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# WATER SUPPLY AND DEMAND MANAGEMENT SYSTEM: A CASE STUDY OF CHENNAI METROPOLITAN CITY, TAMIL NADU, INDIA.

N.Bavana<sup>a</sup>, A.Murugesan<sup>b</sup>, C.Vijayakumar<sup>b</sup>, T.Vignesha<sup>a</sup>

<sup>a</sup>PG Scholar, Department of Industrial Safety Engineering,

<sup>b</sup>Head of Department of Mechatronics Engineering,

K.S.Rangasamy College of Technology, Tiruchengode, TamilNadu, India.

E-Mail Id: sahananedu@gmail.coma, shavisaka@gmail.coma, murugesanhema2000@yahoo.co.inb

#### ABSTRACT

This study addresses the problems of supplying water to rapidly growing Chennai City. It is, one of the major metropolises of India, and is situated at the northern coastal edge of the State of Tamil Nadu. The city is more well-known by its older name of Madras. Currently, Chennai is inhabited by more than 7 million people in an area of 176 sq km. water supply for this population is maintained by tapping a combination of surface storage reservoirs and aquifers. In the year 2003-2004, Chennai experienced a severe water crisis: the piped supply for the entire city was virtually shut down for a 12-month period. Consumers became dependent on private tanker suppliers trucking in untreated groundwater from peri-urban areas.

This study accomplishes three goals: understanding the dynamics of the Chennai's water supply and give a detailed account of the urban water system. Secondly, it integrates socio-economic behavior of the consumers by conducting a field survey. Finally, it compares a wide-range of policy options that cannot be done with existing frameworks.

**Keywords**: water crisis, water supply, socioeconomic behavior, field survey, reservoirs and aquifers.

# 11NTRODUCTION

We are living in planet that is dominated by water. More than 70% of the Earth's surface is covered with this simple molecule [3]. Scientists estimate that the hydrosphere contains about 1.36 billion cubic kilometers of this substance mostly in the form of a liquid (water) that occupies topographic depressions on the Earth [4]. The second most common form of the water molecule on our planet is ice. If our planet's ice melted, sea level would rise by about 70 meters. Thus water is the elixir of life, a precious gift of nature to mankind and millions of other species living on the earth. It is fast becoming a scare commodity in most part of the world. Water resources comprising of surface water (river and lakes), ground water and marine and coastal waters, support all living things including human beings [5].

In the year 2025, more than two billion people will live in the world's urban areas, than in 2000 and much of this population growth will occur in the

developing world. Among the biggest challenges associated with the growth in cities is delivering safe water to all at an affordable price [6].

We are selected Chennai as our case study area in part because of the severity of its water problem and the pressing need for innovative solutions. However, the choice of Chennai as a case study city was also opportunistic, because as a citizen we suffered from a severe drought in 2003 and 2004 followed by the heaviest rains in its recorded history in 2005. The fortuitous occurrence of both extremes within our study and the availability of both socio-economic survey data and physical data for both events, made an integrated analysis possible. Keeping the above in mind, in this report, we are trying to find out how the current frameworks about urban water supply are fragmented and inadequate for addressing Chennai's water problem. The study also reports scenarios of what will be the city's water demand may look like in 2025, using reasonable projections of population and historical rainfall record was used to generate scenarios of future rainfall.

The aim and objective of the study are

- 1. To analyses and understand the distribution of fresh water sources and water supply system in Chennai City.
- 2. To study the future prediction on distribution of water supply and demand based on population
- 3. To describe in terms of water quality and daily usage of water in household, by taking a case study in one of the zones of Chennai Corporation.

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4. To suggest ways and means of improving upon what has been built so far, into the future, and the specific recommendations emerging from the study.

Figure (1.1) shows the Chennai city zone map for the sample study area VI- Thiru Vi Ka Nagar.

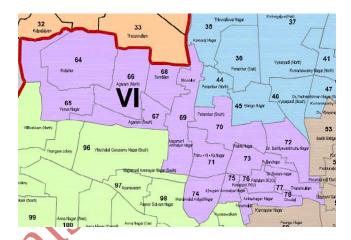


Figure 1.1 Map showing the study area VI

For the domestic water supply and demand scenario from the current status to the future gap between supply and demand, the data was collected pertaining to river basins, ground water availability and quality, rainfall for the present distribution and population for the present and future. The population data required for the study is collected from Directorate of Census Operations, Chennai, Tamil Nadu. The estimated values by using various techniques for the analysis are population projection, demand assessment and rainfall pattern are discussed in the following sections.

