How would it affect your coffee if you stopped using a water filter? Answers from a sensory perspective

How different tap water types affect the flavour of coffee and espresso

A BRITA WHITE PAPER

BRITA

1. Abstract

In the hotels, restaurants, and catering (HoReCa) sector, as well as in most other businesses where coffee and/or espresso[1] are prepared for large numbers of people, the realisation prevailed many years ago that, in the vast majority of cases, the tap water used needs to be treated first. The Specialty Coffee Association (SCA) makes detailed specifications for doing this in its *Water Quality Handbook* [1]. The principal goal pursued with filtration technologies is to protect coffee machines from scale and other deposits or, worst-case, irreversible damage from corrosion. However, this article focuses on the sensory effects that using *unfiltered* tap water can have on coffee. It describes in detail the possible impacts they can have on the most commonly occurring water types worldwide, namely water containing chlorine and/or organic compounds, 'scale water', 'gypsum water', softened water, 'salty water', soft water and 'very soft water'. For each water type, one or more appropriate filtration technologies are then briefly presented, and the expected positive sensory effects described.[2]

2. Introduction

The road to coffee which is good-tasting in every respect is long and winding, with many forks that lead to dead ends. Coffee is a demanding beverage: a diva that is unforgiving of mistakes, punishing every one with loss of flavour. A wide range of factors have to be skilfully managed down through the value chain to achieve a cup of coffee that genuinely delights the senses. Along the way, filtration of the brewing water is often justified by arguing that it protects the coffee machine from deposits or corrosion. If you share this view, you're absolutely right – but did you know that filtering the water also adds value by enhancing the sensory experience of drinking coffee? This article examines the flavour of coffee and reveals in detail what actually happens in sensory terms when unsuitable tap water is used. It then also becomes clear that there are more reasons than one to filter the water.

This article is also intended to help you in another sense. If you've taken steps to protect your machine by suitably treating the water but still aren't satisfied with how the coffee tastes, there may be an alternative solution that achieves both goals, namely protection of the machine as well as good flavour. To cite just one example, central softening units have been installed in many modern, commercially used buildings to prevent unsightly scale spots and deposits in pipes and equipment. It could even be that you're renting and operating a gastronomic facility in a building where this is the case but you aren't aware of it yet. If so, this might be the reason why the coffee that you so meticulously prepare has a clearly pronounced roasting aroma and tastes bitter even though your coffee machine is protected from scale. In this case, a decarbonisation filter could mitigate the pronounced roasting aroma and bitterness to yield coffee with a more harmonious flavour profile. This and other aspects are discussed in the further course of this article.

[1] The statements in this white paper that refer to 'coffee' can generally also be applied to espresso.
[2] Although a favourable water composition is an important contributor to great-tasting coffee, it alone is no guarantee of success. It also depends on the choice of coffee beans, how it is prepared, and subjective perceptions. The statements made here about water quality and the associated sensory expectations presuppose the use of good-quality beans and correct preparation of the coffee.

3. Executive summary

- When water from precipitation percolates through the ground, it picks up other atoms and molecules along the way. Water therefore inevitably contains a blend of minerals and chemicals, and its exact composition – and therefore its properties – also varies from place to place.

- Water composition not only influences the sensory properties of the water itself but also those of coffee brewed with it. Coffee associations such as the SCA (Specialty Coffee Association) and the DKV (Deutscher Kaffeeverband = German Coffee Association) make specific recommendations on the ideal composition of coffee water.

- The overall sensory experience of coffee that is referred to as 'flavour' comprises three components: aroma (smell), taste and body (touch, an aspect of mouth-feel).

- BRITA has assigned the water grades that occur around the world to types and, where expedient, assigned names of its own invention to describe them more aptly. This categorisation is based on experience, and the nomenclature is *not* generally used in either science or ordinary language.

- All kinds of water except soft water mask coffee's full flavour potential [1] and deviate from the recommendations of the SCA and DKV for achieving 'good' coffee. However, there are definitely personal preferences that deviate from these recommendations; flavour preferences are often cultural in nature, in addition to being shaped by sensory experiences that individuals have in childhood.

