International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 03 | Mar-2018 www.irjet.net p-ISSN: 2395-0072

# Hardness Removal of Groundwater by using Optimum Lime-Soda Process

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**Abstract -** *Hard water can cause many problems including scaling and excessive soap consumption. In the Surat city, hard water is mostly found in the East, South and north zone. It ranges between 450-550 mg/L as CaCO3 or beyond 250 mg/L as CaCO3 for very hard waters. The acceptable water hardness range is between 100-200 mg/L as CaCO3. A water softening experiment was conducted in replicate to observe the changes in parameters such as total hardness and pH with varying dosages of lime and soda ash. A lime and soda ash dosage range of 1 % of the stoichiometric amount was chosen for the experiments. The samples used were groundwater from four different zones of Surat bore well average total hardness of 500 mg/L as $CaCO_3$. Results indicated that an increase in lime dosage caused a decrease in total hardness concentrations. The pH continually increased with adding lime and soda ash dosage.*

***Key Words***: **Hardness, Lime, Soda ash, Groundwater**

## 1. INTRODUCTION

Groundwater normally remains in the subsoil for many years before it is pumped up or flows out into the surface water. Due to the long residence time in the subsoil, groundwater is in chemical equilibrium. Groundwater comes in contact with the atmosphere when it is pumped up or discharged into surface water. When water is heated the equilibrium is changing, the $Ca^{2+}$ and $HCO_3^-$ ions will precipitate in the form of calcium carbonate ($CaCO_3$). Especially high concentrations of $Ca^{2+}$ and $HCO_3^-$ ions will lead to inconveniences for the customers because of the calcium carbonate scaling (e.g., deposits in water boilers). To prevent precipitation of calcium carbonate at the customers' taps, calcium ions are partially removed from the water by drinking water companies. This is called softening. Lime-Soda water softening method is one of the most traditional chemical method in water purification process used for reducing the hardness of ground water.

Hard water is very dangerous to human body especially on hair and skin. It contains high rate minerals of calcium and magnesium and also contains bicarbonate and chloride. In a present, one of the most important things is to provide safe and soft water to the public. Many processes are available at present time to remove hardness of calcium and magnesium like, boiling of water, Chemical Precipitation, Ion-exchange resin, Reverse osmosis, Synthetic resin, etc. Chemical precipitation is one of cheapest process to softening water in easy way. As we know different location has different hardness and chemical mineral in groundwater. Standard categories of hardness of water listed below.

**Table -1:** Standard categories of hardness of water

| Sr. no. | Hardness range(mg/l) | Degree of hardness |
|---|---|---|
| 1. | 0-50 | Soft |
| 2. | 50-100 | Moderately soft |
| 3. | 100-200 | Moderately hard |
| 4. | 200-300 | Hard |
| 5. | >300 | Very hard |

### 1.1 Softening Methods

Surface water hardly exceed hardness level above 200 mg/1 and softening is not at all required in most of the cases, unless the water is being polluted by some effluent sources. However, in case of groundwater, hardness level more than 1000 mg/1 are quite common. Since, softer water is corrosive, hence public water supply are usually not softened below 30 to 50 mg/1. The most accepted and commonly used water softening methods are precipitation and cat ion exchange. In order to obtain maximum profit, the factors tobe considered are the choice of a softening process, the raw water quality, the end use of the softened water, the cost of softening chemicals and the ways and cost of disposing of waste streams.

Precipitation methods The principle behind the precipitation method is to bind calcium cat ions Ca and magnesium cat ions Mg , with ions of $CO_3$ and OH . The precipitate $CaC0_3$ and $Mg(OH)_2$ thus formed are removed from the water. Quick lime CaO, slaked lime $Ca(OH)_2$ , soda ash $NaC0_3$ and sodium hydroxide (caustic soda) NaOH, are commonly used reagents in water softening. Depending upon the quality of initial water, the following main precipitation methods are distinguished. a) Lime softening b) Lime - Soda softening c) Sodium Hydroxide softening

Lime affects the carbonate hardness (alkalinity) and therefore can be practiced in order to decrease the carbonate hardness of the initial water. This method does not result in deep softening. Magnesium is removed from water if sufficient excess of OH" are present. Water dissolved carbon dioxide is removed, total solids in the treated water diminishes and the total hardness in the lime treated water also decreases. But the pH increases to 10 or beyond. When lime is added to the hard water following reactions occurs, In the above reactions, downward arrows indicate the insoluble products.

