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# Increased Willingness to Pay for Safe Drinking Water: A Case Study of South-West Guwahati

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## Abstract

A water treatment scheme is being implemented in South-West Guwahati with financial assistance from Jawaharlal Nehru National Urban Renewal Mission. However, the scheme is finding intense opposition from local population due to planned charging of tariff on the supplied water. Presently, groundwater is being used for domestic purposes by the people of the area, but it is suspected of contamination with natural sources. Therefore, there is a need to make the population aware of existing quality of groundwater used by them which shall likely to assist them in taking a decision for procurement of water from the scheme. Groundwater from 1296 household sources were collected for assessing the water quality. It is observed that concentration of iron exceeded in 708 sources while concentrations of fluoride and arsenic exceeded in 200 and 126 sources respectively. Also a questionnaire survey was carried out before and after assessing the groundwater quality to assess increased willingness to procure water from the scheme. Around 48% surveyed household indicated their willingness to purchase water without knowing the water quality of their household source. But after knowing the groundwater quality, the willingness to pay for water from the scheme increased to 74%. Hence, awareness of groundwater quality helped increased acceptance and willingness to pay for safe drinking water from the scheme.

**Keywords:** Fluoride and Arsenic, Questionnaire Survey, Safe Drinking Water

## 1. Introduction

Water is one of the most important gifts to mankind from the nature. It is essential for survival and good health. Over 97% of earth's water is in oceans as salt water. Around 2% is stored as fresh water in glaciers, ice caps, and snowy mountain ranges. It leaves only 1% of the earth's water to meet our day-to-day water needs. Our fresh water supplies are stored either in the soil (aquifers) or bedrock fractures beneath the ground (termed as groundwater) or in lakes, rivers, and streams on the earth's surface (termed as surface water)[22].

Water required for beneficial use are derived from either surface water or groundwater source. Groundwater is considered as major source of drinking water, especially in rural and peri-urban areas. The government has constantly encouraged installation of hand pumps and deep tube-wells to fetch drinking water in rural areas[11]. It generally

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does not contain any bacteria and is free from turbidity, hence safer when compared to surface water. However, groundwater may contain several contaminants due to percolating water and anthropogenic sources. Anthropogenic sources contaminating groundwater includes releases or spills from stored industrial wastes, septic tank, land fill leachates, leaky petroleum storage systems etc[4].

In urban areas, water is supplied by urban local bodies on payment of nominal tariff. However, the municipal city limits are constantly expanding.With rapid growth of urbanization, to cope up with water needs of expanding cities and increasing population, Government of India has introduced various schemes viz. Accelerated Urban Water Supply Programme, Low Cost Sanitation Programme, Mega City Scheme, National Slum Development Prorgramme, Scheme for Integrated Development of Small and Medium Towns and Jawaharlal Nehru National Urban Renewal Mission (JNNURM). As of now around 71% of Indian urban population have either piped water to their household or public tap at a common area in their locality. But, unfortunately in rural areas the access to piped water is hardly 28%[12].

Guwahati city is one of the most rapidly growing cities in India. Due to rapid growth in population and expanding municipal limits, there is a huge demand for potable water. Existing water supply facilities are heavily deteriorated, surpassed the design life and have insufficient infrastructure to cover water need of the entire population. Presently, it provides water to only 30% of the city's population[3]. Apart from the water supply system, a large percentage of the population are dependent upon groundwater and tanker truck. Hence, to improve the accessibility of safe drinking water, the Ministry of Urban Development, Government of India is implementing four water treatment and supply schemes in Guwahati city. These schemes are coming up in North Guwahati, South-Central Guwahati (both funded by Japan International Cooperation Agency), South-West Guwahati (funded under JNNURM) and South-East Guwahati (funded by Asian Development Bank). This study is confined to the scheme being constructed under JNNURM in South-West Guwahati. This scheme would establish a water treatment plant with a capacity of 108 MLD. The area covered under this water supply scheme consists of a mixed population of low income group, high income group and a few slum areas whose requirement for amount of water is different. The willingness of these groups to spend money for procuring water from the scheme is apparently dissimilar. However, there has been wide spread protest from public in Guwahati against proposed water supply schemes. This protest was mainly due to lack of consultations with the citizens, insufficient information sharing regarding funds, funding agencies, companies and parties availing contracts, time-frame for the project, service rates, etc. Moreover, they feel lack of involvement in the decision making process and tariff setting process of the proposed new schemes. They blame government of incorporating private sector in development and construction of the project. The people fear that involvement of private sector would lead to very high tariff on the supplied water[18,20,21]. Therefore, the local public insists the local authorities to continue with the existing arrangements of water supply and improving the same.

