# SKBU
# ENVS

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# MESUREMENT OF WATER HARDNESS AND REMEDIAL MEASURES FROM TAP AND WELL

## Water hardness :

Hard water is water that has high mineral content (in contrast with "soft water"). Hard water is formed when water percolates through deposits of limestone, chalk or gypsum, which are largely made up of calcium and magnesium carbonates, bicarbonates and sulfates.

Hard drinking water may have moderate health benefits. It can pose critical problems in industrial settings, where water hardness is monitored to aviod costly breakdowns in boilers, colling towers, and other equipment that handless water. In domestic settings, hard water is often indicated by a lack of foam formation when soap is agitated in water, and by the formation of limescale in kettles and water heaters. wherever water hardness is a concern, water softening is commonly used to reduce hard water's adverse effects.

## Measurement :

Hardness can be quantified by instrumental analysis. The total water hardness is the sum of the molar concentrations of $Ca^{2+}$ and $Mg^{2+}$, in mol/L or m mol/L units. Although water hardness usually measures only the total concentrations of calcium and magnesium (the two most prevalent divalent metal ions), iron, aluminium, and manganese can also be present at elevated levels in some locations. The presence of iron characteristically confers and brownish (rust-like) colour ~~to~~ the calcification, instead of white (the colour of most of the other compounds).

water hardness is often not expressed as a molar concentration, but rather in various units, such as degrees of general hardness (dGH), German degrees (°dH), parts per million (ppm, mg/L, or American degrees), grains per gallon (gpg), English degrees (°e, e, or °clark), or French degrees (°fH; °f or °HF; lowercase f is used to prevent confusion with degrees Fahrenheit). The Table below shows conversion factors between the various units.

Hardness unit conversion.

| | 1 mmol/L | 1 ppm, mg/L | 1 dGH, °dH | 1 gpg | 1 °e, °clark | 1 °fH |
|---|---|---|---|---|---|---|
| mmol/L | 1 | 0.009991 | 0.1783 | 0.171 | 0.1424 | 0.09991 |
| ppm, mg/L | 100.1 | 1 | 17.85 | 17.12 | 14.25 | 10 |
| dGH, °dH | 5.608 | 0.05603 | 1 | 0.9591 | 0.7986 | 0.5603 |
| gpg | 5.847 | 0.05842 | 1.043 | 1 | 0.8327 | 0.5842 |
| °e, °clark | 7.022 | 0.07016 | 1.252 | 1.201 | 1 | 0.7016 |
| °fH | 10.01 | 0.1 | 1.785 | 1.712 | 1.425 | 1 |

The various alternative units ~~&~~ represent an equivalent mass of calcium oxide (CaO) or calcium carbonate ($CaCO_3$) that, when dissolved in a unit volume of pure water, would result in the same total molar concentration of $Mg^{2+}$ and $Ca^{2+}$. The different conversion factors arise from the fact that equivalent masses of calcium oxide and calcium carbonates differ, and that different mass and value units are used. The units are as follows:

- Parts per million (ppm) is usually defined as 1 mg/L $CaCO_3$ (the definition used below). It is equivalent to mg/L without chemical compound specified, and to American degree.
- Grains per Gallon (gpg) is defined as 1 grain (64.8 mg) of calcium carbonate per US. gallon (3.79 litres), or 17.118 ppm.

- a m mol / L is equivalent to 100.09 mg / L $CaCO_3$ or 40.08 mg / L $Ca^{2+}$
- A degree of general Hardness (dGH or 'German degree (°dH, deutsche Harte)' is defined as 10 mg/L CaO or 17.848 ppm.
- A Clark degree (°Clark) or English degrees (°e or e) is defined as one grain (64.8 mg) of $CaCO_3$ per Imperial gallon (4.55 litres) of water, equivalent to 14.254 ppm.
- A French degree (°fH or °f) is defined as 10 mg / L $CaCO_3$, equivalent to 10 ppm.

