3-6 Mechanism of water softening

Clay minerals may attain a net negative charge by ion replacement in which Si(IV) and Al(III) ions are replaced by metal ions at similar size but lesser charge. This negative charge must be compensated by association of cations with the clay layer surfaces. Because of their structure and high surface area per unit weight, clays have a strong tendency to absorb cations(Ca^{++}, Mg^{++}) from water. One noticed this in sample 1 which has 17% clay (page 62) and it is always the best for removing water total hardness. But in samples 2, 3, 4 and 5 when hard water is passed through a bed of modified clays, the calcium and magnesium are taken up and held by the sodium cation exchanger (modified clays) which simultaneously gives up equivalent amount of sodium ion exchange for them.

Reverse Osmosis, this is an applied pressure that can remove many types of molecules and ions and bacteria from water i.e. isolation of large molecules (retaining of ions through pores with small molecules like H_2O can pass) the membrane used, is of special type of polymeric matrix e.g. West Soba, Blue Nile, East Nile, could be used for earths of existence as solutes.

Ion exchange: replacing of$Ca^{+2}$and $Mg^{+2}$by Na^+ and K^+. Zeolites can be used for softening water (Metuchen 1961). Cation exchangers have adsorption power for divalent cations more than monovalent cations. Adsorption power for all cations increases with increasing atomic weight, table (19), on page 67 sample 3,4 and 5 are the best because the high content of easy removing ions of Na^+ and K^+. But sample 1and 2 are the least.

Molecular sieves: species with a kinetic diameter which makes this too large to pass through a modified clays pore are effectively “sieved” this “sieved” effect can be utilized to produce sharp separation of molecules by size and shape.

Aluminosilicates can be used as molecular sieves also zeolites can be used as sieves, those having pore of definite sizes ranging from 4Åto13Å as stated by (Bulut and Baysal 2006). It is noticed that the task was done as volume isolation of cations more than electrostatic or exchange or even adsorption, the best samples are 1, 2, and 3.

Adsorption of Ca^{+2} and Mg^{+2} on clays:

It could be visualized as adsorption of Ca^{+2} and Mg^{+2} on clays as physical adsorption that need only contact between cations and clays as "physisorption" i.e. involving electronic, electrical, electrostatic attachment on surfaces that could be classified by easy desorption, and for further attachment as chemisorption like any chemical reaction between the cations and earths.

One can involve XRD and EM to measure the degree of the strong (binding) attachment between $Ca^{+2}$and Mg^{+2} on the earths. Sample 1 is hematite. However sample 2 contains enstatite and albite. Sample 3 is labrodorite. But samples 4 and 5 are diopside and plagioclase feldspar respectively.

The X-Ray Diffraction showed that all earths were aluminosilicates with different orientations and the bonding strength between the constituent varieties of compounds to give a cluster of specific nature.

Reverse osmosis mechanism depends upon the physical and mechanical force applied to enforce the membrane, while the bigger particles are retained on the membrane and then discarded.

Ion exchange mechanism that uses the concept of solvation power of H^{+} and OH^{-} i.e. by exchanging the Na^{+} and K^{+} by Ca^{+2} and Mg^{+2} . As a result the ions of Ca^{+2} and $Mg^{+2}$are isolated by attachment to the clay precipitates while Na^{+} and K^{+} are passing through with the water to the boiler without making hardness. Therefore samples 4 and 5 are the best suit for ion exchange mechanism.

The molecular sieves of earths are working as inert volume isolation of substrates, regardless of ionic or even covalent or dative bonds.

The sieving mechanism is working for isolation of calcium and magnesium large ions by the surfaces of the earths and even further by fractures and inner pores of earths.

The XRD and Electron Microscopy studies for earths can give a clear picture for that mechanism.

The adsorption is the best mechanism to apply for Ca^{+2} and Mg^{+2}onto earths using many concepts, but the most suitable one is that of Freundlich solid /liquid adsorption i.e. the amount of the adsorbates(Ca^{+2} andMg^{+2}) on the earths as adsorbents could give a clear view about the attachment nature, this is known as physical adsorption,(physiosorption).

The physiosorption is usually followed by chemical adsorption (chemisorption) i.e. like a chemical reaction with strong bonds between the Ca^{+2} and $Mg^{+2}$and the earths.

The chemisorption follows σ- bond attachment accompanied by π- back donation resulting in a very strong and stable attachment.

Sample 5, 4 and 3 may be good examples of hardness removal by the adsorption mechanism.

One can classify the 5 earths according to the previous mechanism for the best removing action of the hardness (scales) from the industrial waters. The adsorption is the best mechanism followed by ion –exchange and the finally molecular sieves. For the revers osmosis, one can conduct studies shortly.

Conclusion

This study shows the possibility to use some local soil as a synthetic resin to remove hardness from industrial water. The following results were obtained according to the efficiency of hardness removal by different alkali concentration, for NaOH the efficiencies were in the range 50% to80% for Jurdiga sample, the West Nile clay in the range 18% to 70% , East Nile clay 13% to 70% , Blue Nile 8% to 62% and West Soba 18% to 48% . The pilot results gave efficiency of scale removal of 40% from (250g earth treated with 0.1M NaOH), gave 18 liters of soft water while the calcined samples gave 8 liters. The SPSS results showed that there were no immaterial differences in using NaOH or KOH. The differences that in concentration of the base as given by ANOVA.

The chemical analysis and XRF showed that the samples were aluminum silicates. While XRD showed the dominant of hematite, of West Nile clay while feldspar of East Nile clay, Blue Nile and Jurdiga.But West Soba was diopside and microcline mineral. Grain size distribution range from silty clay to fine sand.

Recommendation

The used earths contain amounts of Ca^{+2} and Mg^{+2} as waste products, then for further research work, the waste could be moulded, calcined and material impact tested as ceramic bricks. Also for further work should be conducted to investigate the recovery efficiency of made resin as well as be examined other local clays to be a potential polymer resin to remove hardness in water.

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