The vast majority of us depend on tap water for all our needs both domestic and industrial This is the same tap water that we use to drink, cook, wash and bathe in, and our water companies claim that it is amongst the safest and highest quality mains water available in the EU (yet the sales of bottled water have never been stronger!). At that same time, we are told that the quality of our tap water is the underlying (and often overlooked) cause of many chronic health problems.

It is standard practice to add certain additives to water to make it safe or better for human consumption (chlorine, fluoride) as our water companies have a legal responsibility to provide us with water that is safe to drink.

Time for a little chemistry.

Water and the solutes dissolved within it are made up of ions.

Ions are atoms that are electrically charged and are commonly the building blocks for other molecules. The charge may be positive or negative, depending on the type of ion, with every ion having a charge, which cannot change. In electrolysis, which involves the use of two oppositely charged electrodes (negative and positive) to separate out ions in a solution, the positive electrode is called the anode and the negative electrode is called the cathode. Consequently, negatively charged ions are attracted to the positively charged anode (and are therefore called anions), where as the positively charged cations are attracted to the negative cathode.

For example, if salt (sodium chloride) is put into water, it dissolves and then dissociates into two separate ions - a positive sodium ion (or cation, Na^+), and a negatively charged chloride ion (or anion, Cl^-). So in solution, sodium chloride no longer exists and it's ions are free to move and combine with other ions of an equal and opposite charge.

Consequently, all ions can be split into two groups; the positively charged cations such as calcium, magnesium, sodium, iron (all metals) and the negatively charged anions such as bicarbonate, carbonate, chloride, sulphate, nitrate etc.

Fortunately, the vast majority of impurities and inconsistencies between our tap water and that of pure water are due to an excess of specific ions. And as these ions will either have a negative or positive charge, with a little applied chemistry, we can target and remove these offending ions using water purifiers.

Carbon filters

There are many different grades of carbon, ranging from granulated activated carbon (GAC) to ultra compact coconut shell carbon. If this filter is used to filter out sediments, then iron and even calcium will plug up the microscopic areas of adsorption, shortening its effective life considerably, so sediment pre-filtration is recommended. The carbon filter removes a host of contaminants such as chlorine, pesticides, herbicides and other organic materials that could not be removed by ion exchange in the later cartridges.

What is the difference between absorption and adsorption?

A sponge absorbs water into the inside of its porous structure. Ion exchange resins are not porous and so we describe the action by which they attract and retain ions on to their surface as adsorption.

There are several new generation adsorptive media that seek to replace or improve upon the purifying performance of activated carbon. Some are natural media, while others boast patented technology that enables them to adsorb most heavy metals and dissolved gases.

Next: Dealing with the dissolved ions.

After these first two media have worked on the raw tap water, there should only be a significant quantity of inorganic compounds remaining as ION's, which can then be removed using ion exchange technology.

What is ion exchange?

Ion exchange is a reversible chemical process in which the specific ion (such as sodium, Na^+) are released from the insoluble solid medium (which is the ion exchange resin) and exchanged for none-desirable or target cations such as heavy metals. There are two types of ion exchange that can be caused to occur within a water purifier; that which removes target cations and that which removes target anions.

Ion exchange was first discovered in 1845 by an Englishman called Thompson who passed an ammonia-rich solution of manure through some ordinary garden soil, only to discover that the ammonia content of the liquid manure was greatly reduced. It was later shown that the soil contained fine particles of a natural material called zeolite which would even later be shown to have ion exchange properties. We still of course use zeolite today to remove unwanted ammonia from pond water. The water industry has not looked back since, but developed better and more efficient media to do the job of water purification.

How Cation exchange works.

Cation exchange resins are usually made from an inert compound called polystyrene-divinylbenzene which is heated in its manufacturing process with concentrated sulphuric acid, causing a sulphonic group (SO3-) to be permanently fixed on to the structural chemistry of the resin beads. Because these sulphonic groups have a negative charge, they can be charged with positively charged ions (cations) typically sodium (Na+), potassium (K+) or even hydrogen (H+). When tap water containing dissolved cations (such as heavy metals) pass by the resin, then these are exchanged for, and trade places with the loosely held sodium ions on the resin. There will come a time when no more cations can be removed by a fully reacted resin which is then described as being 'exhausted', and which must then be replaced. The better a resin is protected by pre-filtration from fouling contaminants such as iron and chlorine (which can actually cause the resin polymer beads to disintegrate), the longer it's active life will be. Cation exchange resins will remove most metallic, positively charged ions such as barium, cadmium, copper, iron, manganese, zinc, calcium and magnesium.

Consequently, if the flow rate has been sufficiently slow and there has been sufficient active areas for Cation exchange on the resin, then the levels of contaminant cations would have been reduced, and retained within the resin. All this leaves is the negatively charged contaminants or anions which must then be removed before the water can be used.

How anion exchange works.

Anion exchange units use a different resin that works in the opposite way to a Cation exchange resin. It is charged with either chloride (Cl-) or hydroxyl (OH-) ions, which will then be released into the pond water in exchange for the less desirable contaminant anions. Anion exchange removes nitrates, sulphates and other negatively charged ions.

Mixed bed ion exchange.

As the term suggests, these ion exchange media contain both anionic and cationic exchange media, combined as one as a mixture. To ensure that there is efficient purification, mixed bed ion exchange resins are usually used in a series of multiple cartridges, preceded as ever, by at least a carbon filter and at best an additional fine micron mechanical pre-filter.