ESTIMATION OF HARDNESS

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- COURSE CODE : CHY1701
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- SLOT : L25 +L26
- NON CONTACT HOURS GROUP PROJECT

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AIM OF THE EXPERIMENT

To collect samples of water from different buildings in VIT, determine the hardness by EDTA method, remove the hardness by ion exchange method, and then determine the residual hardness.

THEORY

WHAT IS HARD WATER?

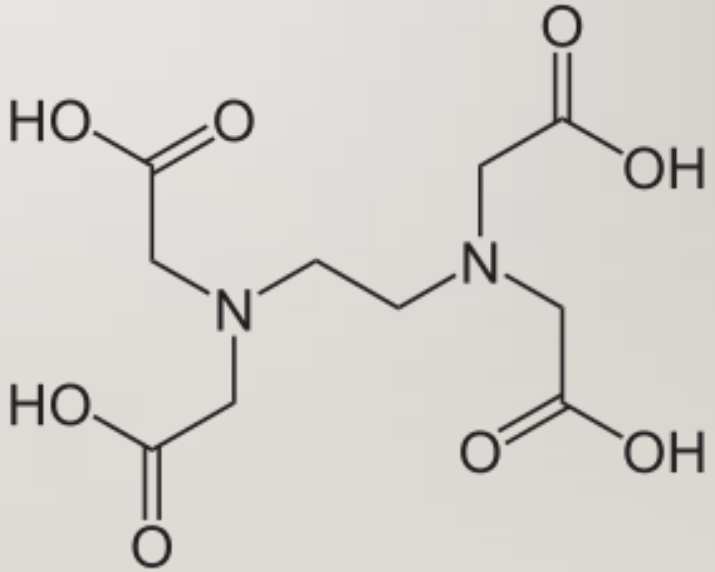
- **Hard water** is water that has a high mineral content.
- The main components of these minerals usually are calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions. But there are also dissolved metals, bicarbonates, and sulfates.

PROBLEMS CAUSED BY HARD WATER

- Fading Laundry
- Spotty dishes
- Hard-to-clean tubs
- Dull hair
- Plumbing build up

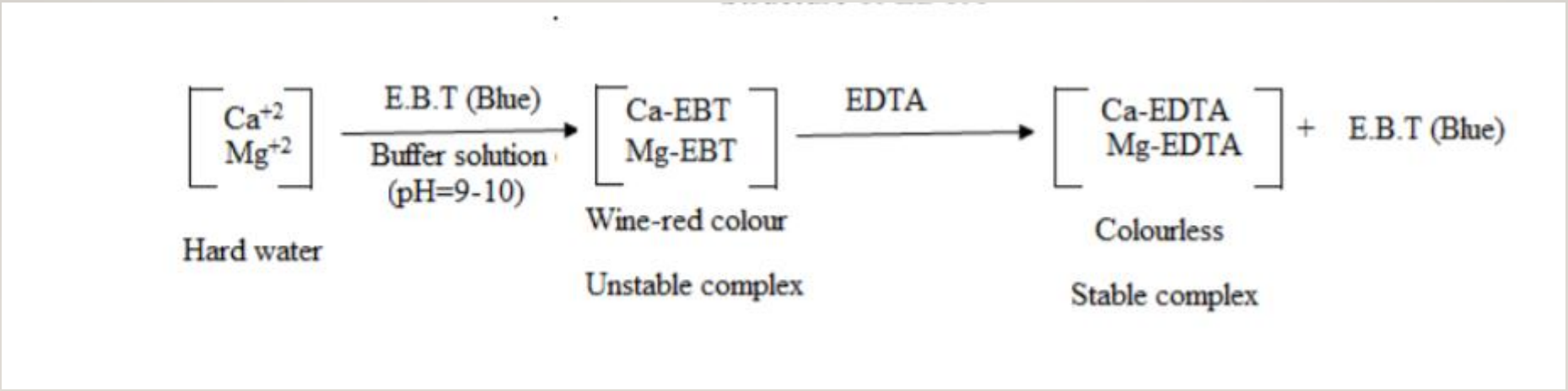
WHAT IS EDTA ?

