Understanding the Science of Pure Water and how you can use it's natural powers!

The chemistry of water alone is a vast subject with many connotations and effects, so I have tried to simplify the descriptions as best I can. Please forgive me if I have not accurately addressed some of the more "involved" questions you have. I would however, be very happy to answer in great detail any questions you have if you send them on to me in the future.

H2O

Water is of course otherwise known as H2O. This being a molecule (more than one atom connected together) made of one Oxygen atom and two Hydrogen atoms. It is relatively a small molecule as well. A lot smaller than the atoms or molecules (compounds or chemicals) that can dissolve in it. This size is important as we will see later when discussing filtration.

This molecule has a very important characteristic. It is what we call "Polar". Just like the earth has two separate and opposite poles, North and South (magnetic opposites), there is an electrical version of this polarity which we describe as "positive" (+) and "negative" (-).
You will be familiar with the positive and negative terminals on a battery. That is the same electrical polarity that the water molecule experiences.

An atom (Hydrogen or Oxygen) has positively charged protons (nucleus – centre) and negatively charged electrons in a "cloud" type arrangement around the centres of the protons.

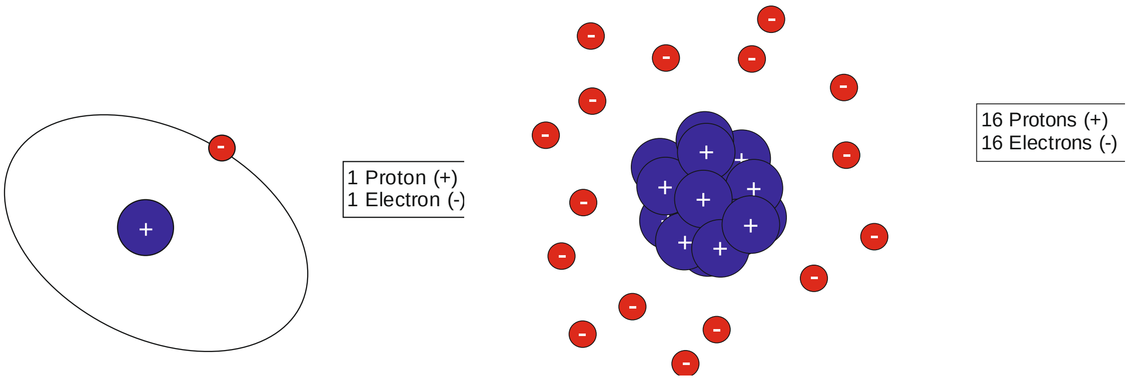

Fig. 1

Now, these electrons tend to gather towards one end of the water molecule, leaving more on one end than the other, so the crowded side has an excessive negative electrical charge, leaving the other end or side more positive.

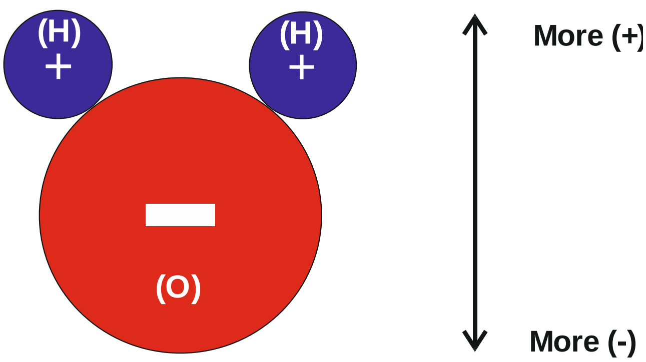

Fig. 2

This results in a Polar body of atoms (molecule) that start to attract the opposite poles of the other water molecules on all sides.

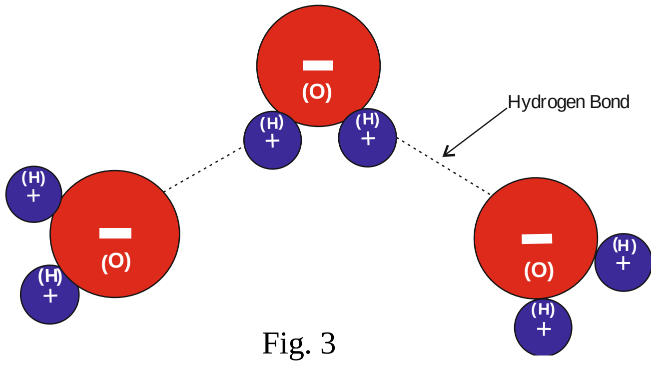

Fig. 3

So these inter molecular attraction pulls all the molecules together making a denser crowd. This results in water as we see it. It is quite heavy and difficult to separate or disperse.
This polar quality makes water quite unique within its family of similar molecules because it would be expected that H_2O would be a gas like CO_2 (Carbon dioxide) or O_2 (Oxygen). The attraction or link between each water molecule is called THE HYDROGEN BOND.
It has a lot to answer for!

