

# Water chemistry

## 2.2.2 Hard versus soft waters

**Hardness** is defined as the sum of the concentrations of **divalent cations** in water. In most cases, it is essentially the sum of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ , both expressed in mg/L. Various other chemical conditions, however, are associated with hardness and its converse, **softness**. Hardness and **alkalinity** are usually closely correlated because they are derived in large part from a common source—**dissolution** of **limestone** ( $\text{CaCO}_3$ ). Hard waters tend to be high in **total dissolved solids** (TDS) and have relatively high pH ( $> 7$ ). Soft waters tend to have low TDS and lower pH. They also tend to be more corrosive to metals and more susceptible to **acidification** by atmospheric acid deposition (because they have less **buffering capacity**). We will use the terms hard water and soft water as shorthand way of describing these broader chemical characteristics.

Hardness – жорсткість

divalent cations – ['daɪveɪlənt 'kætɪənz]

Alkalinity - лужність

dissolution – розчинення

limestone – вапняк

total dissolved solids - загальна кількість розчинених твердих речовин

susceptible – сприятливий

acidification – підкислення

atmospheric acid deposition - відкладення атмосферної кислоти

buffering capacity - буферна ємність

## 2.2.3 Water quality significance of the major and minor ions

The major ions generally do not have negative ecological effects over the concentration ranges at which they occur in fresh water, although elevated salt levels in waters of arid climates can cause problems for agriculture. None of the major ions causes serious health issues for humans within the ranges found in fresh waters, but several ions raise concerns related to human health and drinking water quality.

**Sodium** is implicated in **cardiovascular disease**. **Chloride** causes a salty taste in drinking water, and the **drinking water standard**† for  $\text{Cl}^-$  is 250 mg/L. **Sulfate** also causes taste problems (bitter or **astringent taste**) and has a **laxative effect** at high

concentrations. This can cause **diarrhea problems** for travelers to areas with much higher sulfate concentrations in drinking water than found in their home environments (and also for infants living in such areas), and the drinking water standard for sulfate is 250 mg/L.

**Calcium, magnesium, and potassium** are essential mineral nutrients for humans and aquatic organisms, and the presence of these ions in water is considered beneficial for human health. The hardness cations, primarily  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ , nonetheless cause household problems—soap precipitation causing poor **lathering** and ineffective cleaning, mineral deposits on glassware, and limestone deposits in hot water heaters and pipes. As a result, if high hardness is not removed by a central (municipal) water treatment plant, **consumers** often choose to remove it from their water by **point-of-use ion-exchange softeners**, which replace each  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ion with two  $\text{Na}^+$  ions. Central water treatment plants usually remove hardness by the **lime-soda softening process**.

**Fluoride** has well-known negative effects at higher concentrations. At concentrations only slightly above the optimum for tooth protection, it causes **dental fluorosis**. At higher concentrations it causes a condition called skeletal fluorosis, leading to joint stiffness, arthritic symptoms, and increased risk of bone weakening and fracture.

major and minor ions - великі і малі іони

sodium – натрій

cardiovascular disease - серцево - судинне захворювання

sulfate - сульфат

astringent taste – в'язкий смак

laxative effect - проносний ефект

diarrhea problems - діарея (пронос)

calcium, magnesium, and potassium – кальцій, магній та калій

soap precipitation – осадження мила

lathering – піноутворення

lime-soda softening process - процес пом'якшення кальцієво-натрієво

fluoride – фтор

dental fluorosis - флюороз

## Clarification & Flocculation

Microparticles particles are so small that they simply pass through the **filter media** without being trapped. To make matters worse, these particles develop a negative **electrical charge** and since the charges are all alike, they **repel** one another and do not **clump** together, which would otherwise make them easier to filter out. The addition of a water clarifier will solve this problem. A water clarifier contains a solution of positively charged particles that when added to water, will seek out the negative particles and neutralize their charges. The particles then tend to clump together and are easily filtered out. Clarifier will **reduce maintenance**, improve **filter performance** and **enhance the appearance** of the pool water. In unusual circumstances of severely **cloudy water**, such as you may experience at spring opening, the use of a liquid flocculant or “floc” can also be helpful. A floc works similarly to a clarifier; however, instead of helping to remove small particles through the filter, a flocculant coagulates the cloudy water particles into masses that **settle** quickly to the pool floor so that they can be vacuumed up easily. A liquid floc can be a real benefit in clearing up severely dirty pools in a short period of time. In contrast to the use of **alum based flocs**, these materials do not require **pH adjustment** or result in significant contamination of the water if the circulation system is returned to service before all of the alum has been removed.