EDTA is an aminopolycarboxylic acid and a colorless, water-soluble solid. It is widely used to dissolve limescale. Its usefulness arises because of its role as a hexadentate ("six-toothed") ligand and chelating agent, *i.e.*, its ability to sequester metal ions such as Ca^{2+} and Fe^{3+}. EDTA is produced as several salts, notably **disodium EDTA** and **calcium disodium EDTA**.



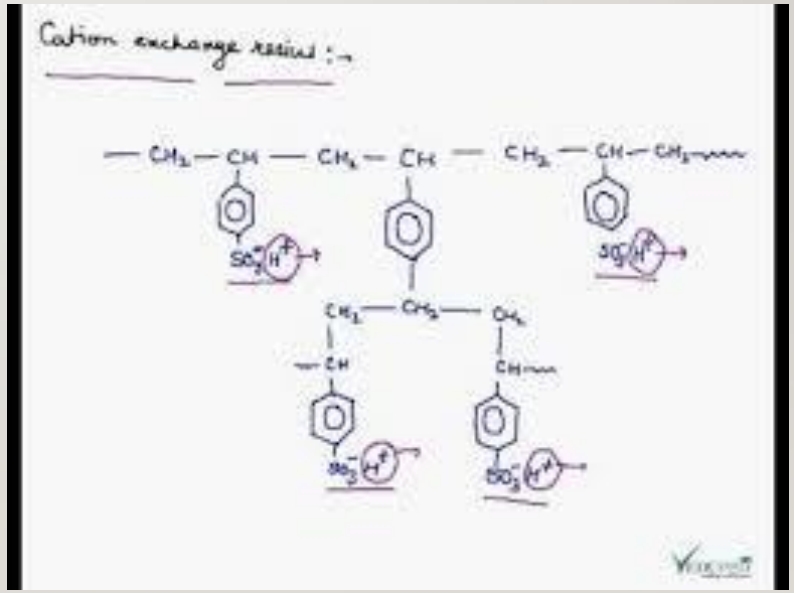
PRINCIPLE OF ESTIMATION OF HARDNESS BY EDTA

EDTA (Ethylenediamine tetra acetic acid) forms colorless stable complexes with Ca2+ and Mg2+ ions present in water at pH = 9-10. To maintain the pH of the solution at 9-10, buffer solution (NH4Cl + NH4OH) is used. Eriochrome Black-T (E.B.T) is used as an indicator. The sample of hard water must be treated with buffer solution and EBT indicator which forms unstable, wine-red colored complexes with Ca2+ and Mg2+ present in water.

