International Journal of Scientific Research & Engineering Trends
Volume 4, Issue 5, Sept-Oct-2018, ISSN (Online): 2395-566X

# Removal of Calcium and Magnesium ions from Ground Water in the Jaffna Peninsula, Sri Lanka by using Chemically Modified Rice Husk

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*Abstract* - **Water hardness due to the calcium and magnesium ions in groundwater have been a devastating effect to the freshwater in the dry zone in Sri Lanka, mainly in the Jaffna peninsula. Jaffna peninsula depends on ground water as there are no other freshwater sources and the rain fall is not sufficient. Study on the removal of calcium and magnesium ions using rice husk (RH) as a low-cost adsorbent was investigated in groundwater of calcium and magnesium ions in the Jaffna peninsula, Sri Lanka. This study was conducted to evaluate the ground water quality and removal of hardness. Fifteen wells were selected in different regions in Jaffna peninsula for ground water samplings. Impact of operational conditions, such as the dosage amount of rice husk and contact time were analyzed for chemically modified rice husk. Here we used HCl and NaOH to modifying the rich husk by chemically at pH 4 and pH 8 respectively. Statistical analysis revealed that the highest removal of $Ca^{2+}$ and $Mg^{2+}$ ions are at pH 4, adsorbent dosage 10 g/L water and 30 minutes of settling time.**

*Keywords* - **Chemically modification, Ground water quality, Rice husk (RH), Total hardness .etc**

## I.INTRODUCTION

The Jaffna peninsula is situated at a longitude of 75˚45′- 80˚20′ and east latitude of 9˚30′- 9˚50′ north, it is surrounded by the sea (Palks straight) on its western, northern and eastern sides and by the Jaffna lagoon in the south.Hard water contains a high content of calcium and magnesium and it is formed when water penetrates through deposits of limestone hard rock. The northern part of Sri Lanka mainly consist the limestone deposits where the water is stored as underground water [1].

In Jaffna peninsula, groundwater is the main drinking water resource. Ground water in Jaffna is widely distributed, but its quantity, quality and availability differ from place to place on climate, rock type and geological structure. Ground water recharge is viewed as a function of effective rainfall. In Jaffna peninsula, this occurs only during the annual monsoon rainfall; i.e. from September to January.

While about 10-15% of rainwater runs off and about 40-48% is lost by evaporation, only 30-32% of the rainfall is left over, for ground water recharge [2]. Calcium and magnesium ions dispersed from the limestone into the ground water system. Hard water is associated with the problems in industries as well as in domestic uses such as laundering, bathing, dishwashers and solar heating system [3].

The excess amount of calcium is associated with kidney stone disease in the human body [4]. To access safe and good quality water, the hard water softening is important in this region. Various methods have been used to remove hardness such as adding $Na_2CO_3$, ion exchange, reverse osmosis and biosorption[5]. Nowadays, agricultural waste materials are getting a wide exposure to the future generation of the material science world.

Rice husk (RH) is one of them, and its global production is approximately 140 million tons per year. The effectiveness of chemically modified RH which are cheaply available in most of the countries for the removal of $Ca^{2+}$ and $Mg^{2+}$from groundwater. The main objective was to examine the possibility of using modified RH to remove $Ca^{2+}$ and $Mg^{2+}$ from groundwater and chemical modification of rice husk to increase the efficiency of removal of $Ca^{2+}$ and $Mg^{2+}$ from the water.

Ground water recharge is the amount of surface rainwater, which reaches the water level by percolation, and it is viewed as a function of effective rainfall, since predisposition is irregular and unreliable.

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International Journal of Scientific Research & Engineering Trends
Volume 4, Issue 5, Sept-Oct-2018, ISSN (Online): 2395-566X

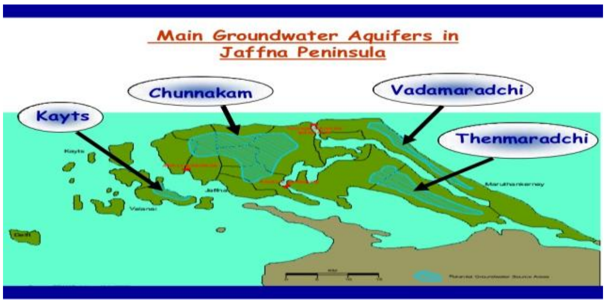


Fig.1 Ground water source areas of the Jaffna peninsula (Source: International Water Management Institute).