#### 2 MATERIALS AND METHODOLOGY

The current study methodology framework outlines the design, structure and the steps followed in the research. The study research design for the

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current research on urban water supply is divided into The sources of **surface water** are the reservoirs at two separate problems: (a) The managing and storing Redhills. Poondi. Cholavaram the raw water resources (water resources) and (b) Chembarambakkam, Porur Lake, Veeranam Lake and also from Kandaleru Reservoir in Andhra Pradesh Treating and delivering it to the final consumer (the water delivery) each addressing a different goal. under Telugu Ganga Project. The characteristics of Studies addressing these problems tend to be fairly existing surface sources are presented in Table (2.1). independent. The main focus of the water resources management is the fair and optimal allocation of water resources between agriculture, industry, urban

## Table 2.1 Water Storage Capacity of Reservoirs

| Water Storage Capacity of Reservoirs |                    |  |  |  |  |  |
|--------------------------------------|--------------------|--|--|--|--|--|
| Reservoirs/Lake                      | Capacity in (Mcft) |  |  |  |  |  |
| Poondi                               | 3,231              |  |  |  |  |  |
| Cholavaram                           | 881                |  |  |  |  |  |
| Redhills                             | 3,300              |  |  |  |  |  |
| Chembarambakkam                      | 3,645              |  |  |  |  |  |
| Total                                | 11,057             |  |  |  |  |  |
|                                      |                    |  |  |  |  |  |

Source: Chennai Metro Water, 2011, Tamil Nadu

# 2.1 Data collection

Data collection is general comprises of two types primary data and secondary data.

spatial scales and use different units of analyses.

and eco-system needs. In contrast, the goal of the water (and sanitation) delivery is to improve public health, and the quality of life in urban areas. Moreover, these different attentions address different

Primary data: Data that are gathered for a specific research in response to a particular problem, through interviews, questionnaires or observations.

Secondary data: Data that have been obtained from various kinds of documents such as research reports, annual reports given or published by government of TamilNadu, books, and articles.

#### 2.2 Distribution of supply system.

The Chennai Municipal Water Supply and Sewerage Board (CMWSSB), a statutory body established in the year 1978, is responsible for water supply and sewerage services in the Chennai Metropolitan Area (CMA). The main sources of water supply in the metropolitan areas are both surface water and ground water sources. The distribution network in Chennai City covers a length of 2582 Km and is divided into 159 Divisions. About 98% of the population of the city is covered through piped supply and the balance is through water tankers.

In summer and winter seasons from (January to April), draught period **ground water** from well fields are used. There are about five well fields for Chennai city are shown in table 2.2.

Rainfall in India is dependent largely on the southwest and northeast monsoons. Most of the rainfall takes place under the influence of southwest monsoon between June to September except in Tamil Nadu and some other Southern States where it occurs under the influence of northeast monsoon during October and November. In nature surface and ground

water are connected. Only based on rainfall, the surface water and ground water will get recharged Figure (2.1)show the average and total rainfall in mm from the year (1965 to 2014).

| Well Fields   | Year of<br>Commissioning | No. of wells<br>presently<br>yielding water | Yield<br>MLD<br>during<br>design | Average<br>yeild from<br>Dept. wells<br>in 2005 |
|---------------|--------------------------|---|----------------------------------|---|
| Tamaraipakkam | 1969                     | 2 out of 30                                 | 50                               | 1.6   |
| Panjetty      | 1969                     | 1 out of 13                                 | 41                               | 0.08  |
| Minjur        | 1969                     | 5 out of 9                                  | 34                               | 3.1   |
| Poondi        | 1987                     | 4 out of 12                                 | 27                               | 1.2   |
| Flood Plains  | 1987                     | 0 out of 5                                  | 14                               | 0   |
| Kannigaiper   | 1987                     | 0 out of 5                                  | 14                               | 0.01  |
| Total         |                          | 12 out of 74                                | 180                              | 5.99  |

