Technological interventions for safer drinking water in Urban Gujarat

Dr G P Vadodaria,

Principal, L D Engineering College, Ahmedabad

Abstract:

This research paper aims to provide technological options for safer drinking water in Urban Gujarat. The state of Gujarat located in western part of India, with population in excess of 60 million. Gujarat is one of the most urbanized states of India. It has an urban population of 24 million accounting for 42.6 % of total population. Gujarat falls under semi-arid zone. The long sea coastline along Saurashtra, Kutch and other parts creates the problem of salinity ingress, which affects the ground water quality on coastal belt and because of scanty and uncertain rainfall, the replenishment in dam is also not reliable, hence this areas are always under water deficiency. There are 8 Municipal Corporations and 162 Municipalities. Responsibility of water supply in all these cities lies with Urban Local Bodies and water supply is largely concerned in cities of Gujarat. Based on data collection and analysis it is found that, about 85% house-holds are covered by water supply. About 20% of total production of water is dependent on ground water while 66% is in form bulk purchased water. Only 78 ULBs are supplying water more than 100 LPCD. Supply duration noted from 20 minute to 4 hours with varied frequency. Water Treatment Plants in ULBs of the state are conventional Rapid Sand Filter Plant. No advance technology like UV/ Membrane based/ High filter is being used. Due to high level of dependency on ground water, more than 10% of people are getting water with salts i.e. TDS, fluorides, Chlorides etc., which can be considered water quality risk. It has been found that, South Gujarat area suffers Fluoride and Nitrate while North Gujarat suffers the most by excessive fluoride followed by Saurashtra – Kutch and Patan suffer from excessive fluoride in their water supply. High level TDS and salinity is common scenario across the state. Salinity water quality is seen in west Saurashtra & Kutch area. In many cities it is observed that, due to low quantity of water supplied, people often go for tapping private water sources and eventually in many cases it turns out to be ground water, this is an additional risk. Technological options and solutions are suggested in this paper for water quality stress area. Long term solutions and particularly covering conventional & non conventional methods including comparison of modern technological solutions like filtration media up gradation with technology like microfiltration technology, using multimedia structure in new and existing filter beds, Development of Green infrastructure, promotion of rainwater harvesting, option for U/V against Chlorination etc., are suggested.

[Key Words: Quality of Drinking Water in Urban Gujarat, Water Treatment Analysis, Technological intervention for improvement of water quality]

1. Background: Over the past three decades Gujarat has emerged as one of India's most urbanised states with a high level of industrialisation. With nearly 43 percent of its population living in urban areas, Gujarat ranks high on the scale of urbanization. Given this pace of urbanisation, the need to augment the investment levels in improving the urban infrastructure levels would always be critical particularly water supply. Besides, Gujarat falls under semi-arid zone. The long sea coastline along Saurashtra, Kutch and other parts creates the problem of salinity ingress, which affects the ground water quality on coastal belt and because of scanty and uncertain rainfall, the replenishment in dam is also not reliable, hence these areas are always under water deficiency. It has just 2.28% of India's water resources and 6.39% of country's geographical area. The per capita fresh water availability in the State as per the study done in 2001 has been estimated as 1,137 M^3 /annum as against the country's per capita renewable freshwater availability of 2,000 M^3/ annum. Around 80% of the State's surface water resources are concentrated in central and southern Gujarat, whereas the remaining three-quarters of the State have only 20%. The State has an average annual rainfall of 80 cm with a high coefficient of variance over time and space and as a result droughts have been frequent.

Besides, every year, Gujarat will have to provide basic infrastructure facilities to additional 1 million people persons in urban areas just to maintain the current level of service which is also behind the normal level. Besides, population spill over (outgrowth) beyond administrative boundaries of municipal areas has increased over last decade. In 2011, it is estimated that more than 45 areas are developed in OG area having more than 3.5 million populations. The proportion of population residing outside municipal areas has been substantial.
These areas continue to be administered under rural set up resulting into haphazard developments and faced with the problem of inadequate infrastructure. As the infrastructure grows to meet the growing demand, management of the infrastructure and ensuring high quality service delivery & providing judicious quantity of water to 100% of urban population is becoming challenges. Over exploitation of ground water and water scarcity have resulted toll to urban water quality. Therefore, it is attempted here to provide technological solutions to improve quality of drinking water in urban Gujarat.