- The principal water types and how they affect the sensory experience of coffee flavour can be summed up as follows:
  - When chlorine is present in water, even in small amounts, it reacts with substances in the coffee and can alter the resulting beverage's aroma profile in unpredictable ways. In all cases, filtering water with activated carbon is recommended for eliminating this erratically disruptive influence. Organic compounds can also impart an unpleasant odour and taste to water. As soft waters can also consistently or occasionally contain chlorine and/or organic substances, filtration with activated carbon is also recommended for them.

  - Certain substances contained in 'scale water' restrict the sensory effect of natural coffee acids by converting them into substances that do not taste sour. This can in turn amplify the sensory impact of other flavour-defining factors such as bitterness and roasted aromas. Decarbonisation reduces scale-forming ions while also allowing a higher share of acids to persist, resulting in a balanced coffee flavour.

  - Although 'gypsum water' and 'scale water' leave different kinds of deposits, their negative sensory effects on the coffee are comparable. The filtration technology of softening, which is the right choice for protecting the coffee machine from 'gypsum water', can increase bitterness and roasted aromas while keeping the sourness low. Coffee of this kind is widely preferred in Italy and other Southern European countries.

- ◦ Northern Europeans, many of whom don't enjoy the coffee flavour that results from using softened water, can decarbonise it in an additional step to mitigate bitterness and roasted aromas while increasing the coffee's sourness. The coffee tastes more harmonious as a result.
- ◦ 'Salty water' with very high concentrations of sodium and chloride ions occurs in some coastal areas, for example in Spain. In rare cases in which both types of ions exceed the limits of the European Drinking Water Directive, the coffee can taste salty. This makes it expedient to reduce them by demineralisation or reverse osmosis followed by (selective) remineralisation and filtration with activated carbon.
- ◦ In 'very soft waters', the levels of the substances required for coffee flavour to develop are below the thresholds recommended by the SCA and DKV. The natural acids contained in coffee are inadequately buffered as a result, causing the flavour balance to tip excessively in the sour direction. To reduce its sourness, it's necessary to systematically add ions to the water using a mineralisation filter. This neutralises the acids and restores a harmonious balance of flavours.
- ◦ Soft waters, provided that they consistently contain no chlorine and/or organic compounds, are the only ones that reliably yield good-tasting coffee without the need for filtration. The substances they contain fall within the range recommended by the SCA.

- The described effects only apply to black coffee and espresso and not to coffee-based mixed drinks like cappuccino.

4. Why does it make sense to filter the water for making coffee?

Open a textbook and you'll find a definition of water that goes something like this: 'a chemical compound with a molecule comprising two hydrogen atoms and one oxygen atom (H_2O).' However, chemically pure water doesn't occur in nature. Water is known as a universal solvent because it is able to dissolve a wide range of other substances. When water from precipitation percolates through the ground, it picks up other atoms and molecules along the way. So the water we encounter in our everyday lives (in oceans, lakes, rivers, groundwater and tap water etc.) inevitably contains a blend of minerals and chemicals, and its exact composition – and therefore its properties – also varies from place to place.

Other substances dissolved in the water can cause technical problems in coffee machines (for example, by leaving scale deposits) and detract from or alter the flavour of coffee brewed with water containing them. To achieve a flawless cup of coffee with an optimal, harmonious flavour, it's therefore important to avoid certain substances such as chlorine and organic molecules and adjust its mineral content to a 'good' level. The specifications of coffee associations indicate the acceptable concentrations of different minerals. [1]

5. Aroma, taste, body and flavour: what's the difference?

We humans use five senses to perceive food and drink: sight, hearing, smell, touch and taste. In the case of coffee, three are particularly important: smell, taste and touch:

- We use the olfactory bulb, a brain structure at the back of our nose, to smell substances that give off odours (so-called odour-active substances). These define the **aroma** of coffee. Aromas can also be perceived retronasally: when we take a sip of coffee, the aromas migrate from the oral cavity into the nose and reach the olfactory bulb via this route.

- We use our tongue and its receptors to detect the five basic tastes: sweet, sour, salty, bitter and savory (often called by its Japanese name, umami). Together they define the **taste** of a food or beverage. We're unable to taste anything else. For example, if coffee has a chocolaty aroma we don't actually taste it but only smell it (an example of retronasal perception).