## 2. Objective

In order to understand the whole issue of supply of potable water vis-à-vis the public protests and to suggest possible way forward, the present investigation has selected a study area of South-West Guwahati. A water treatment plant and water distribution system are being constructed in this area to serve the entire population of South-West Guwahati. However, there has been continuous public protest against supply of potable water and lack of involvement of public in the decision making process of this project.

The present study is targeted to address following issues: (1) to evaluate willingness of people to procure water from the water supply scheme, without knowing groundwater quality of household source (2) to assess an overview of present groundwater quality of individual household sources and (3)to assess change in willingness to procure water after making people aware of critical water quality parameters associated with their household sources of groundwater.

# 3. Materials and Methods

## 3.1 Sample Size

The entire study area of South-West Guwahati consists of thirteen municipal wards and four village zones comprising number of households. These zones do not fall under municipal administration but are considered a part of Guwahati Metropolitan Area (GMA). The master plan for Guwahati Metropolitan Area (GMA) includes these zones as well into its planning and development. Representative sample size was determined statistically as given by Rammont & Amin[13]. A total of 1296 samples were collected from the study area with around 90-95 samples from each wards/zones. This sample size was taken into consideration for both groundwater quality assessment and house-to-house survey to elicit willingness to procure water from the scheme.

## 3.2 Sample Collection

Map for each ward/zone was reproduced using arcGIS 9. Each ward/zone was divided into grid pattern based on longitude and latitude. The intersection point of longitude and latitude were considered as location for sample collection. Global Positioning System (GPS) was used to track map coordinates in the field. Attempts were made to collect samples in grid-wise pattern but due to population unevenness and presence of marshy lands, it was not possible to carry out grid-wise sample collection in a few situations and for such cases samples were collected from next best alternative location.

The predetermined number of samples were collected by grab sampling in respective localities and quantitative analysis was carried out in the laboratory. The samples were collected from the groundwater source viz. dug well, hand pumps and stored in poly-propylene bottles. For determination of hardness, sodium ($Na^+$), potassium ($K^+$), calcium ($Ca^{2+}$), iron ($Fe^{2+}$) and arsenic ($As^{3+}$) concentration, collected samples were fixed by adding 1 mL of concentrated $HNO_3$ to make its pH less than 2.

## 3.3 Questionnaire Survey

A face to face questionnaire survey was carried out during sample collection to assess public mindset on likely procurement of treated water from the scheme. The data was processed by descriptive statistical analysis and represented as percentage. The second survey was also carried out for the households from where water samples were collected previously but by making them aware of water quality of their source water and to seek a fresh opinion on willingness to procure water from the scheme.

### 3.4 Groundwater Analysis

Physicochemical parameters such as pH, conductivity, alkalinity, hardness, sodium, potassium, calcium, nitrate, iron, fluoride and arsenic were estimated for the collected samples. All analytical estimations were performed according to Standard Methods[1].

## 4. Results and Discussion

### 4.1 Overall Quality of Groundwater

The results of quantitative analysis revealed that pH, conductivity, sodium, potassium, calcium, alkalinity and hardness values were within WHO guidelines[23]. Iron, fluoride and arsenic concentration were observed to have exceeded WHO guidelines across the study area. Hence, these three contaminants were considered as critical parameters. The ward/zone wise percentage to which these samples were in agreement with WHO guidelines[23] and BIS permissible limits[10] are shown in Table 1. The collected sample showed ample variation in quality in terms of iron, fluoride and arsenic. It was attributed to distribution of different types of rocks in the region. The study region has two types of rocks viz. archeangneisses and quaternary sediments[2,16]. The variation in water quality was also reported with depth of the well in same region due to presence of specific layer of minerals at particular depths[15]. This study made an important observation relating groundwater quality with topography of the area. The samples collected in vicinity of foothills were observed to be more contaminated than that of plains. The reason could be explained on the basis of natural contamination phenomenon. The rainwater running from over hills and through percolation dissolved many contaminants, finally contaminating the groundwater near the foothills.

