PROCEEDINGS, 46th Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, February 15-17, 2021
SGP-TR-218

Biodegradable Resin Based Water Softener Technique to Reduce the Scaling Problem in Geothermal Water Flow Lines

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Keywords: scale, geothermal flowlines, biodegradable, flow assurance, Dholera

ABSTRACT

The geothermal water in Gujarat, India consists of large quantities of dissolved salts primarily calcium and magnesium. Over time the scaling caused by these salts decreases the inside diameter of the pipe and increases back pressure on the flow lines, ultimately reducing or stopping the flow. Resin based water softening methods helps in drastically reducing the content of dissolved salts in water, making the water immediately useful for various direct applications as per the Lindal's diagram . The resins are made up of polystyrene and Divinylbenzene (DVB) of diameter 0.3-1.2 mm in the shape of a honey comb. This resins helps in water softening. After multiple softening cycles the beads would get fully covered with salts and would require cleaning/ regeneration. Another unit acts as a regenerator.The resin based softeners are expensive to install and have high maintenance costs. Usage of biodegradable materials such as Algal extracts and seaweeds (Centroceras clavulatum, Enteromorpha flexuosa, Grateloupia lithophila, Enteromorpha intestinalis etc. varieties) can help in overcoming the disadvantages of this process. These materials give excellent reduction in hardness in the leather industry and can be utilized successfully as the water softener as well. The method has been discussed in this study.

1. INTRODUCTION

When we think of utilizing the abundance and goodness of the geothermal water, we have to face the inevitable concern related to the hardness and dissolved solids of the same. The presence of positively charged calcium (Ca++) and Magnesium(Mg++) ions accords to the hardness of water. The higher the concentration of these ions, the harder the water would be (Purolite,2020). The hardness is very critical especially in hot conditions, as it forms scales on surfaces such as heat exchangers and pipelines and leads to the system failure. The hard water needs to be softened for applications in utilization such as irrigation and drinking (Seo et al., 2010). There are many expensive methods which are deployed to soften hard water. The softening methods are useful for low to moderate Total dissolved solids (TDS) water (60-120 mg/l), but fails and are very expensive when dealing with high TDS water (>3000 mg/l also referred as parts per million (ppm))(Ndoye et al.,2018). TDS is not a primary pollutant but high levels of TDS indicate hard water that may lead to scaling in pipes, reduced efficiency of equipments etc. Elevated levels of ions such as aluminum, arsenic, copper, lead, nitrate and others are the reasons for TDS concentration. The researchers in this study have come up with a method which is similar to the resin based water softener method used in the water industry to supply drinkable water to the communities to decrease the TDS levels to the appropriate consumption levels. But the usage of resin has a long term problems associated with it. The resins are made up of non renewable polystyrene and Divinylbenzene and contrary to the popular belief they have a life span of around 10 years, sometimes less based on the condition of water they are subjected to (aquaanalytics, 2020). The hardness of water and the chlorine content in it makes the resins to deplete at a fast rate. When reached the end of a lifespan, the beads add to the spillage into landfill and are disposed off as general waste. Also these water softeners are expensive to install and maintain. They require routine maintenance as Na++ are required to counter the Ca++ and Mg++ ions. It also requires disinfection and filtration before softening.

Instead of using resin as a softening media, we may utilize biodegradable materials such as algae and sea weeds. Sea weeds are used extensively in many industries like fertilizers, soil conditioners, cosmetics and waste water treatment. Studies have indicated seaweeds to be efficient in the removal of toxic metals and ions from industrial water. The seaweeds are also environmental friendly solution to be used (Arthur et al.,2013). They increase the quality of water that passes through them by reducing foaming tendency of water. A schematic has been designed to use algal extracts in order to reduce the TDS of geothermal water located at Dholera, Gujarat, India(Shah et al.,2018). The study area is facing severe scarcity of drinkable water. Fortunately the study area is around 60 kms away from the west sea coast of India, home to many seaweeds (gujenvis, 2020). The seaweeds may be utilized for softening of the high TDS water located in the study area for utilization by the community.