Table 2.2 Ground Water Well Fields Location and Yield

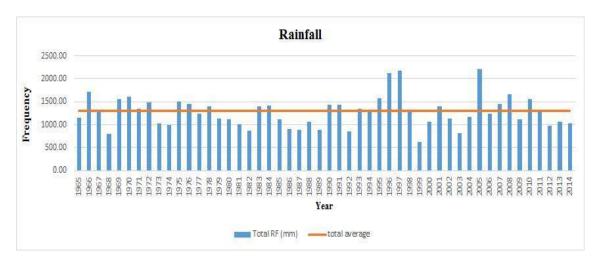


Figure 2.1 Total Rainfall Compared With Average Rainfall Level

### 3. RESULTS AND DISCUSSION

Main categorization of the findings are presented in following steps:

- Future prediction on water demand for growing population.
- A sample case study on daily usage of water in households.
- iii. Water saving awareness survey on water conservation in households.
- iv. Technique that are used to conserve water for future.
- v. Sample Test on Ground Water Quality.

# 3.1 Future prediction on water demand for growing population

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The growing population data were collected from published article by **Directorate of Census Operations, Chennai, Tamil Nadu**, based on that, the increasing population and water demand for future use can be get calculated.

The geometric increase Method is used in this study to forecast the population with the formula given below

# Population forecast = $P_{(predicted year)}$ = Current Population + Average Increment\*1

The census data from the year 1971, were collected and for the year 2021, 2031, 2041, 2051, the Chennai metropolitan area and Chennai city population is forecasted using geometrical increase method formulated and shown in table (3.1).

| Table   |      | 3.1  |      | Populat | ion  |      | forecast |      |      | data |
|---------|------|------|------|---------|------|------|----------|------|------|------|
| year    | 1971 | 1981 | 1991 | 2001    | 2011 | 2021 | 2031     | 2041 | 2051 |      |
| CMA     |      |      |      |         |      |      |          |      |      | •    |
| in      |      |      | 7    | 1       |      |      |          |      |      |      |
| million | 3.5  | 4.6  | 5.8  | 7.1     | 8.7  | 11.5 | 15.3     | 20.4 | 27.2 |      |
| City in |      |      |      |         |      |      |          |      |      |      |
| million | 2.5  | 3.3  | 3.8  | 4.3     | 4.7  | 5.7  | 6.9      | 8.5  | 10.4 |      |

The total demand is calculated as **Total Water Demand = Design Population\* Per Capita Demand** as shown in table 3.2

**Table 3.2 Total Water Demand data** 

| year      | 2021  | 2031  | 2041   | 2051  |
|-----------|-------|-------|--------|-------|
| CMA in    |       |       |        |       |
| Thousands | 1.553 | 2.066 | 2.754  | 3.672 |
| City in   |       |       |        |       |
| Thousands | 0.76  | 0.932 | 1.1.48 | 1.404 |

# 3.2A sample case study on daily usage of water in households

Baseline field aimed survey at understanding the determinants of household water conservation in one of the Zones of Chennai Corporation. This field survey helps us to understand how people use water and how sustainable levels of water use can be achieved and maintained in the long-term. This survey was undertaken among the residents living in Thiru-Vi-Ka Nagar, Zone VI, City Corporation Chennai to develop comprehensive understanding of the social and behavioural aspects of household water use.

A schedule (Questionnaire) was prepared by

questions, the language of the questions and the arrangement of parts of the schedule are not changed. However, the investigator explained the questions if the respondent faced any difficulty. It contains direct questions as well as questions in tabular form. This Schedule included open-ended questions and close-ended questions. Open-ended questions allowed the respondent considerable freedom in answering. However, questions are answered in details by the respondents of study zone shown in table (3.3). Close-ended questions answered by the respondent by choosing an answer from the set of answers given under a question just by ticking.