## II.METHODOLOGY

RH was collected and it was washed several times. This process was repeated at least four times until all the apparent excess material was removed from the rice husks. The cleaned, wet rice husks were dried in the oven at 105° C for 24 hours. The larger cleaned rice husks particles were stored in plastic bottles and kept air tight to avoid absorption of moisture from the atmosphere. These prepared rice husks were used for the experiments. Water samples were taken from prevailing 15wells which are being used by the residents. Initial concentrations of $Ca^{2+}$ and $Mg^{2+}$which present in the collected groundwater samples were analyzed by titration method. For this purpose, EDTA was used.

**1.Determination of the total amount of calcium and magnesium ions-**10.0 mL of aliquots of the sample solution was pipetted. 2.0 mL buffer solution (pH=10), 2 drops of Eriochrome Black T and 1 mL of masking reagent (KCN) were added. It was titrated against standard EDTA solution.

**2. Determination of amount of calcium ion in the presence of magnesium ion-**10.0 mL of aliquots of the sample solution was pipetted. Then 1 mL of KOH (8M) was added. The resulting solution was allowed to stand for 5 minutes. Then 1 mL of masking reagent (KCN) and 2 drops of Patton Reeder's were added. It was titrated against EDTA solution.

**3. Optimization of experimental conditions-**Rice husk was chemically modified by using HCl and NaOH for pH 4 and 8 respectively. Various dosage amounts of rice husk (2.5 g/L, 5.0 g/L, 7.5 g/L and 10.0 g/L water)were examined at pH 4 and 8 with the 30 minutes of contact time, and different settling times (10, 20 and 30 minutes) were examined at pH 4 and 8 with the rice husk dosage of 10.0 g/L water.

## III. RESULTS AND DISCUSSION

**1. Effect of dosage of adsorbent-**

Table 1 Removal of $Ca^{2+}$ from different Water Samples using different Doses of Rice Husk (RH) at pH 4.

| Water Samples | Initial Concentration of $Ca^{2+}$ ion (ppm) | Final Concentration of $Ca^{2+}$ ion (ppm) | | | | $Ca^{2+}$ Removal Efficiency (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RH dose 2.5 g/L water | RH dose 5.0 g/L water | RH dose 7.5 g/L water | RH dose 10.0 g/L water | RH dose 2.5 g/L water | RH dose 5.0 g/L water | RH dose 7.5 g/L water | RH dose 10.0 g/L water |
| 01. | 254.4 | 230 | 209.06 | 189.27 | 156.30 | 9.59 | 17.85 | 25.60 | 38.56 |
| 02. | 75.8 | 70.2 | 63.17 | 57.19 | 45.38 | 7.38 | 16.65 | 24.55 | 40.12 |
| 03. | 69.8 | 63.5 | 58.08 | 51.55 | 41.71 | 9.03 | 16.78 | 26.14 | 40.25 |
| 04. | 111.2 | 102.5 | 92.46 | 80.95 | 67.14 | 7.82 | 16.85 | 27.20 | 39.62 |
| 05. | 114.8 | 105.04 | 95.34 | 85.50 | 70.60 | 8.50 | 16.95 | 25.52 | 38.50 |
| 06. | 98.3 | 89.73 | 82.03 | 73.41 | 60.70 | 8.71 | 16.55 | 25.32 | 38.25 |
| 07. | 63.2 | 58.28 | 52.72 | 47.40 | 37.13 | 7.79 | 16.58 | 25.00 | 41.24 |
| 08. | 69.2 | 63.76 | 57.95 | 52.14 | 40.13 | 7.85 | 16.25 | 24.65 | 42.00 |
| 09. | 104.0 | 95.70 | 86.08 | 75.34 | 63.48 | 7.98 | 17.23 | 27.55 | 38.96 |
| 10. | 124.0 | 114.65 | 103.54 | 91.16 | 74.59 | 7.54 | 16.50 | 26.48 | 39.84 |

International Journal of Scientific Research & Engineering Trends
Volume 4, Issue 5, Sept-Oct-2018, ISSN (Online): 2395-566X

