Disadvantages of Hard Water

A. In domestic use:

1. **Washing:** Causes wastage of lot of soap. The white scum adheres on the fabric giving spots and streaks. If iron and manganese salts are there then may cause staining of cloth.
2. **Bathing:** Cleansing quality of soap is depressed and a lot of it is wasted.
3. **Cooking:** As boiling pint of hard water is high, more fuel and time are required for cooking. Certain foods such as pulses, beans, peas do not cook soft. Tea of coffee prepared has an unpleasant taste and muddy looking extract. Carbonates were found stuck on the inner walls of utensils.
4. **Drinking:** There is a bad effect on our digestion process. Chances of formation of calcium oxalate in the urinary tract are always there.

B. In industrial use

1. Textile industries

- ✓ Uniform dyeing is not possible if hard water is used
- ✓ Hard water decreases the solubility of acidic dyes and basic dyes precipitate out
- ✓ Fe and Mn salts containing water may cause colored spots on fabrics

***2.* Sugar Industry**

- ✓ Hard water results in the formation of deliquescent sugar
- ✓ Cause difficulty in the crystallization of sugar

***3.* Paper Industry**

Fe and Mn salts affect the brightness and color of the paper
Hardness increases the ash content of the paper

***4.* Laundry:**

Mn and Fe salts impart grey/reddish shade to the fabric
Hard water increases soap consumptions

***5. Boilers in steel industries*:** Hard water leads to corrosion and chocking of boiler.

Advantages and disadvantages of hard water

Advantages	***Disadvantages***
1. Taste of water is better than soft water	*1. It produces white precipitate with soap solution. Thus, the washed clothes look dull.*
2. Dissolved Ca-salts helps in producing strong teeth and healthy bones in children	*2. Causes boiler corrosion. Not used in industries like sugar, textiles, paper, etc.*
3. Not a plumbo-solvent	*3. Increases B. Pt. of water.*

Q. 7. Mention some advantages of hard water. (Refer the above table)

Q. 8. Mention some disadvantages of hard water. (Refer above)

Q.9. Mention the disadvantages of hard water in sugar industries. [2 marks]

Ans. Hard water results in the formation of deliquescent sugar. It also cause difficulty in the crystallization of sugar

Q.10. **Mention the disadvantages of hard water in paper and textile industries. [3 marks]**

Ans. Paper Industry:

Fe and Mn salts affect the brightness and color of the paper
Hardness increases the ash content of the paper

***Textile industries*:**

- ✓ Uniform dyeing is not possible if hard water is used
- ✓ Hard water decreases the solubility of acidic dyes and basic dyes precipitate out
- ✓ Fe and Mn salts containing water may cause colored spots on fabrics

Types of Hardness

It is of two types: (1) Temporary Hardness and (2) Permanent Hardness

1. *Temporary Hardness:* It is caused by the presence of dissolved carbonates and bicarbonates (HCO_3^-) of Ca and Mg, heavy metals like Al, Mn and carbonates of Fe. The salts responsible are $CaCO_3$, $MgCO_3$, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$, etc. These salts are thermally unstable and undergo thermal decomposition to form insoluble substance as follows;
   a. $Ca(HCO_3)_2 \rightarrow CaCO_3$ (ppt.) + H_2O + CO_2
   b. $Mg(HCO_3)_2 \rightarrow Mg(OH)_2$ (ppt.) + $2CO_2$

So, temporary hardness can be removed by boiling. It is otherwise known as ***carbonate or alkaline hardness*.**

2. *Permanent Hardness:* It is caused by the presence of chloride (Cl^-), nitrates (NO_3^-), sulphates (SO_4^{2-}) of Ca, Mg, Fe, Al, Mn, etc. The salts responsible are $CaCl_2$, $Ca(NO_3)_2$, $CaSO_4$, $MgCl_2$, $Mg(NO_3)_2$, $MgSO_4$, $Al_2(SO_4)_3$, $FeSO_4$, etc. These salts are thermally stable as present in ionic form in water. So, they can't be remove by heating but removed by softening methods. It is also known as ***non-carbonate or non-alkaline hardness*.**

Total Hardness

All the hardness causing salts contribute towards total hardness. So, total hardness is the sum of temporary and permanent hardness.