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order of

| Tab  | Table 3.3 Zone-VI Thiru Vi Ka Nagar, Chennai City Corporation, Tamil Nadu |            |            |             |            |  |  |
|------|---|------------|------------|-------------|------------|--|--|
| Ward | Name of the ward  | No. of     | No. of     | Household   | % to total |  |  |
| No   |   | Households | Population | Interviewed | sample     |  |  |
|      |   |            |            |             | Size       |  |  |
| 64   | Kolathur  | 18420      | 72144      | 9           | 14         |  |  |
| 65   | Venus Nagar   | 24471      | 95564      | 7           | 12         |  |  |
| 66   | Agaram (North)  | 12896      | 50926      | 5           | 8          |  |  |
| 67   | Agaram (South)  | 9710       | 37331      | 3           | 5          |  |  |
| 68   | Sembium   | 8456       | 32999      | 4           | 7          |  |  |
|      | Nagamanl Ammaiyar   |            |            |             |            |  |  |
| 69   | Nagar   | 6509       | 27133      | 2           | 3          |  |  |
| 70   | Perambur (South)  | 6214       | 26313      | 2           | 3          |  |  |
| 71   | Thiru Vi Ka Nagar   | 2948       | 12091      | 3           | 5          |  |  |
|      | Dr. Sathiyavanimuthu  |            |            |             |            |  |  |
| 72   | Nagar   | 7870       | 32446      | 2           | 3          |  |  |
| 73   | Pulianthope   | 5841       | 22662      | 5           | 8          |  |  |
| 74   | Maraimalai Adigal Nagar   | 14580      | 56960      | 2           | 3          |  |  |
| 75   | Kosappet  | 15314      | 60126      | 2           | 3          |  |  |
| 76   | Pattalam  | 6123       | 24524      | 6           | 11         |  |  |
| 77   | Thatankullam  | 6211       | 23619      | 6           | 11         |  |  |
| 78   | Choolai   | 5624       | 23476      | 3           | 4          |  |  |
|      | Total   | 151,187    | 598,314    | 61          | 100        |  |  |
|      |   |            |            |             |            |  |  |
|      |   |            |            |             |            |  |  |

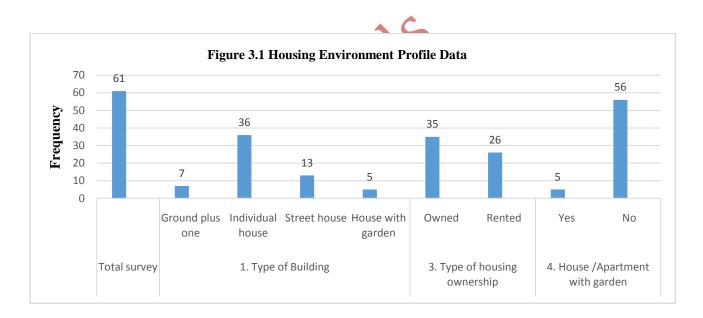
The information gathered from the respondents through a questionnaire schedule are

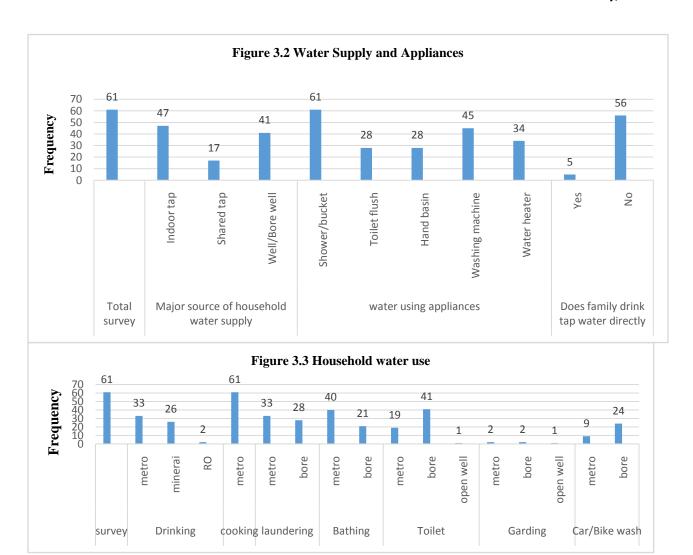
- 1. Types of housing: There are four different type of housing are categorized namely (a) House with the garden, (b) Individual House, (c) Ground plus one (Multi-Storage), (d) Street house. In which out of 61 respondents, 36 are owned by Individual house and Majority of 56 are house without garden, shown in Figure (3.1).
- 2. Water supply and Appliances: Major source of household water supply are (a) Indoor tap, (b) Shared tap, (c) wellbore well, in which 47 are owned by indoor tap and rest of 41 uses open well or bore well. Respondents uses all the application such as

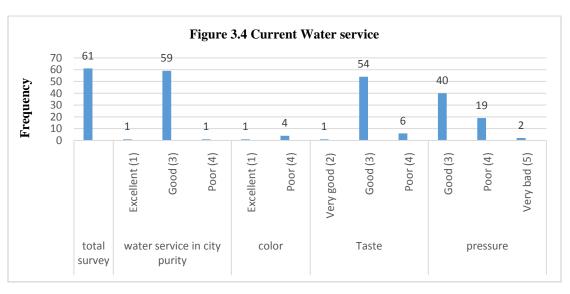
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(shower/bucket, toilet flush, hand basin, washing machine and water heater shown in Figure (3.2).