What's IN Water?

Well, H_2O of course. But when we ask that question, we don't really mean that do we? We know "there are all sorts in the water". So let's use what we learnt about the structure of water and go deeper. What we are asking about is what is in between or amongst the water molecules. Generally, we can divide these things into two types.

The first is the things that are not actually dissolved in the water. They may appear as if part of the water, but in fact they are very small fine particles of a substance that have dispersed evenly throughout the water and often discoloured or changed the appearance of the water. For example, a muddy puddle of water or a cloudy pond, look the way they do because of tiny dust like particles held between the water molecules. The water molecules are unchanged and the mud or dirt is unchanged. They are just mixed together like different coloured marbles. In some cases, the polarity of the water contributes, but let's just keep this simple!

Even milk is a similar arrangement, except that the white fat globules are liquid not solid like dirt or mud. They produce a similar appearance but are called a suspension and unlike the solid particles, normal filtration will not separate the water from the fatty oils. So this first type of situation is when the substances in the water can be physically removed by filtration or settle out, if left standing. They have not changed their structure or the structure of the water. This is not an aqueous solution.

The second type of situation is when the substance in amongst the water molecules is actually physically changed in state i.e. from a solid (lump of sugar/salt) to a liquid state. This can not be filtered or separated as in the first example. The solid has broken up and each individual atom or molecule is now surrounded by water molecules. The polarity of the water has caused this.

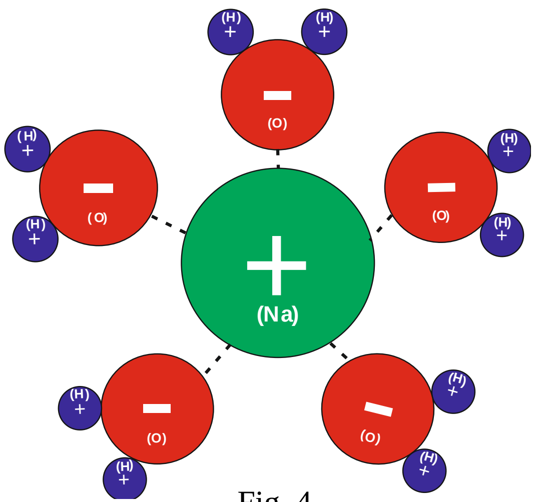

Fig. 4

This has happened because the substance has an electrical polarity of its own, but this time, when out of water, it creates a crystal (salt). This crystal is held together by electrical charges, but when placed in water, the negative parts of the solid are torn away by the positive ends of the water molecules and the positive parts of the solid get the same treatment from the water molecule's negative ends. We call this dissolving in water and forming a solution.

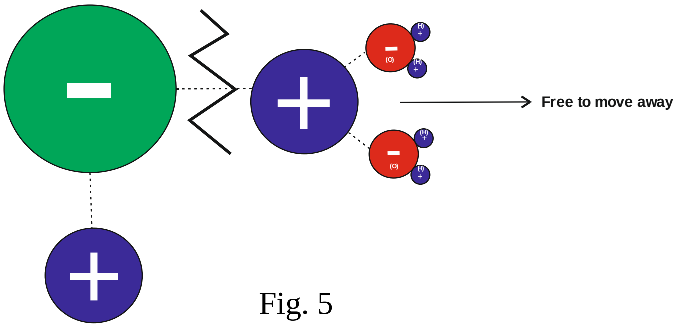

Fig. 5

Now we all know that not everything dissolves in water. So, why some and not others? It's down to the structure again. The compounds that dissolve in water are called Ionic compounds. They have the electrically charged element available to easily join up and move in the water.

Not all ionic substances dissolve in water freely, but let's just focus on the structure to simplify the concept.

This explains why grease and oils do not mix with water or dissolve in water. They do not have this charged polarity or structure and so there is no attraction between the water molecules and the oil molecules etc.

So to summarise

Dirty water is just holding particles that we see as discolouration and you can filter these out. Clean tap water appears colourless but has a lot of ionic compounds (minerals) dissolved into it, which have become part of the whole new structure.

The Concept of "Pure" Water Simplified

In order to really appreciate what this topic is about, we must use the correct terminology. So the following pages will define, clarify and even give you definitive numerical values for water purifying and levels of purity. Whilst some of this may seem overkill for the pure water cleaning contractor, I want to give you the ammunition to cut down the B.S that you will no doubt be told by all sorts of people.

Units of "Purity"

The first terms you need to know are the units that the purity is measured in. The most commonly referred to is ppm. This stands for "Parts per Million".
What is agreed is that 1mg (one thousandth of a gram) when added to 1 litre of water and it dissolves (remember what type of compound this needs to be) it produces a solution of 1ppm of mineral i.e.