### 4.2 Iron

As per WHO guidelines and BIS permissible limits, iron in drinking water should be below 0.3 mg/L[10,23]. Consumption of iron contaminated water has no adverse health effect but it may stain clothes, utensils and impart bitter taste and odor to water. Most of the samples were observed to have exceeded the WHO guideline/BIS permissible limits. Figure 1 shows sample locations exceeding(> 0.3 mg/L) and within (< 0.3 mg/L) the permissible limit. It was observed that none of the wards/zones recorded 100% compliance with WHO guidelines for iron (Table 1). The lowest percentage of samples in agreement with guidelines is in wards 2, 4, 8, 9 and zone3.The overall agreement was estimated as 54% for iron.

### 4.3 Fluoride

As per WHO guidelines and BIS permissible limits, fluoride in drinking water should be below 1.5 mg/L[10,23]. Fluoride in optimum amount helps to prevent dental caries. Excess consumption of fluoride may cause dental cavities, skeletal and non-skeletal forms of fluorosis[14,17]. Samples collected showed traces of fluoride in certain wards. Figure 2 shows the sample locations exceeding (> 1.5 mg/L) as well as within (< 1.5 mg/L) permissible limits. The lowest percentage of samples is in agreement with guidelines/permissible limits in ward 2, 12 and 13.However, out of the total samples collected around 14% samples did not comply with WHO guidelines/BIS permissible limits.

## 4.4 Arsenic

High-level of arsenic exposure is associated with chronic health effects including cancer of bladder, lung, liver, kidney, and skin[24]. The biological mechanisms of arsenic may relate to oxidative stress, altered DNA methylation and repair, cell proliferation, gene amplification, and chromosomal abnormalities[7,9]. As per WHO guidelines/BIS permissible limits, arsenic in drinking water should be below 10 µg/L[10] WHO, 2004). Figure 3 shows water sample locations in the study area exceeding (> 10 µg/L)and within (< 10 µg/L)guidelines/ permissible limits. The lowest percentage of samples in agreement with guidelines/permissible limits is in ward 7.However, only 91% of total samples complied with guidelines/permissible limits for arsenic.

## 4.5 Willingness to Pay

The study attempted to evaluate public willingness to procure water from the scheme before and after assessing the groundwater quality of the household sources.

### *4.5.1 Before Assessing Groundwater Quality*

Face to face questionnaire survey and results of descriptive statistical analysis showed that people were unaware of groundwater quality. Around 99.7% people had never got checked groundwater quality of their source water. The people were unaware of heavy metal or other contaminations but found to be more concerned about visible impurities and concentration of iron imparting staining of clothes, utensils etc. From the questionnaire survey results

**Table 1.** Percentage agreement of contaminants with WHO guidelines/BIS permissible limits in respective wards/zones

| Wards | Percentage agreement with guidelines(WHO, 2004)/BIS permissible limits[10] | | |
|---|---|---|---|
| | Iron | Fluoride | Arsenic |
| Ward 1 | 91% | 100% | 100% |
| Ward 2 | 11% | 66% | 100% |
| Ward 3 | 77% | 100% | 69% |
| Ward 4 | 0% | 89% | 72% |
| Ward 5 | 98% | 91% | 100% |
| Ward 6 | 28% | 98% | 91% |
| Ward 7 | 85% | 93% | 28% |
| Ward 8 | 8% | 100% | 92% |
| Ward 9 | 8% | 100% | 79% |
| Ward 10 | 36% | 88% | 100% |
| Ward 11 | 88% | 84% | 94% |
| Ward 12 | 82% | 42% | 100% |
| Ward 13 | 85% | 69% | 100% |
| Zone 1 | 30% | 84% | 100% |
| Zone 2 | 72% | 100% | 97% |
| Zone 3 | 23% | 97% | 98% |
| Zone 4 | 41% | 99% | 98% |
| **Total Samples** | 54% | 86% | 91% |