- **3. Household water use:** Water is essential for all the purposes such as (drinking, cooking, laundering, bathing, toilet, gardening, car/bike wash) were majority of 80% people uses bore well water for all the appliances and for drinking purpose 60% of people consume mineral water and rest 40% consume metro water shown in Figure (3.3).
- **4. Current Water Services**: People in the community rated that service provided by the metro water board must get improve in its purity, pressure and taste along with the color shown in Figure (3.4).







## 3.2.1 Results and Views from public

As a result of the study people in this locality are rated water shortage, water pollution, air pollution and land pollution as a **very serious problem** in future years. Public ratings on current existing water supply service given by the government are **satisfactory**. Views from the public they gave suggestion as, if the supplied water quality has improvement monthly expenses spent by the public on buying water can which coast amount Rs. 600 to 1000 can be diminished.

# 3.3 Water saving awareness survey on water conservation in households

Another set of survey on water saving awareness was taken among younger generation (16-80) in 61 household. In these there were 65 member, of which 15 member were surveyed. And as a result, the respondent were agreed that water saving in and around house is a must and they were in social pressure to save water for future generation. They

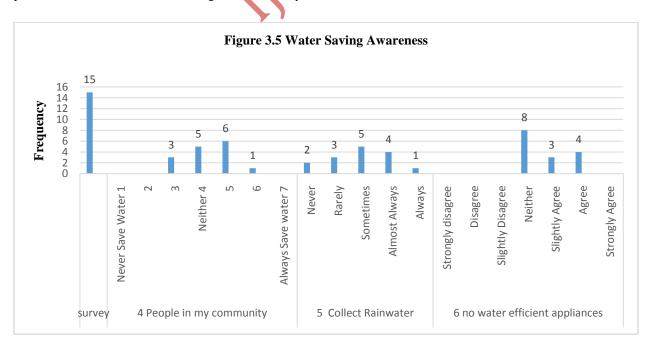
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also strongly agree that they feel guilty if water is not saved for future.

They also rated that, People in their community are strongly in need for saving water in and around the house and garden. Majority of the people says that, they do not use any water saving appliances such as (spray tap, low-flow shower head etc.). Close-ended questions answered by the respondent by choosing an answer from the set of answers given under a question just by ticking

The information gathered from the respondents through a questionnaire schedule are tabulated and presented below .

Water Saving Awareness: People in the community were asked for saving water by collecting rainwater and using water efficient appliances, in which majority of people 5 respondent out of 15 answered that they sometimes only, follow the activity of saving the rainwater as shown in Figure (3.5).



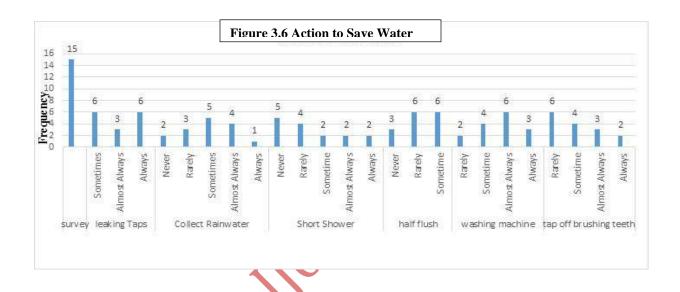
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As the result of the study, the respondent in

3.3.1 Results and Views from public

and around the locality are aware of saving water. Action to save water are (fixing leaking taps, collect rainwater, short shower, use half flush, run washing machine on full load, turn off tap while brushing),

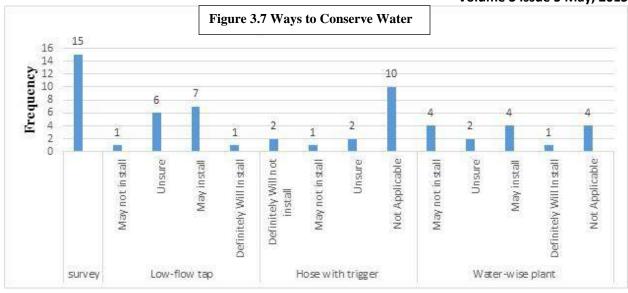
different ratings of answers were obtained from the public in which majority of respondent 6 out of 15 answered that they **rarely** follow the action to save water condition as shown in below Figure (3.6).