2. Data & Analysis: Data regarding availibility of water, sources, network facilities, Water Treatment Plants, supply duration, quality of water etc., from all 170 ULBs of Gujarat covering 162 Municipalities & 8 Municipal Corporations have been collected and analyzed. It is found that, about 85% house-holds are covered by water supply. Total production of water is about 4100 MLD. About 20% of total production of water is dependent on ground water while 66% is in form bulk purchased water. Only 78 ULBs are supplying water more than 100 LPCD. Duration of supply varies from 20 minutes to 4 hours. Frequency of water supply is also noted different across the state.

All WTP in the state are conventional Rapid Sand Filter Plant. No advance technology like UV/ Membrane based/ High filter is being used. Due to high level of dependency on ground water, more than 10% of people are getting water with salts i.e. TDS, fluorides, Chlorides etc., which can be considered water quality risk.

Depletion of Ground water resources, more and groundwater quality deteriorates due to the discharge of untreated industrial effluents, urban wastewater, over use of pesticides by irrigators and seawater intrusion either directly from casual disposal or indirectly as seepage from treatment lagoons or infiltration from surface watercourses or canals are likely water quality threat.

It has been found that, South Gujarat area particularly Navsari district suffers Fluoride and Nitrate while North Gujarat suffers the most by excessive fluoride followed by Saurashtra – Kutch and Patan suffer from excessive fluoride in their water supply. High level TDS and salinity is common scenario across the state. Salinity water quality is seen in west Saurashtra & Kutch area. In many cities it is observed that, due to low quantity of water supplied, people often go for tapping private water sources and eventually in many cases it turns out to be ground water, this is an additional risk.

There are region specific issues and require to identified each one and have to provide appropriate type of the technological solution at treatment level as well as at monitor level.

3. Technological Options for Safer Drinking Water :

In some case of urban Gujarat, for improving quality of water additional water treatment for removal of fluoride, Nitrate, Salinity, TDS etc., Referring various literature and looking to the international practice and available combinations of options for quality of water in Urban Gujarat can be_

1. **Technology options to improve quality of drinking water: Additional Treatment: Fluoride Removal:** As per IS: 10500 it desirable to have fluoride less than 1.5ppm. Number of technologies, for several defluoridation processes based on adsorption and ion exchange in filter systems, coagulation and precipitation and membrane filtration processes have been developed and tested globally. Suggestive methods used for the removal of fluoride from drinking water can be described as below:

   - **Adsorption and ion-exchange:** In case of high level of fluoride, the passage of water through a contact bed where fluoride is removed by ion exchange or surface chemical reaction with the solid bed matrix of activated alumina.

- **Activated carbon:** Prepare layer of carbon saw dust in alum solution forms. Spread one layer above rapid sand filter an excellent defluoridating carbon. The defluoridating process is between carbon and fluoride. Alkali digested (1 % KOH) and alum soaked (2% alum) carbon removed 320 mg fluoride per kg and showed maximum removal efficiency at pH 7.0.

- **Coagulation-precipitation:** The aluminium sulphate and lime based coagulation-flocculation sedimentation process for defluoridation can also be adopted. Technique (NEERI suggested) involves addition of aluminium salts, lime and bleaching powder followed by rapid mixing, flocculation sedimentation, filtration and disinfection. Aluminium salt may be added as aluminium sulphate or aluminium chloride or combination these two. Aluminium salt is only responsible for removal of fluoride from water. The dose of aluminium salt increases with increase in the fluoride and alkalinity levels of the raw water. The selection of either aluminium sulphate or aluminium chloride also depends on the sulphate and chloride contents of the raw water to avoid exceeding their permissible limits. Lime facilitates formation of dense floes for rapid setting. Bleaching powder is added to the raw water at the rate of 3mg/L for disinfection.