- The surfaces of our mouth are covered with tactile nerve endings which let us feel the consistency of a food or beverage, which is called mouthfeel. In the case of coffee, **body** is one of several tactile sensations. It is usually defined as the perceived viscosity, weight or fullness of the coffee as we swirl it around in our mouth. [2]

These three sensory inputs combine to create the overall sensory impression of a coffee's **flavour**. In a narrow sense, flavour is therefore a composite of aroma, taste and mouthfeel. More broadly, it is also defined by what we see, hear and feel with our hands. [3]

If you ask ten coffee lovers what 'good' coffee is, you'll receive an equal number of different answers. Every coffee drinker has their own definition of 'good' coffee, and it can vary greatly depending on family or regional customs. Some people, for example, prefer coffee with a distinctly sour note, while others favour a bitter taste. Nevertheless, coffee experts agree that, for the majority of people, a harmonious balance of flavours is important for a 'good' coffee. All of the relevant sensory dimensions – like aroma, taste and mouthfeel – should be in an equilibrium relative to one another. No single attribute – such as sourness, bitterness, fruitiness or roasted aromas – should dominate, and the coffee's body should be neither too thin or watery nor too thick or heavy.

Overview of water types and the most popular filtration technologies and how they can affect the flavour of coffee

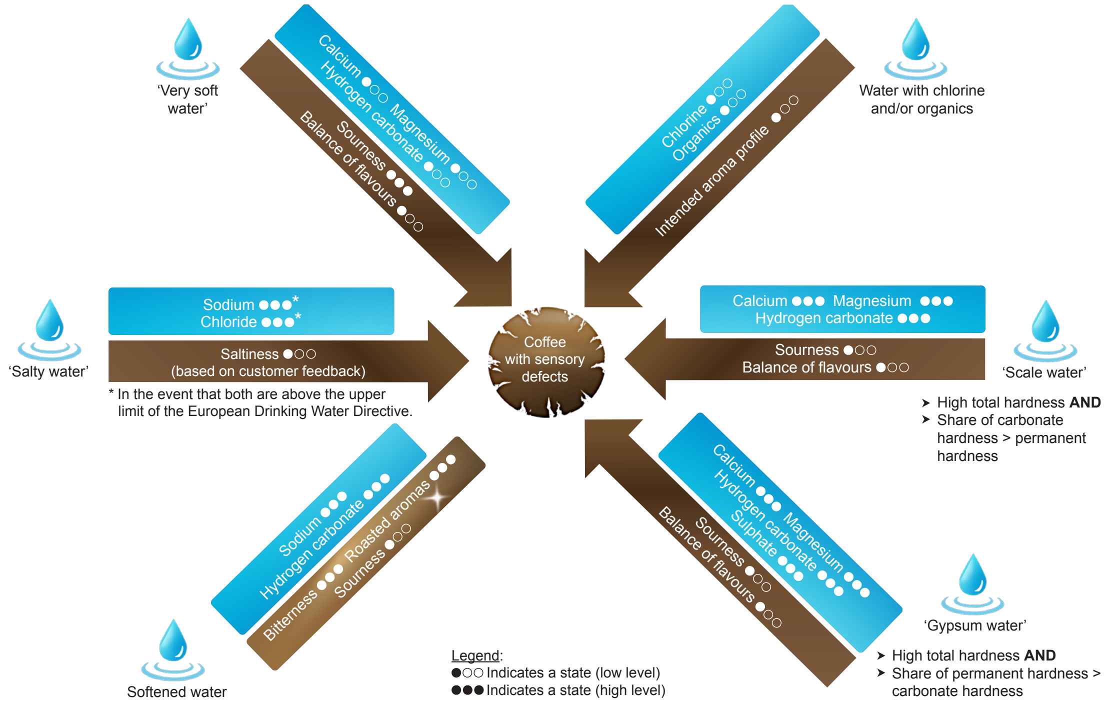

Figure 1: Different types of water, the excess or lack of sensorily relevant ingredients (except sulphate) and resulting negative effects on coffee.