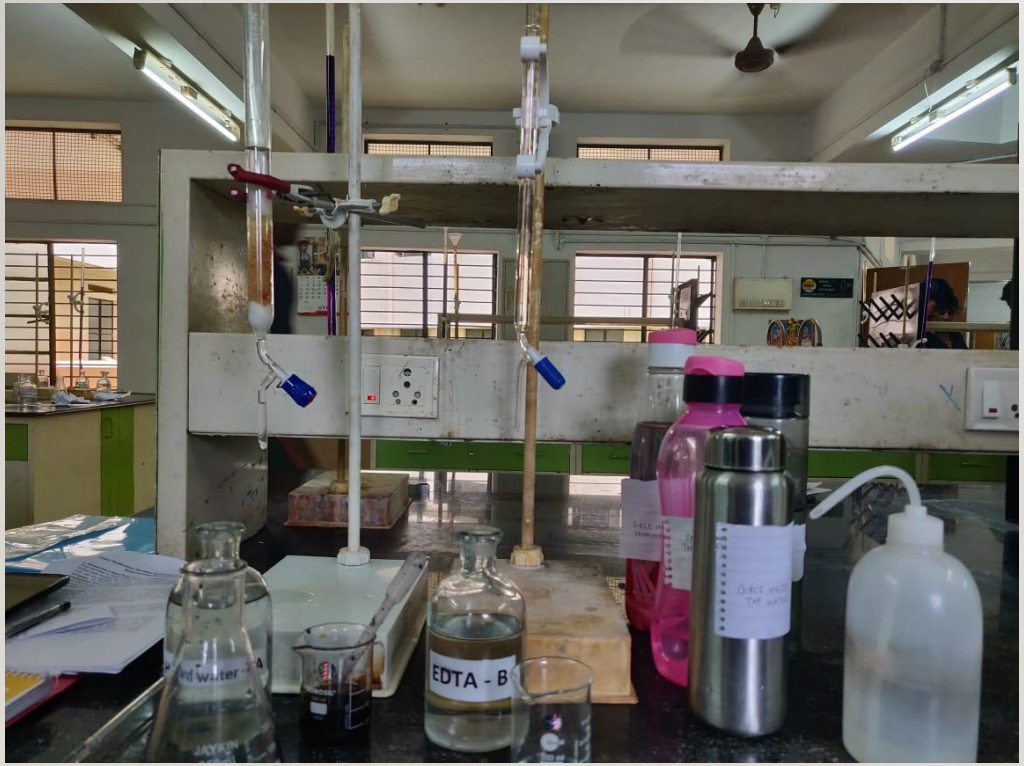


REMOVAL OF HARDNESS USING ION EXCHANGE RESINS

Ion exchange is a reversible process. When hard water is passed through cation ion-exchange resins packed in a narrow column, Ca^{2+} and Mg^{2+} cations in hard water are exchanged with Na^{+} or H^{+} ions in the resins. The exhausted resins can be regenerated by passing 10% dilute HCl through the column.



REQUIREMENTS



- **Reagents/Solutions:**

Standard hard water, 0.01 N EDTA solution, EBT indicator, hard water samples, ammonia buffer solution, and ion exchange resins.

- **Apparatus:**

Burette, Pipette, conical flask, standard flask, burette stand, and ion exchyange column.

PROCEDURE

STANDARDIZATION OF EDTA

(i) 20 ml of standard hard water was pipetted into a conical flask.

(ii) 5 ml of buffer solution and few drops of Eriochrome Black-T were added. The indicator, which is originally blue color would acquire a wine-red color.

(iii)The solution was titrated with EDTA solution taken in the burette, till the wine red color changed to blue which was the end point. This burette reading of EDTA was taken to be V1 ml.

Therefore, 1ml of EDTA required 20/V1 mg of $CaCO_3$ for complexation.

DETERMINATION OF TOTAL HARDNESS

The above titration method was repeated for sample hard water instead of standard hard water. The burette reading was taken to be V2.

1ml of EDTA required 20/V1 mg of $CaCO_3$ for complexation.

20 ml of sample hard water consumed V2 ml EDTA = V2 x 20/V1 mg of $CaCO_3$ eq.

1000 ml of hardwater sample consumed V2 x 20/V1 x 1000/20 = V2/V1 x 1000 ppm = X ppm

Therefore, total hardness = X ppm

REMOVAL OF HARDNESS USING ION EXCHANGE RESINS AND CALCULATION OF RESIDUAL HARDNESS

The water sample was passed through a cation exchange resin and the titration was repeated with the same sample. The burette reading was noted as V3

1ml of EDTA required 20/V1 mg of $CaCO_3$ for complexation.

20 ml of sample hard water consumed V3 ml EDTA = V3 x 20/V1 mg of $CaCO_3$ eq.

1000 ml of hardwater sample consumed V3 x 20/V1 x 1000/20 = V3/V1 x 1000 ppm = Y ppm

Therefore, Residual hardness = Y ppm

Hardness removed = X – Y ppm

OBSERVATIONS

STANDARDIZATION OF EDTA

S.No	Volume of standard hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V1) (ml)
1	20	0	17.9	17.9
2	20	0	18	18
3	20	0	18	18

Concordant Titre value = 18 ml
Therefore, V1= 18 ml.

