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Optimisation for Lime Soda Ash Water Softening Process with Low-Cost Adsorbent for Reducing the Total Hardness of Water

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ABSTRACT

Lime soda water softening is traditional method. Water hardness can cause many problems including scaling and excessive soap consumption. In present investigation, water softening experiments were conducted to observe the changes in total hardness with varying dosages of lime and soda ash for different time intervals and with use of RHP adsorbent of desired doses. Results indicated that an increase in lime & soda ash dosage with adsorbent caused decrease in total hardness of water samples. For 50 cm3 of synthetic water sample, use of 17.5 cm3 Lime with 12.5 cm3Soda ash dose with 0.500g RHP adsorbent dose gave 58.88% hardness reduction in 1hourin economical way.

Keywords: Water Hardness, Lime, Soda ash, adsorbent, water sample

I. INTRODUCTION

Water is essential for survival of human being. Groundwater is the main source of domestic, industrial and agriculture supplies in many regions of India. There is an increasing demand for groundwater due to surface water quality deteriorationand scarcity in rainfall. Many times, available groundwater is called as hard water, because Calcium (Ca^{+2}) and Magnesium (Mg^{+2}) ions are present in it. Hard water can cause corrosion and silting in industrial operations. Water hardness is a measure of the quantity of divalent ions such as calcium, magnesium and/or iron in water. Water hardness is identified in form of bicarbonates, Chlorides and Sulphates and should be below the BIS standard IS 10500:2012 for drinking water. Currently methods like chemical precipitation using lime, nanofiltration, carbonnanotubes, electrocoagulation etc are available for water softening, but are not suitable because these processesare energy consuming ,expensive and difficult to operate and cause large volumes of sludge. Hard water is very dangerous to human body especially on hair and skin. This gave need of search of environment friendly, low-cost, and low energy processes for water softening. So current investigations include use of lime & soda ash in optimized doses with *Rice Husk Powder*(*RHP*)as an adsorbent .

II. METHODS AND MATERIAL

The EDTA titration method was used to measure the total hardness of the ground water (Kasun T. Samarasiri, 2016) .Quick lime CaO, Slaked lime $Ca(OH)_2$, Soda ash $NaC0_3$ and Sodium hydroxide (NaOH, are common water softening reagents (Kasun T. Samarasiri, 2016).In present investigations, use of Lime & Soda ash combination is studied to reduce water hardness along with use of adsorbent.Different variables studied to optimize the process are given in following table-

Sr no	Variable parameters	Different levels used		
		1	2	3
1	Retention time	30minutes	60minutes	80minutes
2	Lime dose for 50 cm3 Water sample	10cm³	12.5 cm³	17.5 cm³
3	Soda ash dose for 50 cm3 water sample	5 cm³	7.5 cm³	12.5 cm³
4	pH	Neutral	9.6	10.6

Table 1- Different variables used for optimisation of lime sodaprocess

Four different treatments given to synthetic water samples are discussed below-

Treatment 1

In treatment 1, a sample of 50 cm³ synthetic water sample was taken in conical flask and 10 cm³ of lime and 5 cm³ of Sodaash is added and shaken in horizontal viabrator for 30 minutes. Thenit was filtered and the hardness was measured by EDTA titration method. The initial pH value was determined. The initial total hardness of the sample 340 ppm was reduced into 310 ppm after treatment. The percentage reductionof the total hardness is 8.82%.

Treatment 2

In treatment 2, 50cm³ synthetic water sample was taken in conical flask and 12.5cm³ of lime and 17.5 cm³ of soda ash is added to it and shaken in viabrator for 60 minutes.Then it was filtered and the hardness was measured by EDTA titration method.After the treatment,the initial total hardness of the sample is 340 ppm was reduced into 260 ppm .The percentage reductionof the total hardness is 23.53%.Furthur treatment should be given to reduce more water hardness,

Treatment 3

In treatment 3, a sample of 50 cm³ synthetic water sample was taken in conical flask and 17.5cm³ of lime and 12.5 cm³ of soda ash is added to it andis shaken in viabrator for 80 minutes. Thenit was filtered and the hardness was measured by EDTA titration method. The initial pH value was determined. The initial total hardness of the sample is 340ppm and after treatment, was reduced by 200 ppm. The percentage of the total hardness reduction of the treatment 3 was found 47.17%.