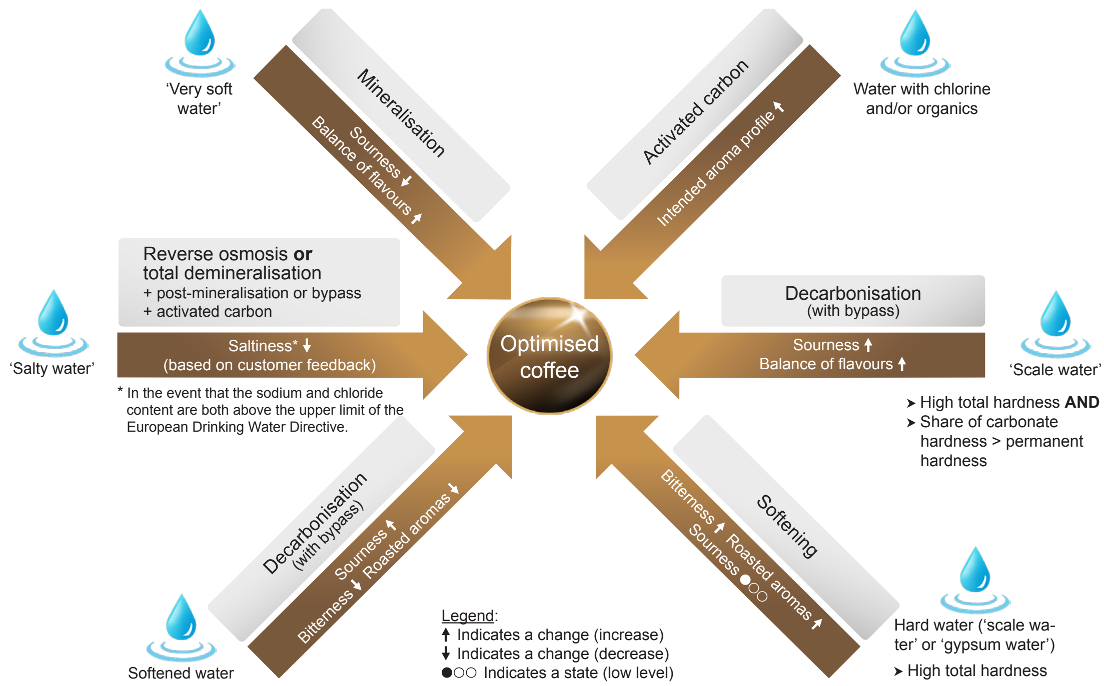

Figure 2: The positive sensory impacts of different water treatment technologies on coffee depending on the composition of the initial water.

6. Types of water[3]

In the vast majority of industrialised countries, tap water can be used to make coffee without any health concerns.

In the following, first the most common types of tap waters and the sensory relevant substances they contain are presented and then the ways in which they can affect the sensory experience of drinking coffee are described in greater detail.

Various water treatment technologies are available for getting close to the optimal water composition that various coffee associations recommend. The most appropriate technology for each water type is roughly presented below while thoroughly explaining how it improves the flavour of coffee. The technical details of ways to prevent coffee machines from accumulating deposits are only briefly sketched.

6.1 Water containing chlorine and/or organic compounds

Chlorine is often added to tap water by municipal waterworks to disinfect it and prevent recontamination. It has a distinctive taste and odour. Even if you don't smell it at the moment, it can occasionally be present. Using a filter with activated carbon is always essential for consistently preparing good-quality coffee. The reason is that chlorine is highly reactive and readily combines with organic compounds in the coffee, therefore altering their structure and sensory properties. [4]

Chlorine used for disinfection also impart a markedly unpleasant flavour to the resulting brew and should therefore be removed. This is most commonly accomplished with activated carbon filtration systems. [1]

Due to the chemical and sensory changes that chlorine itself undergoes when reacting with coffee constituents, the resulting undesirable changes in the aroma profile aren't directly attributable to it, despite the fact that it has caused them. It is therefore always advisable to filter water – including so-called soft waters – to reduce its chlorine content. Coffee associations including the SCA or the DKV recommend using water without any chlorine to achieve the best coffee brew. [1] [5]

[3] BRITA has undertaken a categorisation in 'scale water', 'gypsum water', 'salty water' and 'very' soft water based on extensive practical experience in connection with protecting coffee machines and other equip ment. These terms are helpful for explaining relevant aspects, but it should be stressed here that they are *not* generally used in either science or ordinary language.