Clarification & Flocculation - Освітлення і флокуляції

To make matters worse – на довершення

Clump – брила, збиратись в групи

reduce maintenance - зниження експлуатаційних витрат

filter performance – показники фільтра

enhance the appearance – поліпшити зовнішній вигляд

severely cloudy water - сильно каламутна вода

settle – осідати

pH adjustment – регулювання pH

## pH

pH is the term used to refer to the degree of activity of an **acid** or **base** in the water and is the most important chemical factor in swimming pools. pH is measured on a scale from 0 to 14 with 7 being neutral. A pH value between 0 and 7 is considered acidic with 0 being the greatest acid activity and getting weaker as it

approaches a value of 7. A value of 7 to 14 is considered basic with 14 being the greatest base activity. Pool water pH is best kept in the range of 7.2 to 7.8. When pH remains below 7.2, the water is considered to be corrosive. Maintaining the pH higher than 7.8 will increase the tendency to form **scale** or cloudy water. Calcium, the major component in scale, is a relatively unstable mineral and when the pH is high, the calcium is not as soluble and it will have a greater tendency to precipitate or “fall out” of solution resulting in cloudiness or scale. High pH will also reduce chlorine effectiveness resulting in the need to maintain higher chlorine levels to achieve maximum **sanitization**. If the pH is low, sodium carbonate, otherwise known as pH Up or soda ash, is added to raise the pH. If the pH is high, pH Down is used. pH Down comes in two forms: liquid acid (muriatic acid) or dry acid (sodium bisulfate)

scale – накип

sanitization – знезараження

muriatic acid – соляна кислота

sodium bisulfate – сульфат натрію

## **IRON**

When dissolved in water, iron is colorless but will react almost instantly with chlorine or other oxidizers to produce a rusty red color in water, or worse, orange colored staining. As little as 0.1 ppm of iron is all that is needed to result in colored water and stains. The most common source of iron in pool water is the fill water.

0.1 ppm - Part per million.

## **COPPER**

A common cause of green water and stains ranging in color from blue-green to black is copper. **Copper** sources are more varied than iron. Copper can enter the pool water from corrosion or galvanic activity in copper heaters, from **copper-based algaecides** and from the source water. Copper problems are often indicated by pool water with a true clear green color, whereas green water caused by algae would be green and cloudy. Copper, not chlorine, is also the responsible agent when hair or fingernails turn green.

copper-based algaecide – альгіцид на основі міді

## **TOTAL DISSOLVED SOLIDS**

**Total dissolved solids** (TDS) are normally the least worrisome factor. TDS is the sum of all materials dissolved in the water and normally runs in the range of 250 ppm

and higher. There is much discussion over what levels are considered too high, but there is no real lower limit.

Total dissolved solids – загальний солевміст

## **SANITIZATION**

The process of controlling bacteria in the water is known as **sanitization**. Sanitization is not to be confused with the control of algae in the pool water, as algaecides are best used for that purpose. While a wide variety of methods for sanitizing pools are available, the two most common methods are chlorine and bromine. Other processes have also gained more attention, including PHMB (**biguanide**), ozone and **ionizers**. Each has its strengths and weaknesses.

Sanitization – знезараження

PHMB (biguanide) -polyhexamethylene biguanide -  
полігексаметиленгуанідин бигуанидов,

Ionizers - іонізатори

## **Free Chlorine**

Free chlorine is actually composed of two types of compounds: HOCl (hypochlorous acid) and  $\text{OCl}^-$  (hypochlorite ion). This is important because they exist together in a condition or state known as **equilibrium**. This means that together they make up 100% of the free chlorine content, but that content consists of some of each. It is important to note that only the HOCl component is effective as a sanitizer. Therefore, it seems logical that we would want as much of the free chlorine as possible made up of the HOCl. However, the level of HOCl and  $\text{OCl}^-$  present is dependent upon the pH.