**Lime Addition:-**

| Hardness | | Lime | | Precipitate |
|---|---|---|---|---|
| $CO_2$ | + | $Ca(OH)_2$ | -- > | $CaCO_3 + H_2O$ |
| $Ca(HCO_3)_2$ | + | $Ca(OH)_2$ | -- > | $2CaCO_3 + 2H_2O$ |
| $Mg(HCO_3)_2$ | + | $Ca(OH)_2$ | -- > | $CaCO_3 + MgCO_3 + 2H_2O$ |
| $MgCO_3$ | + | $Ca(OH)_2$ | -- > | $CaCO_3 + Mg(OH)_2$ |

$CO_2$ does not contribute to the hardness, but It reacts with the lime, and therefore uses up some lime before the lime can start removing the hardness.

Lime - Soda softening method is commonly practiced in most of the Public water supply. (Belan1984) The method is universal because waters of almost any composition may be treated with lime and soda. In this treatment, two reagents are being used namely lime and soda ash. Lime as discussed earlier, decreases the carbonate hardness, ($Mg^{2+}$) and removes $C0_2$ from the water. Soda on the other hand reduces the non - carbonate hardness, mainly due to $Ca^{2+}$, that showed after the liming and the reaction occurs after the addition of soda ash is as follows.

**Lime and Soda ash Addition:-**

| | | Lime | | Precipitate |
|---|---|---|---|---|
| $MgSO_4$ | + | $Ca(OH)_2$ | -- > | $Mg(OH)_2 + CaSO_4$ |
| | | Soda ash | | Precipitate |
| $CaSO_4$ | + | $Na_2CO_3$ | -- > | $CaCO_3 + Na_2SO_4$ |

## 2. METHODOLOGY

### 2.1 Study Area

In this study Samples were taken from different zones of surat city which contain high amount of hardness and different sampling point of different zones of surat city are (1) Makna village (2) Varchha (3) Udhna (4) Ved .Ground water samples were collected from bore well three times in summer season.

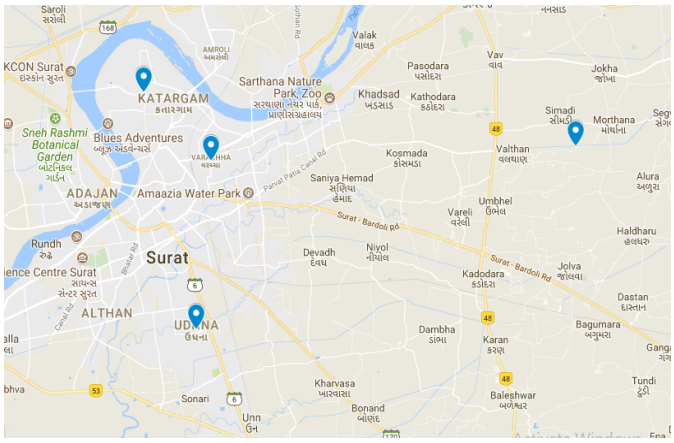


**Figure-1:** Map of Surat city showing different sampling point


**Figure-2:** Zones of Surat city

In the present study three types of treatment were performed on hard water

viz, 1) Lime solution 2) Lime-Soda solution.

Samples were first analyzed by EDTA method for measuring initial hardness then Jar test was performed for giving treartment to the sample water for hardness removal. Procedure for jar test and EDTA method are explained below.

**Jar test**: Jar test is a laboratory procedure where varying dosages of alum are tested in a series of glass or plastic jars under identical conditions. An experiment performed by jar test on the water sample which is done by following steps:

1. Determine the pH of the raw water sample.

2. Place 1 liter of raw water in each of the three beakers of the laboratory stirrer. Immerse blades and stir the raw water samples at about 100 rpm.