Organic compounds in water can also induce an unpleasant odour and taste. They include, for instance, metabolic waste products from bacterial decomposition of leaves and other parts of plants. An example is geosmin, tiny amounts of which can give surface water, and consequently also drinking water, a foul, earthy or musty odour and taste reminiscent of beetroot or rain on a hot summer day [6].

Figure 3: Chlorine and/or organic compounds in tap water can diminish or impair the desired coffee aroma profile.

To illustrate this, whereas most people experience half a litre of water containing a single cube of sugar as sweet, they can still perceive the foul smell of geosmin when the same miniscule amount of it is distributed among more than 33 thousand milk tank lorries filled with water. Coffee associations like the SCA or the DKV recommend using water with no odour for the best coffee brew. [1] [5]

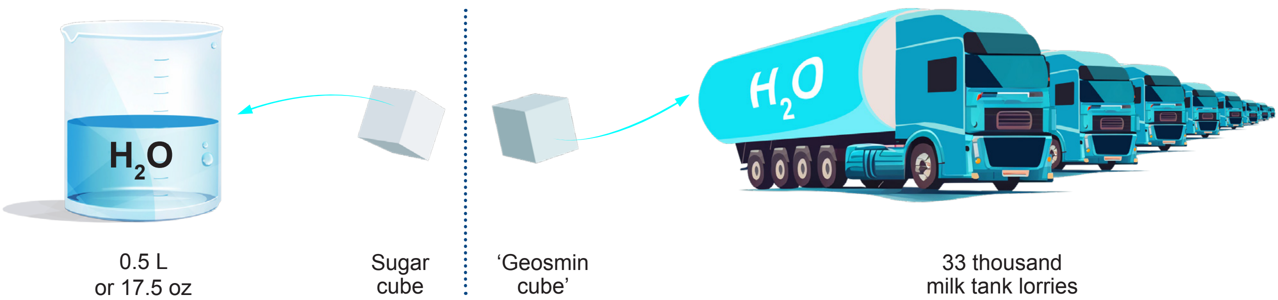

Figure 4: A sugar cube dissolved in half a litre of water is just above the perception threshold for most people. [7] In stark contrast, if the same amount of geosmin is added to the volume of water needed to fill 33,000 milk tank lorries with a capacity of 30,000 litres (= 7,925 U.S. gallons) each, it is still noticeable to most people. [6] This shows that we respond very sensitively to even the tiniest concentrations of geosmin in tap water.

To efficiently mitigate the adverse effects of chlorine and/or organic compounds on coffee's aroma profile, the tap or feed water needs to be filtered with activated carbon.

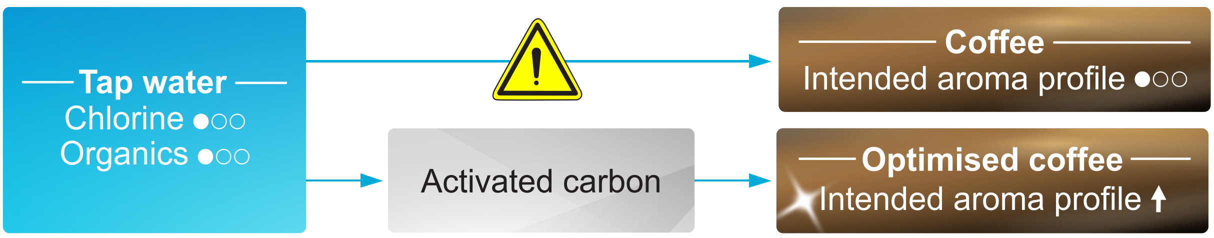

Figure 5: Chlorine and/or organic compounds can result in an unintended aroma profile in the coffee. Filtration technologies involving the use of activated carbon are an efficient way to reduce unpleasant sensory effects and allow the desired aroma profile to unfold.

