for disinfection) and Alum dosing (For sedimentation) becomes higher and dosing quantity changes according to the seasonal variation in Yamuna river water.

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