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| 11. | 187.0 | 171.57 | 155.39 | 137.27 | 111.73 | 8.25 | 16.90 | 26.59 | 40.25 |
| 12. | 75.0 | 68.58 | 61.61 | 56.01 | 44.76 | 8.56 | 17.85 | 25.32 | 40.32 |
| 13. | 93.2 | 85.44 | 76.87 | 69.30 | 55.38 | 8.32 | 17.52 | 25.64 | 40.57 |
| 14. | 97.2 | 88.01 | 80.92 | 70.71 | 57.92 | 9.45 | 16.74 | 27.25 | 40.41 |
| 15. | 103.2 | 93.66 | 86.22 | 77.15 | 62.07 | 9.24 | 16.45 | 25.24 | 39.85 |

Table 2 Removal of $Ca^{2+}$ from different Water Samples using different Doses of Rice Husk (RH) at pH 8.

| Water Samples | Initial Concentration of $Ca^{2+}$ ion (ppm) | Final Concentration of $Ca^{2+}$ ion (ppm) | | | | $Ca^{2+}$ Removal Efficiency (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RH dose 2.5 g/L water | RH dose 5.0 g/L water | RH dose 7.5 g/L water | RH dose 10.0 g/L water | RH dose 2.5 g/L water | RH dose 5.0 g/L water | RH dose 7.5 g/L water | RH dose 10.0 g/L water |
| 01. | 254.4 | 242.79 | 222.39 | 207.23 | 183.44 | 4.56 | 12.58 | 18.54 | 27.89 |
| 02. | 75.8 | 72.17 | 66.36 | 61.41 | 54.68 | 4.78 | 12.45 | 18.98 | 27.85 |
| 03. | 69.8 | 66.38 | 61.17 | 56.95 | 49.59 | 4.89 | 12.36 | 18.40 | 28.95 |
| 04. | 111.2 | 105.91 | 97.25 | 90.35 | 80.67 | 4.75 | 12.54 | 18.75 | 27.45 |
| 05. | 114.8 | 109.11 | 100.43 | 93.38 | 82.80 | 4.95 | 12.51 | 18.65 | 27.87 |
| 06. | 98.3 | 93.17 | 85.66 | 79.92 | 70.24 | 5.21 | 12.85 | 18.69 | 28.54 |
| 07. | 63.2 | 60.34 | 55.33 | 51.52 | 45.34 | 4.52 | 12.45 | 18.48 | 28.25 |
| 08. | 69.2 | 66.04 | 60.50 | 55.98 | 49.37 | 4.56 | 12.56 | 19.10 | 28.65 |
| 09. | 104.0 | 99.13 | 90.70 | 84.91 | 74.31 | 4.68 | 12.78 | 18.35 | 28.54 |
| 10. | 124.0 | 118.09 | 107.75 | 101.37 | 89.92 | 4.76 | 13.10 | 18.25 | 27.48 |
| 11. | 187.0 | 177.20 | 163.49 | 170.28 | 135.42 | 5.24 | 12.57 | 18.40 | 27.58 |
| 12. | 75.0 | 71.09 | 65.26 | 60.76 | 53.51 | 5.21 | 12.98 | 18.94 | 28.65 |
| 13. | 93.2 | 88.40 | 81.41 | 75.79 | 67.43 | 5.14 | 12.64 | 18.67 | 27.65 |
| 14. | 97.2 | 92.29 | 84.95 | 78.73 | 70.00 | 5.05 | 12.60 | 19.05 | 27.98 |
| 15. | 103.2 | 98.25 | 89.64 | 84.32 | 74.84 | 4.79 | 13.13 | 18.29 | 27.48 |

Table 3 Removal of $Mg^{2+}$ from different Water Samples using different Doses of Rice Husk (RH) at pH4

| Water Samples | Initial Concentration of $Mg^{2+}$ ion (ppm) | Final Concentration of $Mg^{2+}$ ion (ppm) | | | | $Mg^{2+}$ Removal Efficiency (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RH dose 2.5 g/L water | RH dose 5.0 g/L water | RH dose 7.5 g/L water | RH dose 10.0 g/L water | RH dose 2.5 g/L water | RH dose 5.0 g/L water | RH dose 7.5 g/L water | RH dose 10.0 g/L water |
| 01. | 7.72 | 7.29 | 6.76 | 6.00 | 5.38 | 5.56 | 12.43 | 22.27 | 30.31 |