2. SUMMARY OF PAST AND CURRENT STUDIES

Resin based water softening methods helps in drastically reducing the content of dissolved salts in water, making the water immediately useful for various direct applications. However the resins suffer from high installation and expensive maintenance costs. They turn to non renewable wastes at the end of their life. Biodegradable materials like algae can be used in place of resins. Algae has been established as one of the methods for TDS reduction in leather effluents (Sharmila and Rebecca, 2019). Marine algae are the group of plants that live in marine environment. They are also called seaweeds and contain photosynthetic pigments. Seaweeds are found in the

coastal region between high tide to low tide and in the sub-tidal region up to a depth of 0.01 % where photosynthetic light is available. Seaweeds grow throughout the world and has not been found to be poisonous (Bold and Wyne, 1978). A study (Sharmila and Rebecca, 2019) shows seaweeds such as Centroceras clavulatum, Enteromorpha flexuosa, Grateloupia lithophila, Enteromorpha intestinalis, Chaetomorpha antennina, and Ulva lactuca, Sargassum sp., Amphiroa sp., Ulva sp., and Hypnea sp. , C. antennina can act as water softeners that reduces the hardness of water from 75 to 100%. Many seaweed powders and sea weed cartridges are available in the market that claims to act as water softeners.

3. PROPOSED METHODOLOGY OF IMPLEMETATION

The water softening process requires 7 days. 1-2 days for the preparation of algal extract and 5 days for softening of water. If the tank sizes are optimized, this setup may be utilized as a continuous process.

3.1 Algal extract preparation and Treatment

The seaweeds are required to be dried and powdered. Powdered seaweed would then be soaked in solvents in the ratio of 1:10 and left for 2 days for non-polar solvents (benzene and chloroform) and 1 day for polar solvents (methanol, ethanol, and water). The figure 1 shows a pictorial representation of the method of algal extract preparation. Algal extract and effluent are to be mixed in the ratio of 1:10 and treated for 5 days (Sharmila and Rebecca, 2019). After 5 days, hardness of water can be analyzed (Kotaiah and Swamy, 1994).

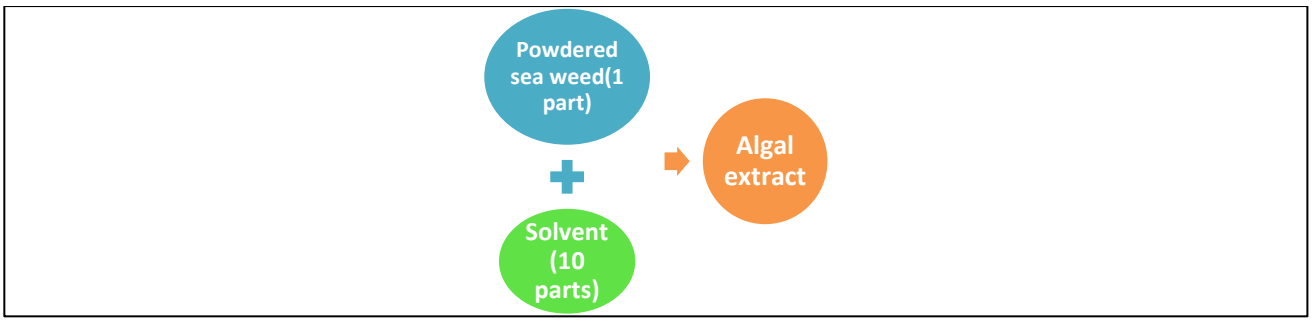

Fig. 1 The powdered seaweed and solvent are required to be mixed in 1:10 ratio and left for 1day for non polar solvents and 2 days for polar solvents

The water present in the study area Dholera is of around 5000 mg/l TDS (Shah et al., 2018). The reduction of hardness upto 75-100% can be obtained by this procedure. The figure 2 shows a schematic represntation of the reaction of algal extract with hard water. The best seaweeds for that can achieve this reduction are Hypnea sp., Ultva lactuca, Chaetomorpha attenina and Ultva sp (Sharmila and Rebecca, 2019).

It is found that the presence of carboxylic acid in the algal extract reduces the hardness. The carboxylic acid reacts with the calcium, magnesium and metal ions and forms salt, water and carbon dioxide. This salt dissolves in water. Many studies suggest there is a decrease in the fluoride level and seaweeds also acts as antifoaming agent in the geothermal water (Sharmila and Rebecca, 2019). However, there are no reports to justify the statement; it might be the reason for the reduction of hardness. It also reduces the fluoride level in water and also acts as antifoaming agent. Ethanol was found the best solvent for the algal extract preparation.