6.2 Hard water (referred to here as 'scale water' and 'gypsum water')

Most European waters are 'hard', meaning that they pose a risk of 'hard' deposits that resist dissolving. In chemical terms, hard waters are characterised by high concentrations of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions on the cation side ($^{+}$) and a correspondingly large amount of hydrogen carbonate (HCO_3^-), sulphate (SO_4^{2-}), nitrate (NO_3^-) and chloride ions (Cl^-) on the anion side ($^{-}$)[4,5]. Summing up, all hard waters exhibit high total hardness as just defined.

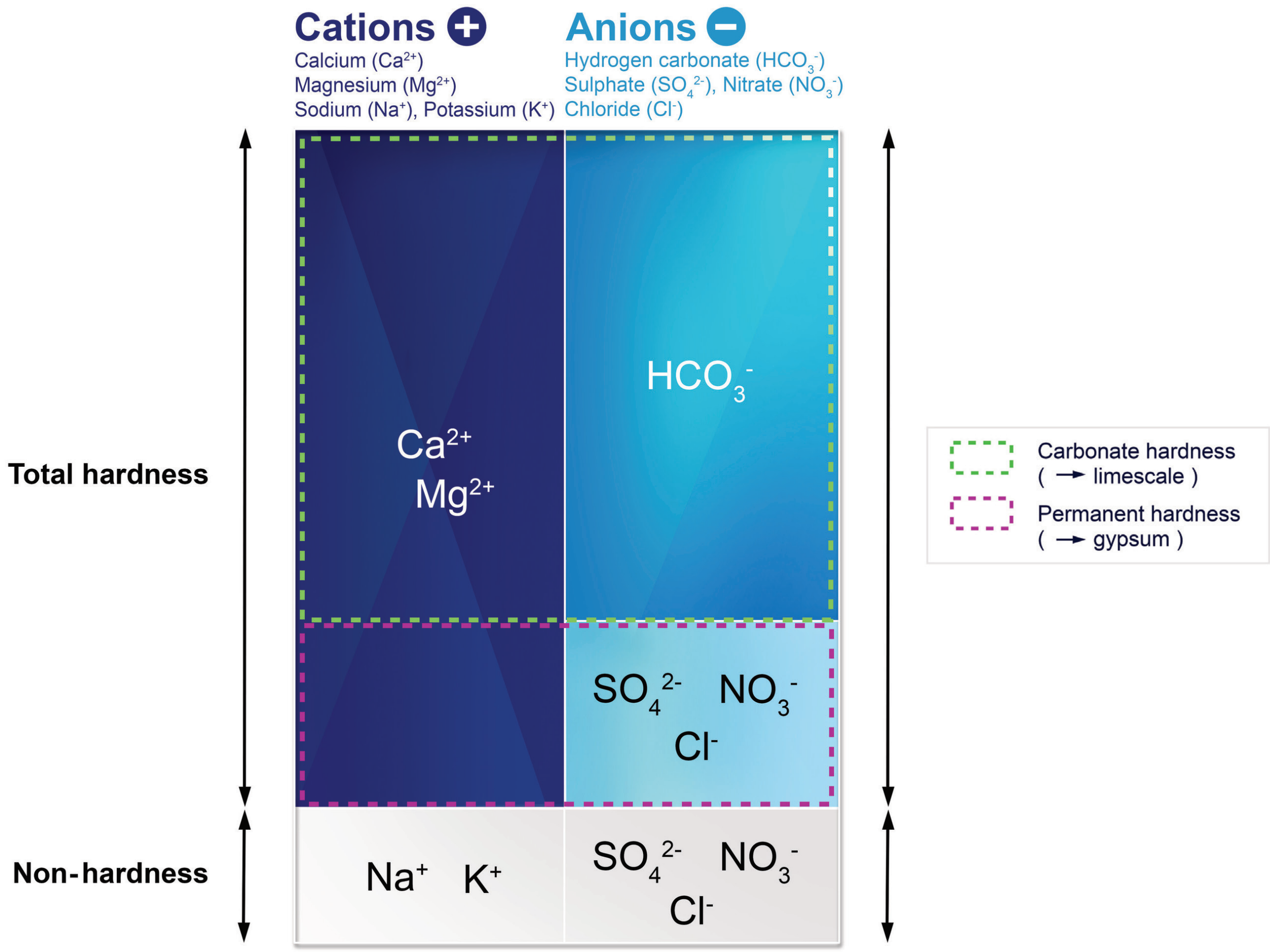

Figure 6: The most commonly occurring ions in European tap waters and their relative shares as they predominantly occur. The absolute quantities of the ions involved and their relative percentages in tap water can vary greatly, however. The shares of carbonate hardness, permanent hardness and non-hardness shown here broadly apply to most European waters but can vary significantly between countries and regions.

4 Sulphate (SO_4^{2-}), nitrate (NO_3^-) and chloride (Cl^-) only play a minor sensory role.
5 BRITA defines water with a total hardness >6°dH (≙>107 ppm $CaCO_3$) **and** a carbonate hardness >5°dH (≙>89 ppm $CaCO_3$) as 'hard'.

Within this definition, there are two types of hard water. **Carbonate hardness**, also known as temporary hardness, because the resulting deposits can be removed with acid, accounts for the lion's share of the total hardness in one type. The other is dominated by **permanent hardness** caused by mineral deposits that are impossible to dissolve with acidic solutions or by other means.[6] Carbonate hardness refers to the amount of hydrogen carbonate associated with calcium and magnesium ions dissolved in water, and when it is high BRITA classifies it as **'scale water'**, a reference to the calcium carbonate ($CaCO_3$) deposits that it can leave. The second type is referred to by BRITA as **'gypsum water'**, owing to the fact that the dissolved minerals responsible for permanent hardness can form gypsum deposits ($CaSO_4$) when heated. This is illustrated in the following graphic:

