



Engineering Chemistry

CYC 102

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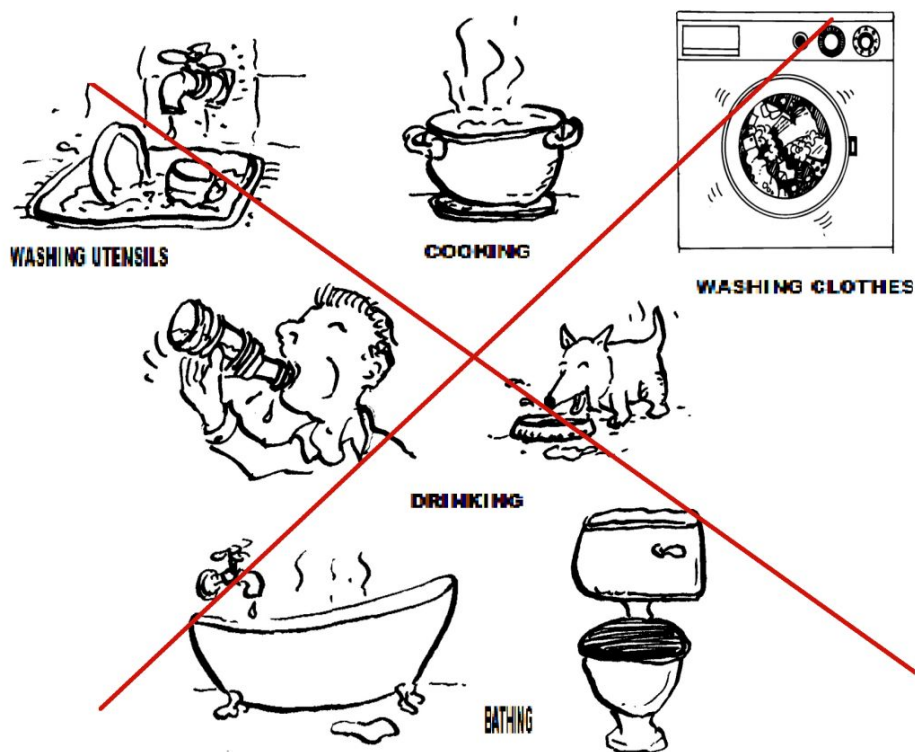
Overview

- Disadvantages of using hard water
- Degree of Hardness
- Units of Hardness
- Summary
- References
- Topics to be covered in next lecture



Disadvantages of using hard water

For Domestic Use



**HARD WATER IS NOT
SUITABLE FOR ALL THESE
PURPOSES**





Disadvantages of using hard water...Contd.

For Industrial Use

- **Paper**

Ca and Mg effects the properties and quality of paper

- **Textile**

Ca and Mg contaminants induce poor quality of shades.

- **Sugar**

Nitrates and sulphates of Ca and Mg hinders crystallization of sugar.

- **Boilers**

Scales formation, Wastages of fuel.



Degree of Hardness

- The expression of hardness producing salts usually expressed in terms of an equivalent amount of CaCO_3 .
- Calcium Carbonate is chosen as a standard for reporting hardness of water due to following reasons:
 - ✓ Molecular weight (100) and equivalent weight (50) is a whole number, so the calculations in water analysis can be simplified.
 - ✓ Most insoluble salt that can be precipitated in water treatment.

Degree of Hardness...Contd.

- The conversion of the hardness causing salts into CaCO_3 equivalents is expressed as:

$$\text{Equivalent of CaCO}_3 = \frac{[\text{Mass of hardness producing substance}] \times [\text{Chemical equivalent of CaCO}_3]}{[\text{chemical equivalent of hardness producing substance}]}$$

$$= \frac{[\text{Mass of hardness producing substance}] \times [50]}{[\text{chemical equivalent of hardness producing substance}]}$$

$$= [\text{Mass of hardness producing substance}] \times (\text{multiplication factor}) \text{ in mg/L or ppm}$$



Multiplication Factor for different salts

Salt/ion	Molar mass	Chemical Equivalent Or Equivalent Weight	Multiplication factor for converting into equivalents of CaCO_3
$\text{Ca}(\text{HCO}_3)_2$	162	81	100/162
$\text{Mg}(\text{HCO}_3)_2$	146	73	100/146
CaSO_4	136	68	100/136
CaCl_2	111	55.5	100/111
MgSO_4	120	60	100/120
MgCl_2	95	47.5	100/95
CaCO_3	100	50	100/100
MgCO_3	84	42	100/84
CO_2	44	22	100/44
$\text{Ca}(\text{NO}_3)_2$	164	82	100/164
$\text{Mg}(\text{NO}_3)_2$	148	74	100/148
HCO_3^-	61	61	100/122
OH^-	17	17	100/34
CO_3^{2-}	60	30	100/60
NaAlO_2	82	82	100/164
$\text{Al}_2(\text{SO}_4)_3$	342	57	100/114
$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$	278	139	100/278
H^+	1	1	100/2
HCl	36.5	1	100/73



Units of Hardness

- **Parts per Million (ppm)**

The number of parts of calcium carbonate equivalent hardness presents in 10^6 parts of water.

1 ppm = 1 part of **CaCO₃ equivalent** hardness in 10^6 parts of water.

- **Milligrams per litre (mg/l)**

The number of milligrams of calcium carbonate equivalent hardness presents per litre of water.

1 mg/L = 1 mg of **CaCO₃ equivalent** hardness in 1 L of water.

- **Clark's degree (°Cl)**

The number of parts of calcium carbonate equivalent hardness presents in 70,000 or (7×10^4) parts of water.

1° Clarke = 1 part of **CaCO₃ equivalent** hardness per 70,000 parts of water.



Units of Hardness...Contd.

- Degree French (°Fr)

The number of parts of calcium carbonate equivalent hardness presents in 10^5 parts of water.

$1^\circ \text{Fr} = 1$ part of CaCO_3 equivalent per 10^5 parts of water.

- ✓ **Interconversion of Hardness units**

As $1 \text{ ppm} = 1 \text{ part per } 10^6 \text{ parts of water}$

$1^\circ \text{Fr} = 1 \text{ part per } 10^5 \text{ part of water}$

$1^\circ \text{Cl} = 1 \text{ part per } 70,000 \text{ parts of water}$

Therefore, $10^6 \text{ ppm} = 10^5 ^\circ \text{Fr} = 70,000 ^\circ \text{Cl}$

Hence, $1 \text{ ppm} = 0.1^\circ \text{Fr} = 0.07^\circ \text{Cl} = 1 \text{ mg/L}$

$1 \text{ mg/L} = 1 \text{ ppm} = 0.1^\circ \text{Fr} = 0.07^\circ \text{Cl}$

$1^\circ \text{Cl} = 0.7^\circ \text{Fr} = 0.07 \text{ ppm} = 0.07 \text{ mg/L}$

$1^\circ \text{Fr} = 10 \text{ ppm} = 10 \text{ mg/L} = 0.7^\circ \text{Cl}$



Summary

- ✓ Hard water unfit for drinking, cooking, bathing, washing etc.
- ✓ Hardness classified as carbonate and non-carbonate hardness.
- ✓ Hardness always expressed as CaCO_3 equivalent.
- ✓ Hardness of water can be expressed in different units.
- ✓ Different units of hardness ppm, mg/L, $^\circ\text{Cl}$ and $^\circ\text{Fr}$.

Reference

- O.G Palanna, “ Engineering Chemistry” Page No. 263-268.

Topics to be covered in next lecture

- Numerical based on hardness of water
- Hardness determination by EDTA method



Thank You!