1 milligram of salt dissolved in 1 litre of water = 1ppm salt (Nacl)

This is suggesting that there is one million times more water than the salt added. There is only one part of a million units of water that is the salt.

Let's appreciate the physicality of 1ppm of salt. Think about an IBC tank. This is the big white caged plastic tank in a cube shape that you see on lorries or sitting in yards. These tanks hold

1000 litres of liquid. So to achieve 1ppm solution, we would need to add 1 gram of salt i.e. the size of a small sugar lump to 1 full IBC tank of water. When it is fully dissolved, we have 1ppm water solution of salt. It's not a lot is it? This is an important image to consider because the whole point of pure water window cleaning is that the glass is left free of any mineral spots or streaks. So you will need to question – what is pure enough before spots are seen? This is a common argument I hear and ultimately a subjective point.

To keep this in perspective, the ppm of minerals in the water we have delivered to our houses varies from as low as 25ppm (Scotland) to 700ppm (South Coast). This occurrence is due to the ground composition that the rain water falls on or is collected in.

This brings us to the next term – TDS – meaning Total Dissolved Solids in the water.

This is how some testing instruments deliver a ppm reading.

So – 1ppm = TDS of 1

Notice this describes "dissolved" solids so we are talking about a solution.
You will see later how important TDS readings are for you when choosing the right equipment and approach to your cleaning.

Another related term is ppb – or parts per billion. This is just a fraction of a ppm.

i.e. 1ppm = 1000ppb

So as soon as the TDS reading on your tester shows less than 1ppm, you are dealing with ppb.
So just a fraction below 1ppm may be shown as:
999ppb = 0.999ppm. We are now dealing in ppb. Every handheld TDS meter will show "000ppm" (scale 1 – 999ppm) when testing deionised water that has just been produced using a column of mixed bed resins. This means that the water produced is containing less than 1ppm, so it will in actual fact be water that can be described as ppb water. We just don't know if it's 1ppb or 900 ppb. Keep this in mind when claims of a special new technique say that purification has been taken to new realms. It's all a matter of what units of measurement you use to describe an effect.

Probably the most useful term and unit used is conductivity. This is the measure of how easily an electrical current passes through a solution. The units are science/meter or more appropriately to our scope of science here micro-siemens µs/cm-1.

It is in actual fact conductivity that is measured by all the electronic meters that we use to measure water purity. The meter then converts the reading to TDS (ppm) so we can use the data to compare values.

The micro-siemen (µs/cm) is related to the ppm range as follows:

1ppm (TDS) = approx 2 µs/cm

But only at these very low levels can you approximately double the TDS value at higher levels it is almost 1:1 ratio.
So let's go as low as we can so you can see where the purity range realistically starts. If you measure the conductivity of just water with only the water molecules contributing to this reading you get 0.005 µs/cm at 25oC . That is 55 thousandths of 1 µs/cm. This also equates to another term used, particularly in the USA, of 18 megohm (mΩ/cm). "18 meg" is accepted as the best we are going to get.

But this "special" water does need special attention. As soon as it is exposed to air, the conductivity increases tenfold due to the CO_2 extracted from the atmosphere. It even needs to be stored in special vessels, as plastic or glass will leak in contaminants.

What are the industry standards?

Thankfully, some people have got together and set some reference standards with different grades to guide us. There are 4 recognised bodies.

- ISO 3696 (1987)
- ASTM (D1193-91)
- NCCLS (1988)
- Pharmacopeia

We will use the first 2 to simplify things. The ISO body we all recognise in the UK as they apply standards to everything and the ATSM is the American society.

		ISO 3696 (1987)			**ASTM (D1193-91)**			
Contaminant	**Parameter**	**Grade 1**	**Grade 2**	**Grade 3**	**Type I***	**Type II****	**Type III*****	**Type IV**
Ions	Conductivity at 25 °C [$\mu S \cdot cm^{-1}$]	0.1	1.0	5.0	0.056	0.1	0.25	5.0

Fig. 6

The Water Fed Pole industry does not talk in terms of ASTM type 2 or 4, this is the realm of the chemists. Just calling water pure, as you can now see is wholly inaccurate and could mean many things. You need to focus on the conductivity or ppm of the water in question so you can at least compare to the table above. However, all that said, what do you need to clean effectively? Any of the above will do a good job, but it’s up to you if you now want to meet a recognised standard.

<u>One final point on terms</u>
We might call it deionised, demineralised, distilled, RO or filtered water. Get it right that it is all the same with the same qualities. Those names just describe what we did to achieve the purity it possesses. It is the conductivity or ppm that matters. The lower these values are, the more capacity the water has to dissolve and hold in solution.