3. Add lime solution into each of the beaker to obtain the desired concentrations in the raw water samples.

4. Let the samples mix at approx. 100 rpm for 1minute, then decrease the speed to approx. 30 rpm. Allow the sample to mix for a period of 10 minutes. Observe any changes in the suspended matter in the sample.

5. At the end of the mixing period, turn off the stirrer, let the flocs settle (at least 20 minutes) and carefully remove the supernatant from each beaker and filter out samples through Whatman paper 42. Determine the pH of each treated water sample.

6. Measure the hardness of the samples and find minimum lime dose to remove hardness.

**EDTA method for determination of Hardness**

1. Pipette 100 mL of water sample after jar test and transfer it to a clean 250mL conical flask.

2. Add 1mL of Ammonia buffer solution to the water sample so that the pH will be maintained between 9 and 10.

3. Add few drops of EBT indicator to the conical flask and the sample turns to wine red in color.

4. Titrate the sample against the EDTA solution in the burette till all calcium and magnesium ions present in the sample reacts with the EDTA. The appearance of blue colour indicates that all Ca & Mg ions are complexed with EDTA and forms a metal EDTA complex i.e., the end point of the titration.

5. Do same procedure after boiling 100ml vol. of sample it will give permanent hardness of sample.

Hardness of given water sample will be found out by following formula.

TotalHardness

$$= \frac{\text{final burette reading} - \text{initial burette reading}}{\text{Volume of sample}} \times 1000$$

**Treatment 1:** In treatment 1 different samples of 500 ml of bore water were taken to beaker and adding optimum dose of lime and soda ash of stock solution (1% solution) were added as a same concentration**.** Then jar test was conducted. After completing jar test samples were filtered through filter paper than hardness were analyzed by EDTA method. Table 1 shows Initial hardness of different zone of Surat city ground water sample. Figure 3 shows Optimum dosing of lime and soda ash and removal of hardness after treatment.

**Treatment 2:** In treatment 2 different samples of 500 ml of bore water was taken to beaker and adding optimum dose of lime and soda ash of stock solution (1% solution) were added as different concentration**.** Then jar test was conducted. After completing jar test samples were filtered through filter paper than hardness were analyzed by EDTA method. Table 1 shows Initial hardness of different zone of Surat city ground water sample .Figure 4 shows Optimum dosing of lime and soda ash and removal of hardness after treatment.

**Treatment 3** In treatment 3 different samples of 500 ml of bore water was taken to beaker and adding optimum dose of lime of stock solution (1% solution) were added as different concentration**.** Then jar test was conducted. After completing jar test samples were filtered through filter paper than hardness were analyzed by EDTA method. Table 1 shows Initial hardness of different zone of Surat city ground water sample. Figure 5 shows Optimum dosing of lime and removal of hardness after treatment.

## 3. RESULT

**Table -2:** Initial Hardness of different water sample

| Sr. no. | Sample description | Avg.Total hardness (mg/l) |
|---|---|---|
| 1. | Makna | 468 |
| 2. | Varachha | 489 |
| 3. | Udhana | 535 |
| 4. | Vedroad | 510 |