- **Chemo defluoridation Techniques:** Chemo-defluoridation technique can also be used in which, the salts of calcium and phosphorous in required dose of chemicals are added in the fluoride contaminated raw water and mixed properly. After 15 to 20 minutes of mixing of the chemicals, water is allowed to flow by gravity into the sand filter at the rate of 300 400 ml/min. Filtered water with fluoride concentration will have less than 1 mg/L. The layer of chemical complex precipitate formed on the sand filter also removes some fluoride from the water during filtration. After about 1 to 2 months of operation, filter will be required to clear with layer of formation of thick layer of sludge.

- **Reverse osmosis and Nano-filtration:** Membrane techniques for removal of fluoride shows, the rejection of fluoride ion higher than 98%. These may be in form of nano-filtration or RO system. Similarly, dialysis and electro-dialysis techniques are also effectively utilized for removal of fluoride. However, membrane technology is costlier, therefore it can be utilized to treat limited to quantity of drinking water & water for cooking and have water kiosk

2. **Technology options to improve quality of drinking water: Additional Treatment: Nitrate removal:** It desirable to have Nitrate level should be less

than 45 ppm. Number of technologies, for several defluoridation processes based on adsorption and ion exchange in filter systems, coagulation and precipitation and membrane filtration processes have been developed and tested globally. Suggestive methods used for the removal of Nitrate from drinking water can be described as below:

Adsorption/Ion exchange, Biological de-nitrification, Catalytic reduction, Reverse osmosis Electro dialysis, blending of water are suggestive techniques for Nitrate. Improperly installed, operated or maintained plants can result in nitrate passing through the treatment process and in some cases concentrating the nitrate above the incoming levels.

- **Adsorption/ion exchange:** Ion exchange process involves passage of nitrate contaminated water through a resin bed containing strong base anion exchange resins that are charged with chloride, As water passes over the resin bed, the resin takes up the nitrate ions in exchange for chloride until the exchange capacity is exhausted. The exhausted resin is then regenerated using a concentrated solution of sodium chloride (brine).

- **Catalytic reduction/de-nitrification:** Metallic catalysts are the process in which, nitrate reacts with hydrogen gas or formic acid and it is converted into nitrogen and water using a solid catalyst. The activity and selectivity of metallic catalysts plays a crucial role for the effective conversion of nitrate to nitrogen gas.

- **Membrane based WTP:** Reverse Osmosis & Electro-dialysis: Reverse Osmosis is an established technology for removal of various contaminants of water. In order to increase the life of membrane in reverse osmosis (RO) process, pre-treatment of contaminated water is essential which is generally achieved by passing it through sand filter, activated carbon filter and micron filter to remove iron, organic matter, excess free chlorine and suspended matter. Electro dialysis (ED) is an electrically driven process that uses a voltage potential to drive charged ions through a semi¬-permeable membrane reducing the nitrate in source water. The separation is accomplished by alternately placed cat ion and anion selective parallel membranes across the current path to form an ED cell. DC voltage potential induces the cat ion to migrate towards the anode through cationic membrane and the anions to migrate towards the cathode through anionic membrane. Electro-dialysis reversal system periodically reverses the polarity of electric field. Both are expensive technology and can be used limited to establish water kiosk

- **Blending/dilution of water:** Blending is another method which also reduces nitrates in/from drinking water. In this process, nitrate contaminated water is mixed with clean water (nitrate free water) from another source to lower or dilute overall nitrate concentration of raw (untreated) water.

3. **Technology options to improve quality of drinking water: Additional Treatment: Salinity & TDS removal:** It has been observed that high value of salinity and TDS is seen across the state where ground water is source of supply. Desalination is a process that removes dissolved minerals from various feed water sources. Most of them are dependent on mainly membrane basis technologies. Choice of desalination process/technology depends upon a variety of factors and is highly site-specific.