Q. 11. Which of the following salt is a non-hardness constituent?

$MgCl_2$, $Mg(NO_3)_2$, $MgSO_4$, $Al_2(SO_4)_3$, $NaHCO_3$

Ans. $NaHCO_3$

Q. 12. Which of the following salts are hardness constituents?

$CaCl_2$, $Ca(NO_3)_2$, K_2SO_4, Na_2SO_4, $NaNO_3$, KNO_3, Fe_2O_3

Ans. $CaCl_2$ and $Ca(NO_3)_2$

Q.13. Which of the following salts are permanent-hardness constituents?

$Ca(HCO_3)_2$, $Mg(HCO_3)_2$, $CaCl_2$, K_2SO_4 and $FeSO_4$

Ans. $CaCl_2$ and $FeSO_4$

Q.14. Which of the following salts are temporary-hardness constituents?

$Mg(HCO_3)_2$, $Mn(HCO_3)_2$, $NaHCO_3$, $CaCl_2$, K_2SO_4

Ans. $Mg(HCO_3)_2$ and $Mn(HCO_3)_2$

Degree of Hardness (Equivalents of Calcium Carbonate)

How to express hardness of water?

As $CaCO_3$ is almost insoluble in water, it hardly contributes towards hardness of water. But, hardness of water is expressed in terms of equivalent amount of $CaCO_3$ due to following reasons:

A. Ease in calculation as its molecular weight is 100.
B. It is the most insoluble salt that can be precipitated during water treatment.

Equivalent of $CaCO_3$ = (S, strength of hardness substance in mg/L) x [100/ (2 x M/n-factor)]

Where, M = Molar mass of hardness substance.

N.B.: n-factor of all Ca and Mg-salts are 2. For aluminum sulphate, it is 6.

✓ All hardness and non-hardness constituents can be expressed as **Equivalent of $CaCO_3$**

Q. 15. Give reason that $CaCO_3$ is used to express hardness of water.

Ans. The hardness of water is expressed in terms of equivalent amount of $CaCO_3$ due to following reasons:

A. Ease in calculation as its molecular weight is 100.
B. It is the most insoluble salt that can be precipitated during water treatment.

Q. 16. What happens when hard water containing temporary hardness constituents are boiled for some time?

Ans. Temporary hardness constituents like $Ca(HCO_3)_2$ $Mg(HCO_3)_2$ are thermally unstable and undergo thermal decomposition to form insoluble substances like $CaCO_3$ & $Mg(OH)_2$ as follows;

c. $Ca(HCO_3)_2 \rightarrow CaCO_3$ (ppt.) + H_2O + CO_2
d. $Mg(HCO_3)_2 \rightarrow Mg(OH)_2$ (ppt.) + $2CO_2$

Units of hardness and their inter-relations

Hardness can be expressed by the four units.

1. Parts per million (ppm): It is the 1 part of $CaCO_3$ equivalent hardness per 10^6 parts of water.
2. Millligrams per litre (mg/L): It is the no of mg of $CaCO_3$ equivalent hardness present per litre of water.
3. Degree French (^{0}Fr): It is the 1 part of $CaCO_3$ equivalent hardness per 10^5 parts of water.
4. Clarke's degree (^{0}Cl): It is the part of $CaCO_3$ equivalent hardness per 70,000 parts of water.

Relationships between various units of Hardness

5. We know that, 1 ppm = 1 part per 10^6 parts of water => 1 part = 10^6 ppm ----(1)
   1 ^{0}Fr = 1 part per 10^5 parts of water, => 1 part = 10^5 ^{0}Fr -------(2)
   And 1 ^{0}Cl = 1 part per 70, 000 parts of water => 1 part = 70,000 ^{0}Cl –(3)
   From equation (1), (2), and (3), we found that
   1 part = 10^6 ppm = 10^5 ^{0}Fr = 70,000 ^{0}Cl
   Or, 10^6 ppm = 10^5 ^{0}Fr = 70,000 ^{0}Cl ---- (4)
   Now Divide Eq. 4 by 10^6, so that **1 ppm = 0.1 ^{0}Fr = 0.07 ^{0}Cl = 1 mg/L**

Q. 17. Show that 1 ppm = 1 mg/L [1 mark]

Answer: 1 mg/L means 1 mg of $CaCO_3$ eq. hardness in 1L of water

= 1 mg of $CaCO_3$ eq. hardness in 10^6 mg of water *** (for water, 1 L is nearly 1 Kg = 1000 g = 1000,000 mg = 10^6 mg)

=> 1 part of $CaCO_3$ equivalent hardness per 10^6 parts of water = 1 ppm (proved)