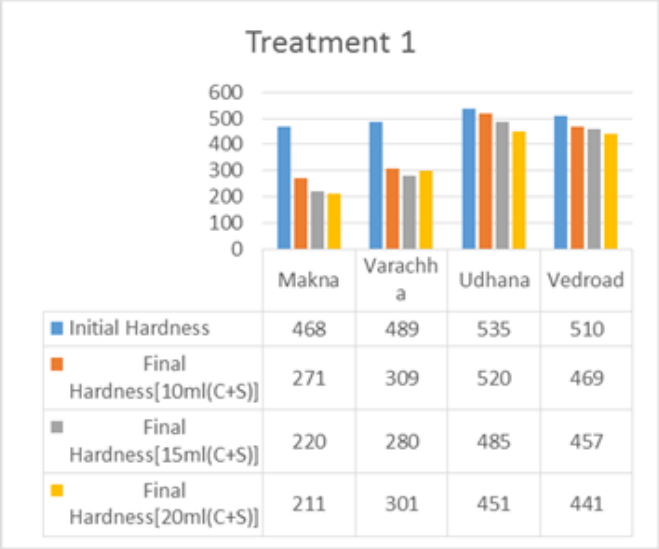


**Figure-3:** Comparison of hardness level before and after the treatment (1) of different water sample

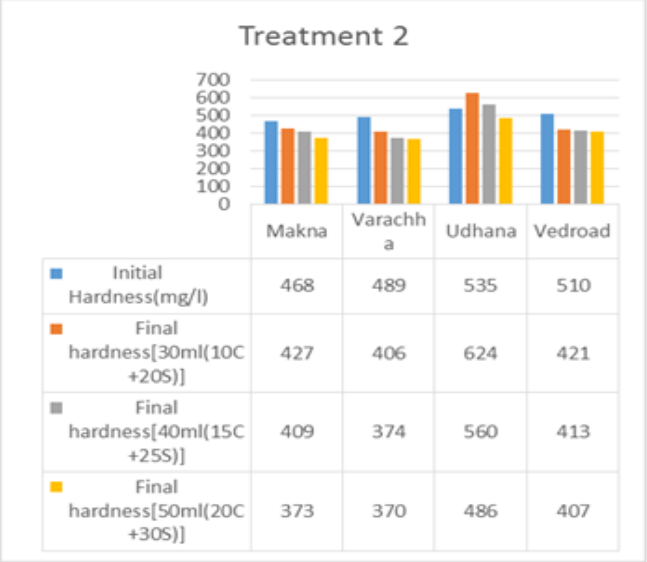


**Figure-4:** Comparison of hardness level before and after the treatment (2) of different water sample

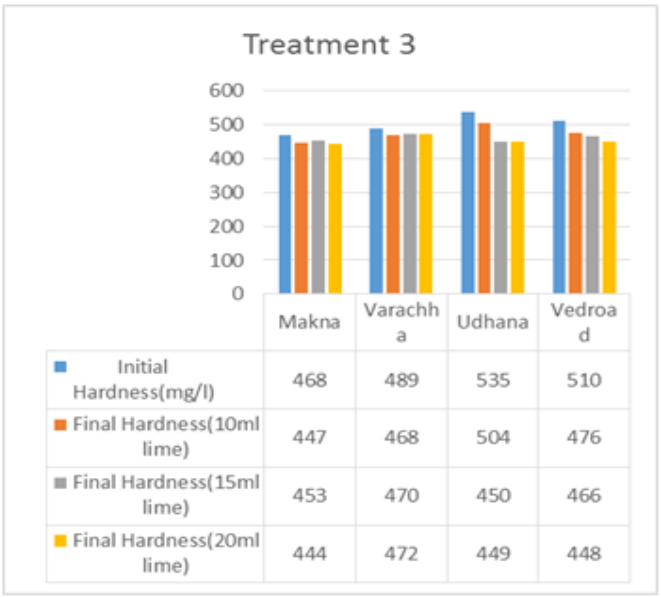


**Figure-5:** Comparison of hardness level before and after the treatment (3) of different water sample

## 4. CONCLUSION

After analysis of different ground water after treatment of softening we observed that in treatment 1 with optimum dose of same concentration of lime and soda ash removal of hardness is maximum of 50.91 percent. As comparing in treatment 2 the removal of hardness by optimum dose of lime and soda ash with different concentration gave maximum hardness removal of 24.34 percent. In treatment 3 adding of optimum lime dose for maximum hardness removal is maximum of 12 percent. As we increase the dose of lime and soda ash maximum hardness will remove by lime soda process as comparing with only lime dosage. Comparing the treatment 1 and 2, the same concentration of lime and soda ash gave better results in removing total hardness. Hardness is caused by polyvalent metallic ions dissolved in water, which in natural water are principally magnesium and calcium. So the adverse effects of such hard water are i. Soap consumption by hard water cause economic loss to water, ii. $MgSO_4$ has laxative effects in person unaccustomed to it, iii. Precipitation by hard water adhere to the surface of tubs and sinks and may stain clothing, dishes and other items. Determination of quality and type hardness of raw water is a must prior to the selection of softening method. Proper selection of method reduces expenditure as well as provides desirable quality of water. However all the methods are suitable depending on the quality of Groundwater.

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