DIFFERENT WATER SAMPLES

SAMPLE 1

BOYS' HOSTEL, TAP WATER

DETERMINATION OF TOTAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	5.7	5.7
2	20	0	5.8	5.8
3	20	0	5.8	5.8

Concordant Titre value = 5.80 ml
Therefore, V2= 5.80 ml
Total Hardness, X= V2/V1 x 1000 ppm = 322.23 ppm

DETERMINATION OF RESIDUAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	0.6	0.6
2	20	0	0.7	0.7
3	20	0	0.6	0.6

Concordant Titre value = 0.6 ml
Therefore, V3= 0.6 ml
Residual Hardness, Y= V3/V1 x 1000 ppm = 33.33 ppm
Hardness removed = X – Y ppm =288.90 ppm

SAMPLE 2

SMV, TAP WATER

DETERMINATION OF TOTAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	6.1	6.1
2	20	0	6.2	6.2
3	20	0	6.2	6.2

Concordant Titre value = 6.2 ml
Therefore, V2=6.2 ml
Total Hardness, X= V2/V1 x 1000 ppm = 344.40ppm

DETERMINATION OF RESIDUAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	0.9	0.9
2	20	0	0.9	0.9
3	20	0	1.0	1.0

Concordant Titre value = 0.9 ml
Therefore, V3=0.9 ml
Residual Hardness, Y= V3/V1 x 1000 ppm = 50.00 ppm
Hardness removed = X – Y ppm = 294.40 ppm

SAMPLE 3

GIRLS' HOSTEL, TAP WATER

DETERMINATION OF TOTAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	5.6	5.6
2	20	0	5.6	5.6
3	20	0	5.6	5.6

Concordant Titre value = 5.6 ml
Therefore, V2= 5.6 ml
Total Hardness, X= V2/V1 x 1000 ppm = 311.12 ppm

DETERMINATION OF RESIDUAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	0.3	0.3
2	20	0	0.3	0.3
3	20	0	0.4	0.4

Concordant Titre value = 0.3 ml
Therefore, V3= 0.3 ml
Residual Hardness, Y= V3/V1 x 1000 ppm = 16.66 ppm
Hardness removed = X – Y ppm = 294.46 ppm

SAMPLE 4

TT, TAP WATER

DETERMINATION OF TOTAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	5.9	5.9
2	20	0	6.0	6.0
3	20	0	6.0	6.0

Concordant Titre value = 6.0 ml
Therefore, V2= 6.0 ml
Total Hardness, X= V2/V1 x 1000 ppm = 333.34 ppm

DETERMINATION OF RESIDUAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	0.3	0.3
2	20	0	0.3	0.3
3	20	0	0.4	0.4

Concordant Titre value = 0.3 ml
Therefore, V3= 0.3ml
Residual Hardness, Y= V3/V1 x 1000 ppm = 16.66 ppm
Hardness removed = X – Y ppm = 316.68 ppm

SAMPLE 5

GIRLS' HOSTEL, DRINKING WATER

DETERMINATION OF TOTAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	0.7	0.7
2	20	0	0.8	0.8
3	20	0	0.8	0.8

Concordant Titre value = 0.8 ml
Therefore, V2= 0.8 ml
Total Hardness, X= V2/V1 x 1000 ppm = 44.44 ppm

DETERMINATION OF RESIDUAL HARDNESS

S.No	Volume of sample hard water (ml)	Initial Burette reading (ml)	Final Burette reading (ml)	Volume of EDTA (V2) (ml)
1	20	0	0.1	0.1
2	20	0	0.1	0.1
3	20	0	0.1	0.1

Concordant Titre value = 0.1 ml
Therefore, V3= 0.1 ml
Residual Hardness, Y= V3/V1 x 1000 ppm = 5.55 ppm
Hardness removed = X – Y ppm = 38.89 ppm

RESULT

SAMPLE NO	SAMPLE FROM	TOTAL HARDNESS (ppm)	RESIDUAL HARDENESS (ppm)	HARDNESS REMOVED (ppm)
1	Boys' hostel, tap	322.23	33.33	288.90
2	SMV, tap	344.40	50.00	294.40
3	Girls' hostel, tap	311.12	16.66	294.46
4	TT, tap	333.34	16.66	316.68
5	Girls' hostel, drinking	44.44	5.55	38.89

INFERENCE

- The water samples of different buildings in VIT are found to be appropriate for drinking and other purposes based on its hardness readings that were calculated.
- Almost all the hardness of water samples was successfully removed by the ion exchange method.

STUDENTS AT WORK


Std. Hard
EDT


Hard
EDT


Std. Hard


Std. Hard