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**POOL (WATER CHEMISTRY) BALANCE**

Water balance is actually the balance of the water chemistry.

a) pH

pH is a means which will indicate the acidity or alkalinity of the water.. It is called the Hydrogen ion concentration. The predominance of Hydrogen ions in the water over Hydroxyl ions gives the acidity to the water and the predominance of hydroxyl ions in the water over Hydrogen ions gives the alkaline content of the water. We can also term the acidity in terms of the Hydroxyl ion concentration but this is not normally used in scientific expressions. Hydrogen ion concentration is obtained by determination of the total hydrogen ion present in the water by electrochemical means - the pH meter. When there are equal number of Hydrogen ions as Hydroxyl ions, the water is said to be neutral. pH is defined as the reciprocal and logarithmic value of the total Hydrogen ion concentration.

Neutral pH is 7, the greatest acidity is 0 (no Hydroxyl ions) while the highest alkalinity is 14 (no Hydrogen ions). Suffice it to say that all liquids (polar) have pH values somewhere between 0 and 14.

We are able to consume liquids with an acidity not lower than 4 (vegetable acids such as citric from lime, tartaric acids from Tamarind etc.). Any lower will burn our gullet. The pH of the acids produced by our stomach can be as low as 1.5

(for digestion) but our stomach protects itself from burning by mucous production. We cannot swim in a water with a pH lower than 6 because our eyes are sensitive to this acidity and will irritate.

We can consume liquids with a pH value up to about 9 (Bicarbonate, carbonate) but any higher will also burn our system. The highest pH we can comfortably swim in is about 9.

For swimming we can have a pH between 6 and 9.5 However the extremes of pH will not be satisfactory on a Sanitation of functional point of view. This is explained under Chlorination.

On a functional point of view, as most swimming pools are constructed either by concrete and metal piping and components (pumps, valves) etc. very low pH will cause corrosion and lead to premature destruction of the components. Concrete walls will slowly etch out and if the walls are tiled, the tiles will also be corroded, become rough and lose the sheen giving the pool a very distasteful and aged look. Therefore the pool should not have water with a pH below 7.

On the other hand if the pH of the water is maintained at very high pH (above 9) then considering the cause of the increase usually due to Carbonates or bicarbonates or hydroxides (byproduct of Chlorination) the increase will cause scaling. Scaling is the deposition of insoluble carbonates on to the surface of the tiles or pipes. The scaling on the tiles create a rough surface that can cause bruises to swimmers and also cause the tiles to lose the sheen. The scaling in the pipes will ultimately block the pipes and reduce the circulation rate, turnover time and effective sanitation. The blocking also can cause increase stress to the pump and filter and will reduce the life of the equipment. Therefore it is necessary by carrying out regular pH tests and adding chemicals and to correct the pH if required.

**Correction of pH**

If the pool is acidic, it can be corrected by adding Sodium Carbonate or Bicarbonate to bring the right pH If on the other hand the pool is alkaline as it often is (the result of Chlorination) acidic salts such as Sodium bisulfate or Hydrochloric acid sometimes called muriatic acid) is added.

The diagram on Figure summarizes the effects of pH on the pool and the chemicals needed to restore the pH to the correct range.

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caused by

acidic makeup water or acid rain and Chlorine gas

caused by liquid/solid

Chlorine sanitize addition alkaline makeup water

|----------------|----------------1----------------|----------------|

6.5 7.0 7.2 7.5 pH 7.8 8.0 8.5

Skin & eye irritation
Corrosion
Etching of plaster or tiles
Excessive use of sanitation agent

Preferred pH level range

Eye irritation
Scaling
Cloudy water
Sanitation ineffective (for Chlorine only)

Raise pH with Sodium Carbonate

(Soda Ash) or Sodium Hydroxide

Lower pH by adding Hydrochloric Acid or Sodium Bisulfate

**Effect of pH on the swimming pool water chemistry**

**b) Total Dissolved Solids (TDS)/ Conductivity**

The total dissolved solid is the amount of dissolved solids in the pool water. The solids in the dissolved form would be Carbonates, Bicarbonates, Chlorides, Nitrates, and Sulfates of Sodium, Potassium, Magnesium, Calcium etc. which may enter the water either by the top up of the water or addition of chemicals. The total dissolved solids described are conductors of electricity and can be determined by the measurement of conductivity. there is a firm relationship between Total Dissolved Solids and Conductivity. The relationship is roughly the TDS is about 0.7 -0.75 times the Conductivity. TDS is expressed in parts per million. (PPM).

The increase in TDS would eventually affect the sanitation efficiency as well as the taste of the water. Further the high TDS would promote sedimentation or scaling of the surfaces of the pool and cause roughness or unsightly appearance. The maximum TDS usually recommended for swimming pools is about 2000 ppm. When this level is reached either the pool is drained and refilled or a portion of the water is replaced with fresh lower TDS water. If the pool is inefficiently chemically treated the water change requirement would be frequent and substantial.

The causes of increased TDS are as follows:

Chemicals - added to maintain the water balance and sanitation

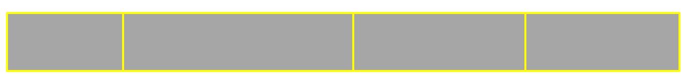
Hard makeup water- high TDS

Evaporation- Concentration of the water by evaporation

**c) Alkalinity**

Alkalinity is the measure of the presence of the buffering capacity in the water. The chemicals that actually control the alkalinity are the Carbonates and bicarbonates. Total alkalinity or m- Alkalinity measures both and p-alkalinity measure only the Bicarbonate levels. The pH levels of each component are indicated in the diagram below.