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|---|---|---|---|---|---|---|---|---|---|
| 02. | 4.84 | 4.56 | 4.17 | 3.76 | 3.32 | 5.78 | 13.84 | 22.31 | 31.40 |
| 03. | 1.44 | 1.35 | 1.24 | 1.11 | 0.98 | 6.25 | 13.88 | 22.91 | 31.94 |
| 04. | 15.62 | 14.74 | 13.55 | 12.00 | 10.73 | 5.63 | 13.25 | 23.18 | 31.30 |
| 05. | 12.44 | 11.72 | 10.78 | 9.64 | 8.46 | 5.78 | 13.34 | 22.50 | 31.99 |
| 06. | 13.74 | 12.90 | 11.86 | 10.65 | 9.25 | 6.11 | 13.68 | 22.49 | 32.68 |
| 07. | 27.92 | 26.27 | 24.22 | 21.58 | 18.85 | 5.90 | 13.25 | 22.71 | 32.49 |
| 08. | 10.56 | 9.93 | 9.09 | 8.19 | 7.23 | 5.97 | 13.92 | 22.44 | 31.53 |
| 09. | 8.89 | 8.39 | 7.73 | 6.82 | 6.09 | 5.62 | 13.05 | 23.28 | 31.49 |
| 10. | 19.68 | 18.58 | 17.22 | 15.18 | 13.21 | 5.59 | 12.50 | 22.87 | 32.88 |
| 11. | 23.76 | 22.41 | 20.53 | 18.37 | 16.00 | 5.68 | 13.59 | 22.69 | 32.66 |
| 12. | 24.70 | 23.27 | 21.29 | 19.09 | 16.67 | 5.79 | 13.80 | 22.71 | 32.51 |
| 13. | 25.25 | 23.74 | 21.72 | 19.59 | 16.99 | 5.98 | 13.98 | 22.42 | 32.71 |
| 14. | 5.86 | 5.50 | 5.11 | 4.49 | 4.01 | 6.14 | 12.80 | 23.38 | 31.57 |
| 15. | 14.35 | 13.52 | 12.45 | 11.11 | 9.67 | 5.78 | 13.24 | 22.58 | 32.61 |

Table 4 Removal of $Mg^{2+}$ from different Water Samples using different Doses of Rice Husk (RH) at pH 8.

Observation of the below 4 Tables (Table: 1, 2, 3 and 4) reveal that the removal of hardness ions increased with increasing dosage amount of rice husk. Here we observe the maximum removal efficiency of calcium and magnesium ions which is around 40% and 30% at pH 4 respectively and around 28% and 26% at pH 8 respectively.

Therefore, we infer that removal efficiency increases as the dosage increases due to the greater surface area available for the sample for adsorption.

| Water Samples | Initial Concentration of $Mg^{2+}$ ion (ppm) | Final Concentration of $Mg^{2+}$ ion (ppm) | | | | $Mg^{2+}$ Removal Efficiency (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RH dose 2.5 g/L water | RH dose 5.0 g/L water | RH dose 7.5 g/L water | RH dose 10.0 g/L water | RH dose 2.5 g/L water | RH dose 5.0 g/L water | RH dose 7.5 g/L water | RH dose 10.0 g/L water |
| 01. | 7.72 | 7.46 | 7.06 | 6.36 | 5.66 | 3.36 | 8.54 | 17.61 | 27.97 |
| 02. | 4.84 | 4.68 | 4.41 | 3.95 | 3.55 | 3.30 | 8.88 | 18.38 | 26.65 |
| 03. | 1.44 | 1.39 | 1.31 | 1.18 | 1.06 | 3.47 | 9.03 | 18.05 | 26.39 |
| 04. | 15.62 | 15.15 | 14.34 | 12.88 | 11.38 | 3.01 | 8.19 | 17.54 | 27.14 |
| 05. | 12.44 | 12.06 | 11.31 | 10.24 | 9.13 | 3.05 | 9.08 | 17.68 | 26.60 |
| 06. | 13.74 | 13.36 | 12.51 | 11.22 | 10.04 | 2.77 | 8.95 | 18.34 | 26.93 |
| 07. | 27.92 | 27.04 | 25.50 | 22.82 | 20.39 | 3.15 | 8.67 | 18.26 | 26.97 |
| 08. | 10.56 | 10.18 | 9.62 | 8.69 | 7.77 | 3.59 | 8.89 | 17.71 | 26.42 |

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Volume 4, Issue 5, Sept-Oct-2018, ISSN (Online): 2395-566X