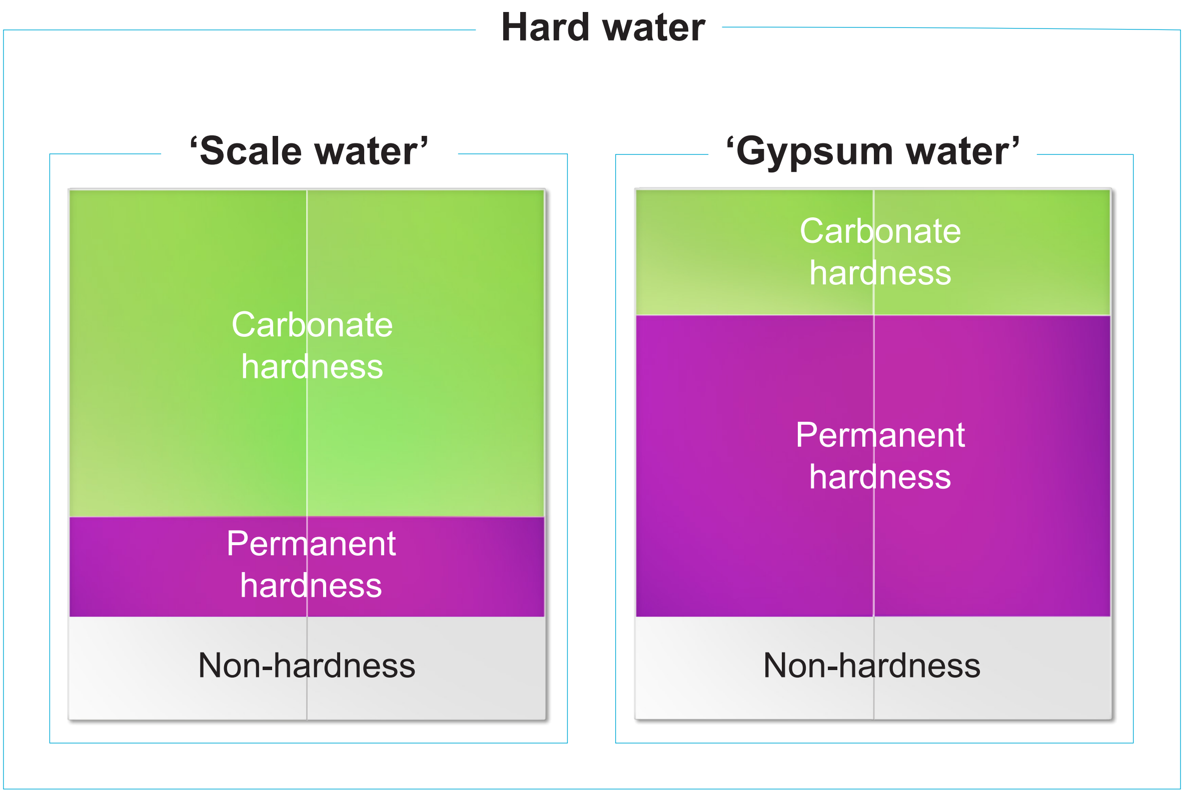

Figure 7: Example distributions of carbonate and permanent hardness in 'scale water' and 'gypsum water'. Together they constitute the total hardness.

[6] Within Europe, carbonate hardness predominates in about 70-85% of all waters, with permanent hardness being more pronounced in only about 10-15%. This is the case, for example, in southern France around Nice and Marseilles and in eastern Germany. 'Non-hardness', a term used by BRITA to designate the ion content of water that leaves no deposits, is much less common in Europe, accounting for only 5-10%; it is most commonly found in countries with long coastlines like Spain, as well as in and around the city of Amsterdam. This statement is based on around 5,000 water samples from various European countries that were analysed in BRITA's laboratory between 2010 and 2020.

But how does hard water affect the flavour of coffee?

The flavour of coffee results from a combination of aroma, taste and body. **Calcium and magnesium ions**, which occur in large quantities in both 'scale water' and 'gypsum water', are required in order to extract the full range of complex coffee aromas. Excessive amounts, however, can result in overextraction and should therefore be avoided. [1] [8].

Hydrogen carbonate is a major ingredient of 'scale water' [9] and can greatly reduce the coffee's perceived sourness [8] [9] by reacting with the acids in it and converting them into substances that lack their sour taste.[7] The effect of neutralising coffee acids on the beverage's overall sourness depends on the share of hydrogen carbonate in the water relative to the proportion of coffee acids with which it can react.