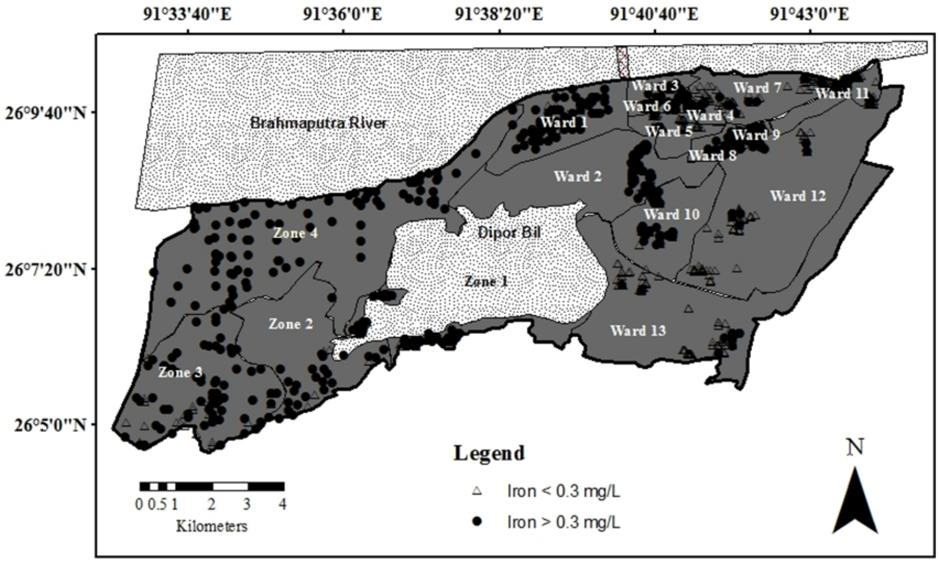


**Figure 1.** Distribution of iron present in groundwater of South-West Guwahati.

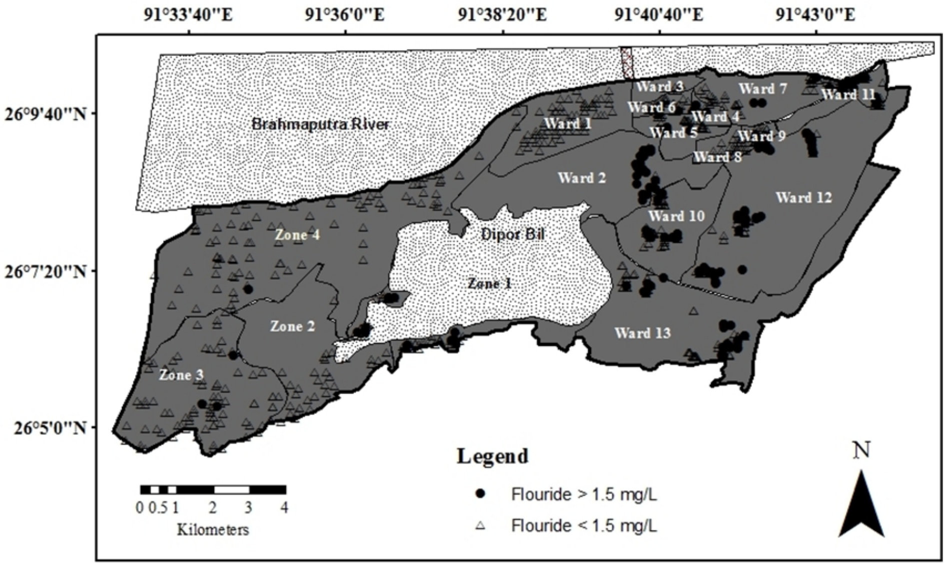


**Figure 2.** Distribution of fluoride present in groundwater of South-West Guwahati.

**Table 2.** Ward-wise distribution of responses in terms of frequency and percentage for different variables

| Wards (sample size) | Response* | Willingness to procure water | | | |
|---|---|---|---|---|---|
| | | Before assessing ground water quality | | After assessing ground water quality | |
| | | *Frequency* | *Percent (%)* | *Frequency* | *Percent (%)* |
| Ward 1 (94) | 0 | 11 | 11.7 | 14 | 14.89 |
| | 1 | 83 | 88.3 | 80 | 85.11 |
| Ward 2 (94) | 0 | 58 | 61.7 | 28 | 29.79 |
| | 1 | 36 | 38.3 | 66 | 70.21 |
| Ward 3 (13) | 0 | 8 | 61.54 | 3 | 23.08 |
| | 1 | 5 | 38.46 | 10 | 76.92 |
| Ward 4 (18) | 0 | 11 | 61.11 | 5 | 27.78 |
| | 1 | 7 | 38.89 | 13 | 72.22 |
| Ward 5 (93) | 0 | 78 | 82.98 | 50 | 22.11 |
| | 1 | 16 | 17.02 | 44 | 77.89 |
| Ward 6 (64) | 0 | 40 | 62.50 | 16 | 25.00 |
| | 1 | 24 | 37.50 | 48 | 75.00 |
| Ward 7 (94) | 0 | 35 | 37.23 | 32 | 34.04 |
| | 1 | 59 | 62.77 | 62 | 65.96 |
| Ward 8 (13) | 0 | 10 | 76.92 | 8 | 61.54 |
| | 1 | 3 | 23.08 | 7 | 53.85 |