Treatment 4-

In treatment 4, sample of 50cm³ synthetic water sample was taken in conical flask and 17.5cm³ of lime and 12.5 cm³ of soda ash and 0.500 gms *RHP* adsorbent (*Rice Husk Powder*) are added and shaken in viabrator for 60 minutes . Then it was filtered and the hardness was measured by EDTA titration method. The initial pH value was determined. The initial total hardness of the sample is 340ppm and after treatment, the hardness was reduced to 150 ppm. It is below desirable level The percentage of the total hardness reduction of the treatment 4 is 55.88%.

Observed graphs for different treatments are as follows-

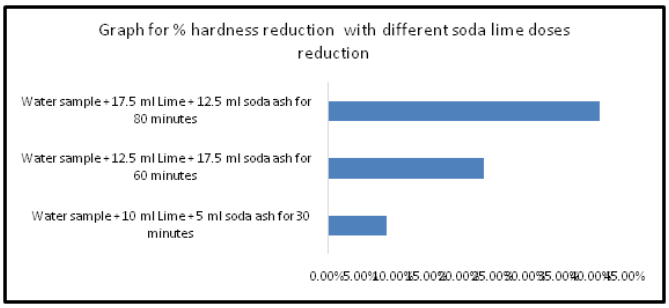

Figure1- Graph showing percent reduction in water hardness with different propotions of sodalime treatment to water sample

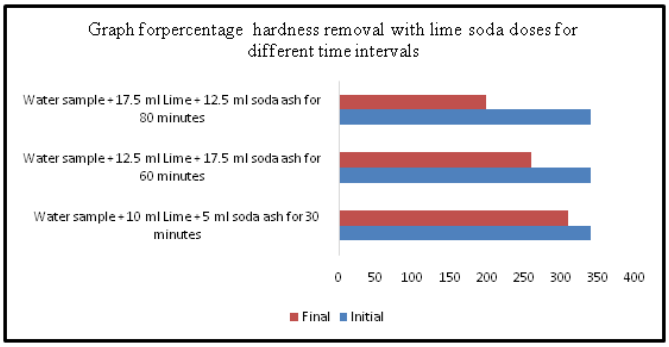

Figure2- Graph showing initial and final percent reductiion in water hardness with different propotions of sodalime treatment to water sample

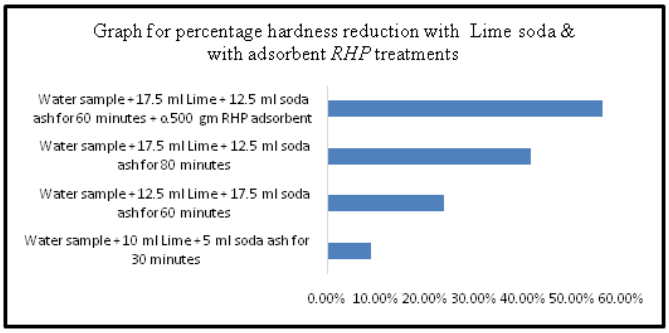

Figure3- Graph showing percent reduction in water hardness with different propotions of sodalime doses treatment to water sample and with 0.500 gms of *RHP* adsorbent .

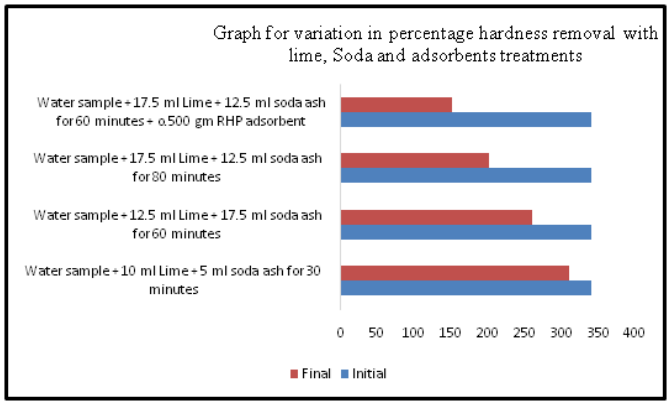

Figure 4- Graph showing initial and final percent reductiion in water hardness with different propotions of sodalime treatment to water sample and with 0.500 gms of *RHP* adsorbent

Similar type of treatments are given to well water by Kusum et, al, in 2016.These lime soda water softening methods are further improvedfor the purification process from different chemical treatments many researchers.