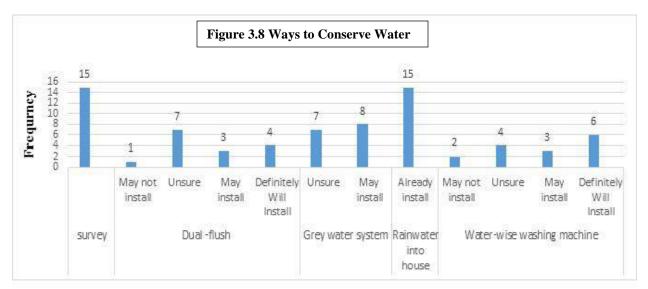


# 3.4 Technique that are used to conserve water for future

In each households to conserve water some of the techniques can be followed such as (low flow taps, hose with trigger, water-wise plant, dual flush, grey water system, directing rainwater into the house, use water-wise washing machine) for this ways to conserve water, majority of 6-7 respondents out of 15 answers that they may install or unsure of following the ways to conserve water as shown in below Figure (3.7, 3.8).







# 3.5 Sample Test on Ground Water Quality

The present investigation indicates that the existing fresh groundwater resources have to be properly managed because majority of the people use ground water as a source for household purpose, so as on testing the ground water samples (open well, bore well)

which have collected from respondents from different wards are reported as "water samples is of satisfactory of water quality" and tabulated belowtable (3.4)

|      | OPEN WELL   |                   |                  |                  |                  |                  |  |  |
|------|---|-------------------|------------------|------------------|------------------|------------------|--|--|
|      |   |                   | Ward:64,65,66    | Ward:67,68,69,70 | Ward:71,72,73,74 | Ward:75,76,77,7  |  |  |
| S.no | Parameters  | Permissible limit | Actual data      | Actual data      | Actual data      | Actual data      |  |  |
| 1    | Colour  |                   | colourless&clear | colourless&clear | colourless&clear | colourless&clear |  |  |
| 2    | Odour   |                   | nil              | nil              | nil              | nil              |  |  |
| 3    | Turbidity   | 10                | 0.2              | 0.4              | 0.4              | 0.5              |  |  |
| 4    | Total dissolved solids at 105 degree celcius (mg/l) | 2000              | 1400             | 800              | 480              | 1100             |  |  |
| 5    | Calcium (as Ca) (mg/l)                              | 200               | 60               | 68               | 22               | 68               |  |  |
| 6    | Magnesium (as Mg) (mg/l)                            |                   | 19               | 46               | 17               | 39               |  |  |
| 7    | Total hardness (as CaCO3) (mg/l)                    | 600               | 330              | 360              | 128              | 330              |  |  |
| 8    | Chlorides (as Cl) (mg/l)                            | 1000              | 550              | 150              | 120              | 410              |  |  |
| 9    | Ammoniacal nitrogen (as N) (mg/l)                   |                   | 0.03             | 0.03             | 0.03             | 0.04             |  |  |
| 10   | Albuminoid nitrogen (as N) (mg/l)                   |                   | 0.04             | 0.04             | 0.04             | 0.22             |  |  |
| 11   | Nitrous nitrogen (as N) (mg/l)                      |                   | nil              | nil              | nil              | nil              |  |  |
| 12   | Nitric nitrogen (as NO3) (mg/l)                     |                   | 2                | 1 4              | 2                | 1920             |  |  |
| 13   | Oxygen absorbed (tidy's 4 hours tet) (mg/l)         |                   | 0.32             | 0.41             | 0.19             | 1.23             |  |  |
| 14   | Hydrogen ion concentration (pH)                     | 6.5 to 8.5        | 8                | 8.5              | 8.3              | 7.9              |  |  |
| 15   | Alkalinity to phenolphthalein (as CaCO3) (mg/l)     |                   | nil              | 32               | 10               | nil              |  |  |
| 16   | Alkalinity to methyl orange (as CaCO3) (mg/l)       | 600               | 400              | 240              | 138              | 244              |  |  |
| 17   | Sulphates (as SO4) (mg/l)                           | 400               | 270              | 170              | 50               | 140              |  |  |
| 18   | Phosphates (as PO4) (mg/l)                          |                   | 0.010            | 0.010            | 0.010            | 0.010            |  |  |
| 19   | Iron (as Fe) (mg/l)                                 | 1.0               | 0.10             | 0.10             | 0.10             | trace            |  |  |
| 20   | Fluorides (as F) (mg/l)                             | 1.5               | 0.10             | 0.10             | 0.10             | 0.15             |  |  |
| 21   | Specific Conductance(micro siemens/cm)              |                   | 2270             | 1260             | 750              | 1700             |  |  |