| Ward 9 (80) | 0 | 60 | 75.00 | 47 | 58.75 |
| | 1 | 20 | 25.00 | 33 | 41.25 |
| Ward 10 (92) | 0 | 70 | 76.09 | 85 | 36.96 |
| | 1 | 22 | 23.91 | 7 | 63.04 |
| Ward 11 (94) | 0 | 68 | 72.34 | 76 | 30.85 |
| | 1 | 26 | 27.66 | 18 | 69.15 |
| Ward 12 (95) | 0 | 59 | 62.11 | 86 | 90.53 |
| | 1 | 36 | 37.89 | 9 | 9.47 |
| Ward 13 (95) | 0 | 65 | 68.42 | 80 | 25.26 |
| | 1 | 30 | 31.58 | 15 | 74.74 |
| Zone 1 (83) | 0 | 50 | 60.24 | 69 | 19.28 |
| | 1 | 33 | 39.76 | 14 | 80.72 |
| Zone 2 (90) | 0 | 35 | 38.89 | 49 | 15.56 |
| | 1 | 55 | 61.11 | 41 | 84.44 |

| Wards (sample size) | Response* | Willingness to procure water | | | |
|---|---|---|---|---|---|
| | | Before assessing ground water quality | | After assessing ground water quality | |
| | | *Frequency* | *Percent (%)* | *Frequency* | *Percent (%)* |
| **Zone 3 (93)** | 0 | 15 | 16.3 | 39 | 42.39 |
| | 1 | 77 | 83.7 | 53 | 57.61 |
| **Zone 4 (91)** | 0 | 33 | 36.26 | 31 | 34.07 |
| | 1 | 58 | 63.74 | 60 | 65.93 |
| **Total samples (1296)** | 0 | 672 | 51.85 | 757 | 25.81 |
| | 1 | 624 | 48.15 | 539 | 74.19 |
| **Household ground-water checked** | 0 | 1293 | 99.7 | - | - |
| | 1 | 3 | 0.2 | - | - |
| **Visible contamina-tion at source water** | 0 | 542 | 41.8 | - | - |
| | 1 | 754 | 58.2 | - | - |