$H^+$ ion $HCO_3^{--}$ ion $CO_3^{--}$ ion $OH^{--}$ ion



|----------|-----------|----------|----------|----------|---------|---------|

**5 6 7 8 9 10 11 12**

**pH value**

On titration with acid Phenolphthalein change color at 8.3 when all the Bicarbonates have been converted to Carbon dioxide. The use of Methyl Orange as an indicator for titration will change color at 7 when all Hydroxides, Carbonate and Bicarbonates are neutralized. The alkalinity using Methyl Orange as an indicator is the M-Alkalinity or total Alkalinity**.**

Alkalinity is measured in parts per million Calcium Carbonate.

The buffering action is as follows:

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Let us say that the pH of the water is about 7.4. When any alkaline substance is added to the pool the Carbonate converts to Bicarbonate and keeps the water below 8.2. When acidic substance is added to the pool Carbonate converts to Bicarbonate to maintain the water in the Bicarbonate range. The buffering action is limited and not indefinite. As our body is quite sensitive to pH changes below 6 and above 10 the buffering action protects the water from extremes of changes of pH. Alkalinity also affects the pool appearance. If too low it may be green and if too high the water would be cloudy.

The proper or acceptable range for Total Alkalinity for swimming pools is between 100 and 160 PPM.

**Problems associated with unbalanced Alkalinity.**

|----------|----------|--- -----|---------|---------|

40 80 100 120 140 180 200 220

ppm Alkalinity

correct range

Low pH
pH fluctuation (no buffer)
Corrosion
eye irritation(effect of low pH)
Green water

High pH
Cannot adjust pH
Cloudy water
Sanitation ineffective

Adjustment of Alkalinity is by adding Sodium Bicarbonate to the pool. If the pool has a very high alkalinity this can be adjusted by adding Hydrochloric Acid (Muriatic acid).

**d) Hardness**

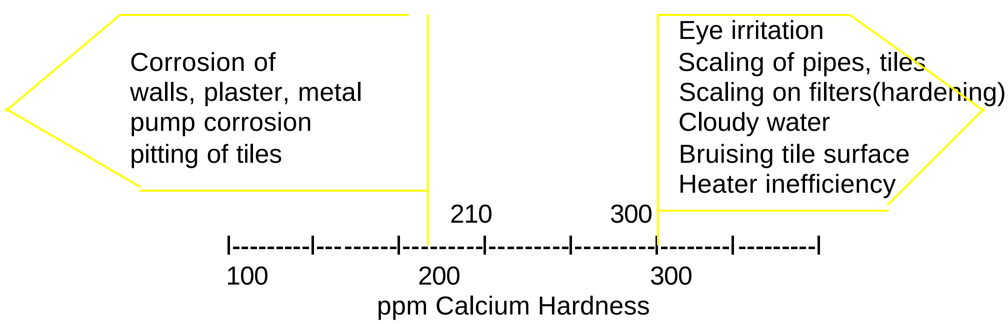
Calcium or Magnesium causes hardness in the water. They can be in combination with Bicarbonate (temporary hardness) or Carbonate or Sulfate (permanent hardness). The flat taste of hard water is the result of the presence of these ions in the water. Generally the Magnesium content is very small compared with Calcium, and Total hardness tests determine both the elements. Hardness is expressed in parts per million (ppm) of calcium Carbonate.

Hardness plays an important part in swimming pool water chemistry. This is purely in the functional point of view. Considering that most pools are made of concrete or tiles which all contain Calcium Carbonate of some kind, there will be a possibility of either the Calcium leaching out of the walls of the pool to the water (corrosion) or Calcium depositing on to the walls of the pool from the water (scaling). This will depend upon the Hardness of the water. The proper or ideal requirement is that neither should happen.

Therefore a degree of hardness is required to protect the tiles and pool surfaces from corrosion. Corrosion takes place when the Hardness is very low. This is often associated with low pH. Corrosion on the tiles or pool surfaces results in pitted tiles or surfaces and the loss of shine or luster or smoothness giving the pool the aged look. The life of the pool is also shortened.

If the pool water is too hard, then the reverse applies, i.e. There is scaling on the tile and concrete surfaces. The scales are in the form of small crusts which also give a motty appearance to the pool tiles and walls. Also the tiles will be rough and cans cause bruises to swimmers on contact. Scaling will also be present in the pipe inner walls and progressively the pipes get clogged and affecting the water circulation and giving greater load on the pump out necessitating the complete change of the pipes and possibly the damaged pump. Filters can be caked by the Calcium deposition and compromise the filtration ability and increase the backpressure causing more damage to the pump. A Hardness balance is therefore a requirement for a well-maintained pool. The range of hardness recommended for the pool is between 170 - 300 PPM

**Effect of Hardness on swimming pool**




## e) Scaling & Corrosion

### Scaling

This is an important topic to deal with in all water circulation systems. Scaling has been discussed under hardness, TDS and alkalinity and pH. Scaling problems can cause quite significant damage to the pool function even if the pool owners are willing to put up with unsightly pools it causes.

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Roughness of the tiles and walls of the pools create problems to the swimmers as they can cause severe bruising. This can give rise to damage claims in public swimming pools. Functionally the pool is harder to disinfect as the conditions of adequate disinfection would not be fulfilled because of associated pH changes. More Chlorine (if used as a disinfectant) may be required and this can be very costly. Scaling in the pipes causes constriction of the pipe and reduced flow rates and increased pressure. Rust can occur in metal pipes rid with scale. Eventually the pipes and other metal parts will have to be changed at very high cost. This is in addition to the changing of the tiles. As we have already mentioned the caking on the filter surface that occurs because of pressure, associated scaling will cause to form a cement like hard layer and completely block out filtration and water flow, damaging the pumps and possibly bursting of pipes. As scaling tendency is directly proportional to the hardness, control of the hardness would alleviate the problem.

BY
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