HCl — [eɪtʃ si: el]

HBr — [eɪtʃ bi: a:]

H<sub>2</sub>SO<sub>4</sub> — [eɪtʃ tu: es ou fɔ:]

CF<sub>4</sub> — [si: ef fɔ:]

Cu<sub>2</sub>O — [si: ju: tu: ou]

2H<sub>2</sub>+O<sub>2</sub>=2H<sub>2</sub>O – [tu: eɪtʃ tu” pl^s tu: gɪv tu: eɪtʃ tu: eu]

H<sup>+</sup> - univalent positive hydrogen ion

Cu<sup>2+</sup> - divalent positive cuprum ion [dai`veilent...]

Al<sup>3+</sup> - trivalent positive aluminium ion [traiveilent...]

Cl<sup>-</sup> - negative chlorine ion

## Combined Chlorine

Free chlorine is highly reactive and once added to water, quickly attacks bacteria as well as bather and other wastes. When this occurs, the chlorine is no longer considered free chlorine but rather its form has changed and is now referred to as **combined chlorine**. Bather and other wastes are largely made up of **ammonia** and **nitrogen compounds**. Combined chlorine is very stable, but has little or no sanitizing ability. Not only is combined chlorine a very poor sanitizer, it is the agent responsible for eye burn and skin irritation and results in the unpleasant chlorine odor often referred to as a pool with “too much chlorine”. It is therefore critical for bather health and comfort that combined chlorine be controlled and kept to a minimum. It is preferable that combined chlorine levels are kept to a maximum of 0.2 ppm.

combined chlorine – зв'язаний хлор

ammonia - аміак

nitrogen compounds – азотні сполуки

## Total Chlorine

This is the sum of the free chlorine and combined chlorine levels. To determine the combined chlorine level, first measure the free chlorine level and then the total chlorine level and then subtract the free chlorine reading from the total reading. The difference in values is the combined chlorine level.

<http://youtube.com/watch?v=kiSkSTYkJVo>

So here's a list of some of the most important **qualities** or parameters that we need to **measure** in order to set a **water quality standard** which is also known as the **water quality index** or WQI for short. Among these parameters we have **total suspended solid, total dissolved solids, turbidity, pH, conductivity, dissolved oxygen, temperature, phosphate, nitrate and fecal coliform or ecoli**.

So now joining me to discuss more in depth. Some of the most common ones from this list that we just read total dissolved solids, total suspended solids and particulates in water can be measured by a test called that ability test. In this test you have a cylindrical long and transparent tube with a colored surface at the bottom as seen in the picture at the bottom right. So as the cylinder is filled with water it becomes more and more hard to appreciate the color differentiation at the bottom.

Once the bottom is no longer appreciable then we start filling it with water and we measured the height it took us no longer to see the bottom.

pH is a measure of how **acid** or **basic** also known as **alkaline** a liquid **solution**. The pH scale ranges usually at room temperature from 0 to 14 and 7 is considered neutral pH. If the value is below 7 the water is considered acid. If it's above 7 is considered alkaline.

Conductivity of the water refers to how well can electricity pass were conducted through the water. The electricity passage is allowed by ions and metals dissolve in water such as salt.

This oxygen is also an important parameter as oxygen needs to be dissolved in water for living organisms. There isn't a high percentage of dissolved oxygen in water fish among other organisms may die. The deeper you go in the water the less oxygen you'll find dissolved in it .

Temperature is another important parameter and just states how cold or warm the water bodies.

Phosphates and nitrates are an important one. This may be found to reach water bodies after these bodies been in contact with fertilizers, pesticides, cleaning compounds and some rocks. The important thing about these chemicals phosphates and nitrate is that the person allows for algae and plankton to grow up rapidly in water bodies as any other aerobic organism. These organisms need oxygen to survive so the more of them the more oxygen consumption therefore less dissolved oxygen in water for fish to breathe. which will eventually cause them to die.

Finally another important parameter to measure is fecal coliform which is actually measured by counting the amount of e.coli bacteria found in water. This bacteria comes mainly from human and animal feces and it's most frequently used as a parameter that determines water quality and **contamination** sources.