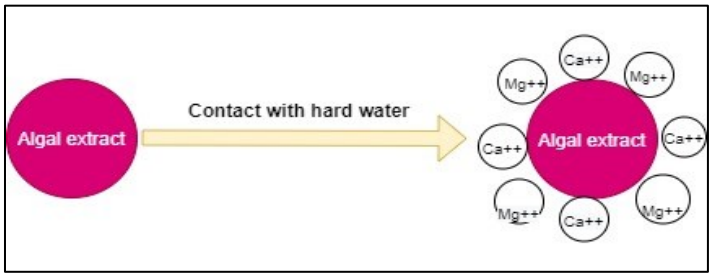

Fig. 2 Algal extract comes in contact with hard water and reacts with the Calcium, Magnesium and other metal ions to soften the hard water

3.2 Proposed design of the softening assembly

The softener assembly would consist of two tanks one for algal extract preparation and the other as softener unit as shown in figure 3. The algal extract preparatory tank shall be utilizing the powdered seaweed which would be soaked in solvents in the ratio of 1:10 and left for 2 days for non-polar solvents (benzene and chloroform) and 1 day for polar solvents (methanol, ethanol, and water). The algal extract thus prepared, shall then be sent into the softener unit where the extract and hard water are mixed together in 1:10 ratio and kept for 5 days, as depicted in figure 4. After the end of 5 days, the reduction of hardness upto 75-100% can be obtained.

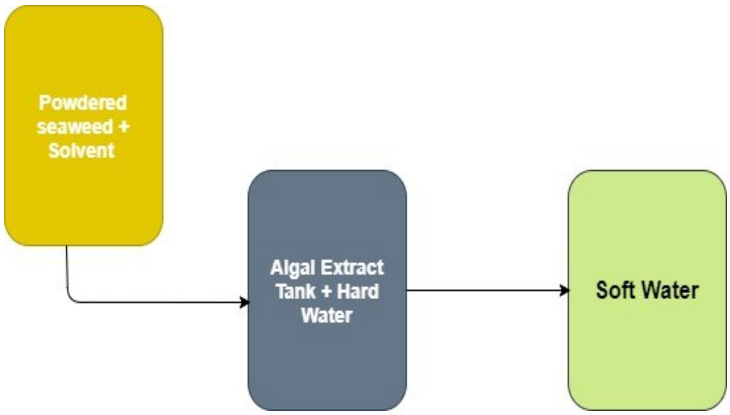

Fig. 3 Schematic representation of the water softening method by using algal extract

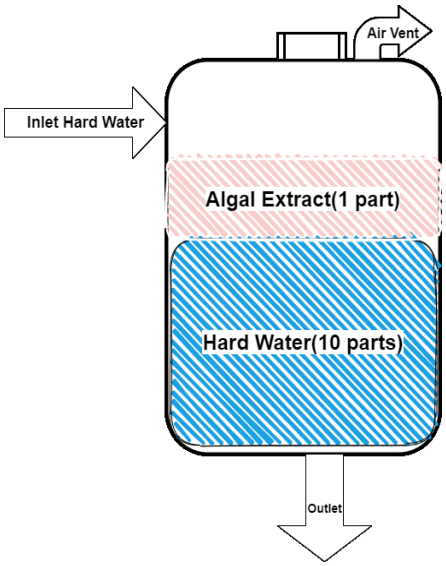

Fig. 4 Schematic of the water softening tank by using algal extract

5. CONCLUSION

With the state of Gujarat facing worst of its water crises in its history, it is the need of the hour to develop an efficient yet sustainable and economic solution for encountering the water woes of the state. Being at the vicinity of sea, implementation of seaweed for water softening is not a herculean task for the study area Dholera. The softening process reduces the TDS of water by reducing the Calcium, Magnesium and other metal cations from the hard water. The removal of these hard ions reduces scale built up in pipes and fittings. Softening also makes water immediately useable for drinking and irrigation purpose. Experimentation needs to be done check the viability of the above study as well as the economic aspects of the same. The usage of seaweeds also is an environment friendly. If the experimentation is successful, seaweed growth may also lead to employment opportunities for the youth of the study area.

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