Report: The water sample is of satisfactory chemical quality and can be used for drinking purpose after boiling or proper disinfection to ensure hygienic safety

|      |   |                   | Ward:64,65,66    | Ward:67,68,69,70 | Ward:71,72,73,74 | Ward:75,76,77,78 |
|------|---|-------------------|------------------|------------------|------------------|------------------|
| S.no | Parameters  | Permissible limit | Actual data      | Actual data      | Actual data      | Actual data      |
| 1    | Colour  |                   | colourless&clear | colourless&clear | colourless&clear | colourless&clear |
| 2    | Odour   |                   | nil              | nil              | nil              | nil              |
| 3    | Turbidity   | 10                | 0.5              | 0.5              | 0.5              | 0.3              |
| 4    | Total dissolved solids at 105 degree celcius (mg/l) | 2000              | 410              | 390              | 550              | 840              |
| 5    | Calcium (as Ca) (mg/l)                              | 200               | 21               | 29               | 29               | 40               |
| 6    | Magnesium (as Mg) (mg/l)                            |                   | 19               | 15               | 10               | 65               |
| 7    | Total hardness (as CaCO3) (mg/l)                    | 600               | 132              | 136              | 212              | 370              |
| 8    | Chlorides (as CI) (mg/l)                            | 1000              | 144              | 120              | 128              | 210              |
| 9    | Ammoniacal nitrogen (as N) (mg/l)                   |                   | 0.04             | 0.03             | 0.03             | 0.03             |
| 10   | Albuminoid nitrogen (as N) (mg/l)                   |                   | 0.048            | 0.040            | 0.048            | 0,048            |
| 11   | Nitrous nitrogen (as N) (mg/l)                      |                   | nil              | nil              | nil              | nil              |
| 12   | Nitric nitrogen (as NO3) (mg/l)                     |                   | 20               | 24               | 2                | -                |
| 13   | Oxygen absorbed (tidy's 4 hours tet) (mg/l)         |                   | 0.42             | 0.63             | 0.42             | 1.44             |
| 14   | Hydrogen ion concentration (pH)                     | 6.5 to 8.5        | 7.9              | 7.8              | 7.9              | 7.7              |
| 15   | Alkalinity to phenolphthalein (as CaCO3) (mg/l)     |                   | nil              | nil              | nil              | nil              |
| 16   | Alkalinity to methyl orange (as CaCO3) (mg/l)       | 600               | 104              | 100              | 188              | 328              |
| 17   | Sulphates (as SO4) (mg/l)                           | 400               | 36               | 30               | 50               | 90               |
| 18   | Phosphates (as PO4) (mg/l)                          |                   | 0.010            | 0.010            | 0.010            | 0.010            |
| 19   | Iron (as Fe) (mg/l)                                 | 1.0               | 0.80             | trace            | 0.10             | trace            |
| 20   | Fluorides (as F) (mg/l)                             | 1.5               | 0.20             | 0.20             | 0.10             | 0.10             |
| 21   | Specific Conductance(micro siemens/cm)              |                   | 630              | 610              | 850              | 1300             |

Report: The water sample is of satisfactory chemical quality and can be used for drinking purpose after boiling or proper disinfection to ensure hygienic safety

#### 4 CONCLUSION

Ground water quality deterioration can be controlled by recharging groundwater through rainwater harvesting and controlling seawater intrusion. Due to the increasing population and demand, proper structure of rainwater harvesting have to be implemented in every house holds for recharging the ground water. For recharging the rain water proper structural work has to be constructed based on the standards. The rainwater treatment process should be done for pure and safe consumption of water. As a suggestion to the public people can be use water saving appliances products (low flow taps, hose with trigger, water-wise plant, dual flush, grey water system, directing rainwater into the house, use water-wise washing machine) in their households and seek for a proper maintenance.

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