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| 09. | 8.89 | 8.56 | 8.09 | 7.30 | 6.47 | 3.71 | 9.00 | 17.88 | 27.22 |
| 10. | 19.68 | 19.04 | 17.97 | 16.23 | 14.56 | 3.25 | 8.69 | 17.53 | 26.01 |
| 11. | 23.76 | 23.13 | 21.60 | 19.55 | 17.53 | 2.65 | 9.09 | 17.72 | 26.22 |
| 12. | 24.70 | 23.82 | 22.64 | 20.20 | 18.21 | 3.56 | 8.34 | 18.22 | 26.27 |
| 13. | 25.25 | 24.27 | 23.04 | 20.69 | 18.62 | 3.88 | 8.75 | 18.06 | 26.26 |
| 14. | 5.86 | 5.69 | 5.35 | 4.80 | 4.28 | 2.90 | 8.70 | 18.09 | 26.96 |
| 15. | 14.35 | 13.92 | 13.08 | 11.81 | 10.53 | 2.99 | 8.85 | 17.70 | 26.62 |

**2. Effect of contact time-**

Table 5 Removal of $Ca^{2+}$ from different Water Samples using different Contact Time with Rice Husk (RH) at pH 4.

| Water Samples | Initial Concentration of $Ca^{2+}$ ion (ppm) | Final Concentration of $Ca^{2+}$ ion (ppm) | | | $Ca^{2+}$ Removal Efficiency (%) | | |
|---|---|---|---|---|---|---|---|
| | | Contact time 10 minutes | Contact time 20 minutes | Contact time 30 minutes | Contact time 10 minutes | Contact time 20 minutes | Contact time 30 minutes |
| 01. | 254.4 | 191.43 | 184.44 | 159.00 | 24.75 | 27.50 | 37.50 |
| 02. | 75.8 | 57.19 | 55.03 | 47.14 | 24.55 | 27.40 | 37.80 |
| 03. | 69.8 | 52.59 | 50.70 | 43.59 | 24.65 | 27.36 | 37.55 |
| 04. | 111.2 | 27.35 | 80.45 | 69.11 | 24.60 | 27.65 | 37.85 |
| 05. | 114.8 | 86.32 | 83.18 | 71.24 | 24.80 | 27.54 | 37.94 |
| 06. | 98.3 | 74.46 | 71.64 | 61.81 | 24.25 | 27.12 | 37.12 |
| 07. | 63.2 | 47.84 | 45.81 | 39.55 | 24.30 | 27.51 | 37.42 |
| 08. | 69.2 | 52.34 | 50.44 | 43.28 | 24.36 | 27.10 | 37.45 |
| 09. | 104.0 | 78.70 | 75.67 | 65.37 | 24.32 | 27.24 | 37.14 |
| 10. | 124.0 | 94.38 | 90.29 | 78.05 | 23.88 | 27.18 | 37.05 |
| 11. | 187.0 | 142.21 | 134.75 | 116.35 | 23.95 | 27.94 | 37.78 |
| 12. | 75.0 | 56.92 | 54.11 | 47.28 | 24.10 | 27.85 | 36.96 |
| 13. | 93.2 | 70.60 | 67.44 | 57.80 | 24.24 | 27.63 | 37.98 |
| 14. | 97.2 | 73.38 | 70.62 | 60.61 | 24.50 | 27.34 | 37.64 |
| 15. | 103.2 | 78.30 | 75.11 | 64.13 | 24.12 | 27.21 | 37.85 |

Table 6 Removal of $Ca^{2+}$ from different Water Samples using different Contact Time with Rice Husk (RH) at pH 8.

| Water Samples | Initial Concentration of $Ca^{2+}$ ion (ppm) | Final Concentration of $Ca^{2+}$ ion (ppm) | | | $Ca^{2+}$ Removal Efficiency (%) | | |
|---|---|---|---|---|---|---|---|
| | | Contact 10 minutes | Contact time 20 minutes | Contact time 30 minutes | Contact time 10 minutes | Contact time 20 minutes | Contact time 30 minutes |
| 01. | 254.4 | 206.7 | 197.79 | 165.99 | 18.75 | 22.25 | 34.75 |