   - **Reverse Osmosis:** Reverse osmosis (RO) is currently one of the fastest growing techniques for the desalination of different types of water. The product water from RO plants have TDS levels ranging between 30 to 500 mg/L.

   - **Electro dialysis:** Electro-dialysis is an electro-membrane process in which transport of ions present in contaminated or blackish is accelerated due to an electric potential difference applied externally.

   - **Solar Humidification /Solar Stills:** Solar energy is one of the most promising applications of renewable energies to seawater desalination. Solar still is basically a large scale shallow water pond if saline water (about 10 cm deep) spread over a large surface area and covered with glass over. The natural sunlight is used for evaporating the saline water and the condensed vapour is collected from the glass-case. Well-managed and maintained solar stills require a solar collection area of about one square meter to produce up to six litters of fresh water per day. This is also of limited use.

While considering Water Treatment Plant (WTP) options and alternatives, it is crucial to consider all aspects that input into the ultimate long term viability and sustainability. These depend on technology choice and the financial implications thereof. Technical experts and administrators together take suitable decision on WTPs. It is natural and decision makers emphasis on use of appropriate technologies, which should low cost, robust, low operator attention systems etc., A significant influencing factor as to sustainability is affordability in terms of capital cost and ongoing running costs of water treatment. It is particularly important to consider this aspect in instances where the initial capital layout of a technologically attractive system is considered to be too high in comparison to competing, yet technologically less sustainable technologies. It is generally observed that capital cost of membrane based technology plant is about 5 to 6 times costlier than conventional rapid sand water treatment plant depending upon the treatment capacity of plant. In case of operating and maintenance cost of membrane based plant cost saving can be made towards lower labour, and chemical requirements however, cost of membrane replacement add amount.

Financial Analysis of Conventional WTP v/s Membrane based WTP				
S. No.	Type of Water Purification Technology	Specific capital Cost (Rs./LPD)	O&M Cost (Paisa/ Litre of purified water)	Removals
Conventional WTP				
1.	Rapid sand type	1 to 1.5	0.03	Bacteria/ Virus/ Turbidity/ Suspended Solids
Membrane WTP				
1.	Ultra Filtration (UF)	10	0.10	Bacteria/ Virus/ Turbidity/ Suspended Solids
2.	Physio-chemical+UF	20	0.20	Single contaminant such as Iron/ Arsenic/ Fluoride
3.	UF+NF/RO	50	0.5	Multi-contaminants such as salinity, heavy metals etc

Of course, there are issues related to removal of useful minerals from water and huge wastage of water in case of membrane based WTP. However, this can also be appropriately stabilized.

1. Conclusion: Because of water scare area and high level of ground water dependency, Urban Gujarat needs some immediate as well as long term solution for safer drinking water. Immediate action depends upon impurities in water during water supply. However, following long term actions are recommended for safer during water in Gujarat

- **Promoting Natural Water Infra structure:** International trend is to preserve and develop green and natural water infrastructure, suitable analysis for Grey V/S Green Infrastructure Development be made and adopted.
- **Promoting Rain water Harvesting:** Conserving the water where it falls & Increasing the retention time of water with the ground to facilitate recharge

  Automation and Instrumentation of WTP: It is strongly recommended that, all WTPS within Municipal Corporations areas, "A" class & "B "class ULBs should have fully automation & instrumentation in WTP.
- **Development of Water Safety Plan & Quality Surveillance system:** A water safety plan is a plan to ensure the safety of drinking water with approach that encompasses all steps in water supply from catchment to consume (WHO, 2006)
- **Proposed Standard Operating Procedure (SoP)for collection of Water Samples :** Based on results of water sampling, appropriate additional water treatment should be done as discussed

- **Installation of water Kiosk:** In case of issues related to contamination of chemical properties, water kiosk can be installed.
- **Capacity Building Programme:** Capacity building plan of Urban Local Bodies (ULB) to enable them for challenging task of preparation of water safety plan, supply and monitoring of water quality, better operation and maintenance of water treatment plant, use and handling of chemicals like Alum, PAC & Chlorine etc., management of SoP and MIS

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