Hard / soft Classification :

As it is precise mixture of minerals dissolved in the water, together with water's pH and temperature that determine the behavior of the hardness, a single - number scale does not adequately decribe hardness. However, the United states Geological survey uses the following ~~call~~ ~~ed~~ classification for hard and soft water.

| Classification | hardness in mg - $CaCO_3$/L | hardness in mmol / L | hardness in dGH/°dH | hardness in gpg | hardness in ppm |
|---|---|---|---|---|---|
| Soft | 0-60 | 0-0.60 | 0 - 3.37 | 0.3.50 | 0.60 |
| Moderately hard | 61-120 | 0.61-1.20 | 3.38-6.74 | 3.56-7.01 | 61 - 120 |
| Hard | 121-180 | 1.21-1.80 | 6.75-10.11 | 7.06- 10.51 | 121 - 180 |
| very hard | ≥ 181 | ≥ 1.81 | ≥ 10.12 | ≥ 10.57 | ≥ 181 |

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## Langelier saturation index :

The Langelier saturation index (sometimes Langelier stability index) is a calculated number used to predict the calcium carbonate stability of water. It indicates, or be in equlibrium with calcium carbonate. In 1936, Wilfred Langelier developed a method for predicting the pH at which water in saturated in calcium carbonate (called $pH_s$). The LSI is expressed as the difference between the actual system pH and the saturation pH.

$$LSI = pH\ (measured) - pH_s$$

* For $LSI > 0$, water is super saturated and tends to precipitate a scale layer of $CaCO_3$.
* For $LSI = 0$, water is saturated (in equilibrium) with $CaCO_3$. A scale layer of $CaCO_3$ is neither precipitated nor dissolved.
* For $LSI < 0$, water is under saturated and tends to dissolve solid $CaCO_3$.

If the actual pH of the water is below the calculated saturation pH, the LSI is negative and the water has a very limited scaling potential. If the actual pH exceeds pHs, the LSI is positive, and being supresaturated with $CaCO_3$, the water has a tendency to from scale. At increasing positive index values, the scaling potential increases.

In practice, water with an LSI between -0.5 and +0.5 will not display enhanced mineral dissolving or scale forming properties. Water with an LSI bellow - 0.5 tends to exhibit noticeably increased dissolving abilities while water with an LSI above +0.5 tends to exhibit noticeably increased scale forming properties.

The LSI is temperature sensitive. The LSI becomes more positive as the water temberature increases. This has particular implications in situations where well water is used. The temperature of the water when it first exits the well is often significantly lower than the temperature inside the building served by the well or at the laboratory where the LSI mesurement is made. This increase in temperature can cause scaling, especially in cases such as hot water heaters. Conversely, system that reduce water temperature will have less scaling.

water Analysis

$pH = 7.5$

$TDS = 320\ mg/L$

Calcium $= 150\ mg/L$ (or ppm) as $CaCO_3$

Alkalinity $= 34\ mg/L$ (or ppm) as $CaCO_3$ LSI formula:

LSI formula.

$LSI = pH - pH_s$

$pH_s = (9.3 + A + B) - (C + D)$ where:

$$A = \frac{\log_{10}(TDS) - 1}{10} = 0.15$$

$B = -13.12 \times \log_{10}(°C + 273) + 34.55 = 2.09$ at 25°C and 1.09 at 82°C

$C = \log_{10}[Ca^{2+} \text{ as } CaCO_3] - 0.4 = 1.78$

($Ca^{2+}$ as $CaCO_3$ is also called calcium hardness, and is calculated as $2.5\,[Ca^{2+}]$)

$D = \log_{10}[\text{alkalinity as } CaCO_3] = 1.53$

## Ryznar Stability Index (RSI) :-

The Ryzner stability index (RSI) uses a database of scale tickness measurements in municipal water systems to predict the effect of water chemistry.

Ryznar saturation index (RSI) was developed from empirical observations of corrosion rates and film formation in steel mains. It is defined as.

$$RSI = 2\,pH_s - pH \text{ (measured)}$$

* For $6.5 < RSI < 7$ water is considered to be approximately at saturation equilibrium with calcium carbonate.
* For $RSI > 8$ water is under saturated and, therefore, would tend to dissolve any existing solid $CaCO_3$.
* For $RSI < 6.5$ water tends to be scale from.

## Puckorius Scaling Index (PSI) :

The puckorius scaling Index (PSI) uses slightly different parameters to quantify the realationship between the saturation state of the water and the amount of limescale deposited.

## Other indices :

Other indices include the Larson-Skold Index, the Stiff-Davis Index, and the oddo-Tomson Index.