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|---|---|---|---|---|---|---|---|
| 02. | 75.8 | 61.62 | 59.16 | 50.14 | 18.70 | 21.95 | 33.85 |
| 03. | 69.8 | 56.57 | 54.19 | 45.96 | 18.95 | 22.35 | 34.15 |
| 04. | 111.2 | 90.68 | 86.58 | 73.39 | 18.45 | 22.14 | 34.00 |
| 05. | 114.8 | 94.15 | 89.49 | 74.90 | 17.98 | 22.04 | 34.75 |
| 06. | 98.3 | 81.17 | 77.12 | 64.64 | 17.42 | 21.54 | 34.24 |
| 07. | 63.2 | 52.20 | 49.56 | 41.17 | 17.40 | 21.58 | 34.85 |
| 08. | 69.2 | 56.98 | 53.52 | 45.70 | 17.65 | 22.65 | 33.95 |
| 09. | 104.0 | 85.85 | 80.10 | 69.05 | 17.45 | 22.98 | 33.60 |
| 10. | 124.0 | 102.52 | 95.55 | 81.65 | 17.32 | 22.94 | 34.15 |
| 11. | 187.0 | 154.55 | 144.27 | 81.54 | 17.35 | 22.85 | 34.24 |
| 12. | 75.0 | 61.89 | 57.97 | 49.35 | 17.48 | 22.70 | 34.20 |
| 13. | 93.2 | 76.46 | 72.27 | 61.40 | 17.96 | 22.45 | 34.12 |
| 14. | 97.2 | 79.70 | 75.18 | 63.95 | 18.00 | 22.65 | 34.20 |
| 15. | 103.2 | 85.14 | 80.00 | 67.82 | 17.50 | 22.48 | 34.28 |

Table 7 Removal of $Mg^{2+}$ from different Water Samples using different Contact Time with Rice Husk (RH) at pH 4.

| Water Samples | Initial Concentration of $Mg^{2+}$ ion (ppm) | Final Concentration of $Mg^{2+}$ ion (ppm) | | | $Mg^{2+}$ Removal Efficiency (%) | | |
|---|---|---|---|---|---|---|---|
| | | Contact time 10 minutes | Contact time 20 minutes | Contact time 30 minutes | Contact time 10 minutes | Contact time 20 minutes | Contact time 30 minutes |
| 01. | 7.72 | 6.82 | 6.63 | 6.18 | 11.66 | 14.12 | 19.94 |
| 02. | 4.84 | 4.29 | 4.13 | 3.87 | 11.36 | 14.67 | 20.04 |
| 03. | 1.44 | 1.26 | 1.23 | 1.15 | 12.50 | 14.58 | 20.14 |
| 04. | 15.62 | 13.83 | 13.38 | 12.48 | 11.45 | 14.34 | 20.10 |
| 05. | 12.44 | 11.01 | 10.69 | 9.95 | 11.50 | 14.07 | 20.02 |
| 06. | 13.74 | 12.09 | 11.78 | 10.97 | 12.00 | 14.25 | 20.16 |
| 07. | 27.92 | 24.69 | 24.02 | 22.25 | 11.57 | 13.95 | 20.30 |
| 08. | 10.56 | 9.34 | 9.09 | 8.50 | 11.55 | 13.92 | 19.50 |
| 09. | 8.89 | 7.86 | 7.61 | 7.12 | 11.58 | 14.40 | 19.91 |
| 10. | 19.68 | 17.42 | 16.86 | 15.68 | 11.48 | 14.32 | 20.32 |
| 11. | 23.76 | 20.94 | 20.31 | 18.97 | 11.85 | 14.50 | 20.15 |
| 12. | 24.70 | 21.82 | 21.15 | 19.84 | 11.65 | 14.36 | 19.65 |
| 13. | 25.25 | 22.41 | 21.74 | 20.16 | 11.23 | 13.90 | 20.15 |

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|---|---|---|---|---|---|---|---|
| 14. | 5.86 | 5.16 | 5.02 | 4.69 | 11.94 | 14.33 | 19.96 |
| 15. | 14.35 | 12.68 | 12.29 | 11.49 | 11.62 | 14.35 | 19.93 |

Table 8 Removal of $Mg^{2+}$ from different Water Samples using different Contact Time with Rice Husk (RH) at pH 8.