III.RESULTS AND DISCUSSION

The method is universal because waters of almost any composition may be treated with lime and soda.Following table2 shows the findings of four different treatments given to water sample in present investigations.

Sr. No.	Treatment	% Reduction Total Hardness
1	Water sample + 10 cm^3 Lime + 5 cm3 soda ash for 30 minutes	8.82%
2	Water sample + 12.5 cm^3 Lime + 17.5 cm3 soda ash for 60 minutes	23.53%
3	Water sample + 17.5 cm^3 Lime + 12.5 cm3 soda ash for 80 minutes	41.17%
4	Water sample + 17.5 cm^3 Lime + 12.5 cm3 soda ash	55.88%

	for 60 minutes + 0.500 gm RHP adsorbent	

Table2 -The percentage reduction in total hardness forfour different treatments given to water sample.

In this treatment, two reagents are being used namely lime and soda ash. Lime 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. (Darshak Vaniya, 2018)

Lime Precipitate $MgSO_4 + Ca(OH)_2 \text{ -- > } Mg(OH)_2 + CaSO_4$

Soda ash Precipitate $CaSO_4 + Na2CO_3 \text{ -- > } CaCO_3 + Na_2SO_4$

In present investigations, when different ratios of lime & water are used in soda lime process, as quantities of lime and Soda ash are increased, the reduction in water hardness is observed. But at 17.5 cm^3 lime 12.5 cm^3Soda ash with adsorbent is best removal 41.17% in time 80 minutes is observed but with for same dosage of lime & soda with adsorbent 0.500gms reductions is increased to 55.88% in 60 minutes. i.e. use of adsorbent decreased time required for process to 60 minutes due to adsorption process at adsorption sites. Similar results with optimum dose of same concentration of lime and soda ash removal of hardness is reported to maximum of 50.91 percent (Darshak Vaniya, 2018) for removal of ground water hardness.Similar studies were carried out by use *of wheat straw ash (WSA) & Rice Husk ash (RHA)* as adsorbents for removal of water hardness (Hari Lal Kharel, 2016) Similarly *DjamelGhernaout et al*, studied process of combination of liming & alum coagulation with alum for dam water with dosages alum = 15, lime = 100, NaOH = 100 mg/L.((Djamel Ghernaout 1, 2018). Similarly effect of pH was studied on precipitation ((Hari Lal Kharel, 2016). Tyler Smith ,2022 reported that Magnesium removal is not typically required in Florida due to the limited amount of magnesium in most source water (Tyler Smith, 2022).

IV. CONCLUSION

Lime soda water softening is efficient traditional, ecofriendly greener method with selection of proper doses of lime and soda ashes makes desirable quality of water.In present investigation, in watersoftening experiments, varying dosages of lime and soda ash for different time intervals and with use of desired dose of *RHP adsorbent* were successful to reduce the total hardness of water significantly till 55.88%.Resultsindicatedthatanincreaseinlime& soda ash dosage with adsorbent caused a decrease in total hardness of water samples. For 50 cm^3 of synthetic water sample, use of 17.5 cm^3 Lime with 12.5 cm^3 Soda ash dose with 0.500g *RHP* adsorbent dose gave 55.88% hardness reduction in 1hourin an economical way. So optimum conditions for Soda lime process for hardness reduction are-

Sr no	Variable parameters	Optimum to be used
1	Retention time	60 minutes
2	Lime dose	17.5 cm^3
3	Soda ash dose	12.5 cm^3
4	Adsorbent dose	0.500 gm
5	pH	Normal

Table3- Optimum conditions observed for Soda lime process for hardness reduction

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