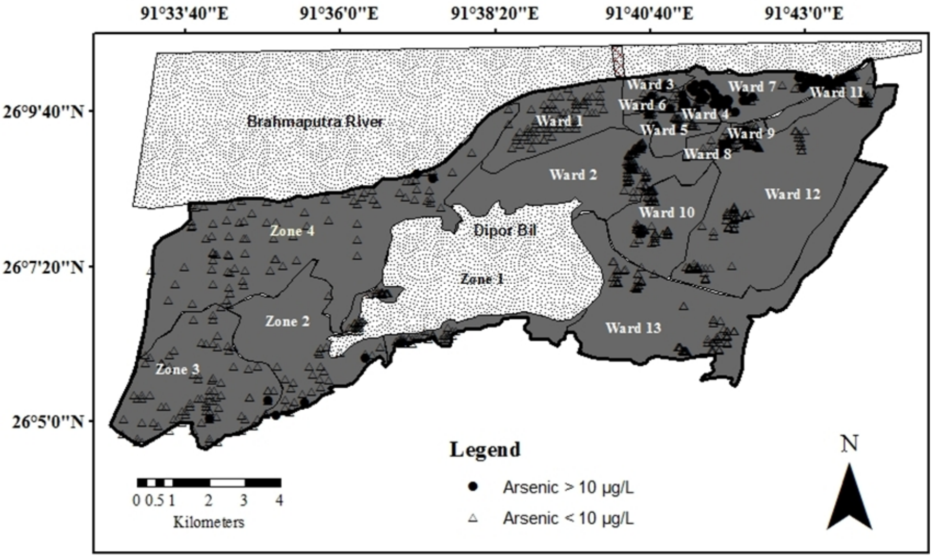


**Figure 3.** Distribution of arsenic present in groundwater of South-West Guwahati.

shown in Table 2, it was observed that the people showed lesser interest to procure treated water from the proposed water supply scheme. The willingness to procure water was very less in ward 5, 8, 10, 9 and 11. Apathetic community nature was due to unspecified tariff charges and lack of knowledge about health hazards of drinking contaminated water. Anger of public was portrayed through intense social opposition considering it as a privatization of water. Whereas the upcoming water supply scheme is fully government owned[6,19]. The study identified that community participation was critical factor which is lacking from the very beginning of the project. The residents were not informed about ownership of the scheme which led to such objections. The literature reported many cases of community opposition to various water projects around the world. This opposition in extreme cases led to failure of several water supply projects. The residents in such projects felt the feeling of being marginalized. They felt as outsiders during the development to operation phase of the projects. They were considered as customers of finished product liable of paying tariffrather than an important stakeholder[5,8].

### *4.5.2 After Assessing Groundwater Quality*

A similar face to face questionnaire survey was carried out after people were informed about groundwater quality of their source water. The awareness about possible health hazards of iron, fluoride and arsenic helped to change mindsets of people for willingness to pay for treated water from the proposed water supply scheme. Percentage of willingness was observed to increase from 48 to 74% after making them aware of the quality of groundwater and its adverse impact on health. Table 2 shows ward/zone-wise willingness to procure water before and after quality awareness. Significant increase in willingness to procure water from the scheme was observed for wards 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13 and zones 1, 2 and 4. For ward 1, 12 and zone 3, the willingness to procure water decreased because the people are more interested to have their own water treatment device.

## 5. Conclusion

In this study, the willingness to procure water from upcoming water supply scheme located in South-West Guwahati was carried out both before and after assessing the groundwater quality. Results of face to face questionnaire and willingness to procure survey carried out before groundwater quality analysis indicate that people were confused about ownership and tariff structures of the water supply scheme. The people were unaware about quality of household groundwater and merely showed interest in procuring water from the proposed water supply scheme. Later, household groundwater analyzed for its physicochemical parameters showed 875 samples were not suitable for drinking purpose out of 1296 samples. Either iron, fluoride or arsenic contaminations exceeded WHO guidelines/BIS permissible limits. The people were informed of the contaminations at their household groundwater and its possible health impacts. This awareness significantly improved willingness to procure/accept water from upcoming water supply scheme. The percentage of willingness to procure/pay increased from 48 to 74% after creating awareness. The study identified community participation plays a crucial part in social acceptance of such projects. The study also pointed out lack of public participation as a result of social in activeness of people as well as lack of efforts from government bodies to do so.

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