| Water Samples | Initial Concentration of $Mg^{2+}$ ion (ppm) | Final Concentration of $Mg^{2+}$ ion (ppm) | | | $Mg^{2+}$ Removal Efficiency (%) | | |
|---|---|---|---|---|---|---|---|
| | | Contact time 10 minutes | Contact time 20 minutes | Contact time 30 minutes | Contact time 10 minutes | Contact time 20 minutes | Contact time 30 minutes |
| 01. | 7.72 | 6.98 | 6.73 | 6.41 | 9.58 | 12.82 | 16.97 |
| 02. | 4.84 | 4.38 | 4.22 | 4.01 | 9.50 | 12.80 | 17.15 |
| 03. | 1.44 | 1.30 | 1.26 | 1.20 | 9.72 | 12.50 | 16.67 |
| 04. | 15.62 | 14.13 | 13.62 | 13.04 | 9.54 | 12.80 | 16.52 |
| 05. | 12.44 | 11.25 | 10.82 | 10.35 | 9.56 | 13.02 | 16.80 |
| 06. | 13.74 | 12.44 | 11.95 | 11.42 | 9.46 | 13.02 | 16.89 |
| 07. | 27.92 | 25.28 | 24.36 | 23.35 | 9.46 | 12.75 | 16.37 |
| 08. | 10.56 | 9.55 | 9.24 | 8.82 | 9.55 | 12.50 | 16.47 |
| 09. | 8.89 | 8.05 | 7.76 | 7.40 | 9.45 | 12.71 | 16.76 |
| 10. | 19.68 | 17.78 | 17.14 | 16.44 | 9.65 | 12.89 | 16.45 |
| 11. | 23.76 | 21.45 | 20.69 | 19.80 | 9.72 | 12.92 | 16.67 |
| 12. | 24.70 | 22.39 | 21.62 | 20.53 | 9.35 | 12.47 | 16.89 |
| 13. | 25.25 | 22.79 | 22.05 | 20.98 | 9.74 | 12.65 | 16.90 |
| 14. | 5.86 | 5.31 | 5.09 | 4.88 | 9.38 | 13.13 | 16.72 |
| 15. | 14.35 | 13.00 | 12.49 | 11.92 | 9.40 | 12.96 | 16.93 |

Also, it can be observed that removal efficiency is maximum when the contact time is maximum, thus providing maximum time for adsorption for the sample. The removal of calcium and magnesium ions which is around 37% and 20% at pH 4 respectively and around 34% and 16% at pH 8 respectively.

**3. Adsorption isotherm studies-**In order to determine the optimize conditions of $Ca^{2+}$ and Mg2+, an analytical study was done on rice husk through isotherm studies. As the pH value of 4 showed the highest removal efficiency, it was selected to conduct this isotherm study. The parameters that were kept constant are the adsorbent dosage (10 g/L) and contact time (30 minutes). Langmuir and Freundlich isotherm models were used to understand the isotherm studies.

Langmuir isotherm: Langmuir isotherm assumes adsorption energies are uniform and independent of surface coverage. Complete coverage of the surface by a monolayer of adsorbate indicates maximum adsorption. The general linear form of Langmuir isotherm is expressed as follows [6],

$$q_e = \frac{(q_m K_a C_e)}{1 + K_a C_e}$$

The above equation can be written as,

$$1/q_e = \left(\frac{1}{K_a q_m}\right)\frac{1}{C_e} + \frac{1}{q_m}$$

Where,

$q_e$- Amount adsorbed at equilibrium (mg/g) $= (C_i - C_e)V/m$ ($C_i$ – initial concentration of adsorbate)

$q_m$- Maximum adsorption capacity of metal ions into adsorbent

International Journal of Scientific Research & Engineering Trends
Volume 4, Issue 5, Sept-Oct-2018, ISSN (Online): 2395-566X

$C_e$ - Equilibrium concentration of adsorbate (unadsorbed ion concentration in solution at equilibrium mg/L)

$K_a$ - Energy of adsorption

The linear plots of $^1/_{q_e}$ Vs $^1/_{C_e}$ and the values of correlation coefficients show that the adsorption obeys Langmuir isotherm model for the rice husk.

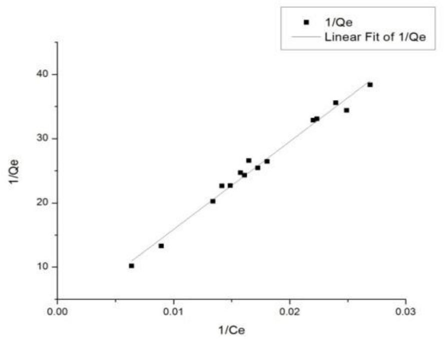


Fig.2 Langmuir isothermal curve for adsorption of $Ca^{2+}$ ions Onto RH at pH 4: contact time= 30 minutes, adsorbent dosage=10.0 g/L

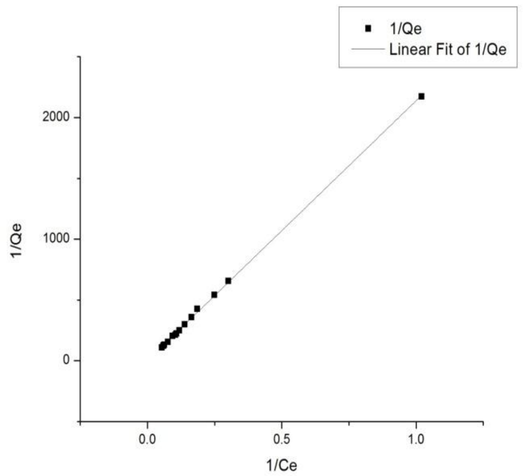


Fig.3 Langmuir isothermal curve for adsorption of $Mg^{2+}$ ions Onto RH at pH 4: contact time= 30 minutes, adsorbent dosage=10.0 g/L.

The values of maximum aads $1/C_e$ capacity of $Ca^{2+}$ ions into RH ($q_m$), energy of adsorption $1/C_e$ and linear correlation coefficient ($R^2$) were found to be 0.4499 mg/g, 0.00163 and 0.98475 respectively. Similarly for $Mg^{2+}$, $q_m$, $K_a$ and $R^2$ were 0.5872 mg/g, 0.0008 and 0.99957 respectively. Freundlich isotherm: The linear form of Freundlich isotherm is expressed as follows,

$$\log q_e = \left(^1/_n\right) \log C_e + \log K$$

Where,

$q_e$ - Amount adsorbed at equilibrium (mg/g)

$C_e$ - Equilibrium concentration of adsorbate (mg/L)

K, n: Freundlich constant The linear plots $\log q_e$ Vs $\log C_e$ and the values of correlation coefficients show that the adsorption obeys Freundlich isotherm model for rice husk.

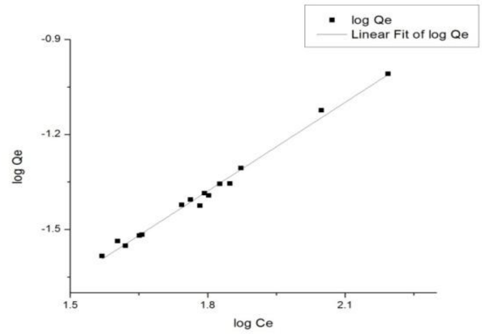


Fig.4 Freundlich isotherm curve for adsorption of $Ca^{2+}$ ions onto RH at pH 4: contact time=30 minutes, adsorbent dose=10.0 g/L

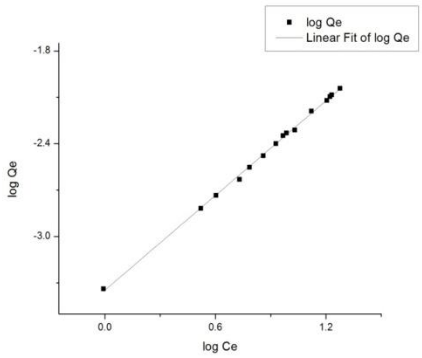


Fig.5 Freundlich isotherm curve for adsorption of Mg2+ ions onto RH at pH 4: contact time=30 minutes, adsorbent dose=10.0 g/L.

Correlation coefficient $R^2$ for $Ca^{2+}$ and $Mg^{2+}$ were 0.98475 and 0.99957 respectively. From these adsorption isotherm studies, the experimental data for the adsorption of calcium and magnesium ions on rice husk provided good fits to both Langmuir and Freundlich isotherm models.

## IV. CONCLUSION

The removal efficiency of Calcium ions found to be higher than Magnesium ions from the ground water. Rice husk has a tendency to adsorb a greater amount of calcium ions in comparison to magnesium ions.Since the rice husk is locally available, then rice husk adsorbents are expected to be economically feasible for removal of hardness from groundwater.Statistical analysis revealed that the highest removal of $Ca^{2+}$ and

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$Mg^{2+}$ ions are at pH 4, adsorbent dosage 10 g/L water and settling time 30 minutes. But, water at pH 4 is not desirable for drinking purpose. Thus, the results suggest that chemically modified rice husk treatment is not useful for softening of drinking water but the technique can be used for other usages which require soft water. In future, we can increase the dosage amount and settling time to remove the high percentage of hardness. And also we can suggest that the analysis for usage of chemically unmodified rice husk for removal of hardness from the groundwater in future.

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