Gypsum water' usually contains quite a bit of hydrogen carbonate as well as a considerable quantity of **sulphate**. Although the presence of sulphate can cause problems by clogging coffee machines with gypsum deposits (calcium sulphate, $CaCO_4$), its effect on the coffee's sensory properties is minor compared to that of hydrogen carbonate.

To sum up, although 'scale water' and 'gypsum water' differ in terms of their hydrochemical composition and the kinds of deposits they cause in coffee machines, broadly speaking their sensory impact on the coffee's flavour is comparable. This is due to the fact that both water types contain large amounts of sensorily relevant calcium, magnesium and hydrogen carbonate ions.

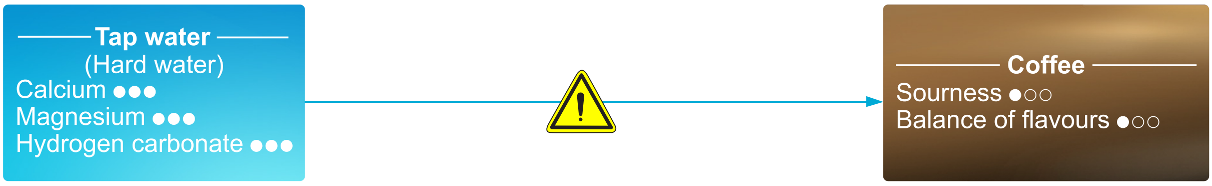

Figure 8: Hard waters contain considerable amounts of calcium and magnesium ions as well as hydrogen carbonate. This can reduce the sourness present in the coffee, resulting in a flavour imbalance.

Either decarbonisation or softening filters can be used to protect coffee machines from scaling. As two different technologies are available for dealing with 'scale water' and these yield different results in sensory terms, the choice of filtration technology is a major factor, along with the coffee beans and mode of preparation, for steering the coffee's flavour in the desired direction. The only option for preventing gypsum deposits is the use of softening filters.[8]

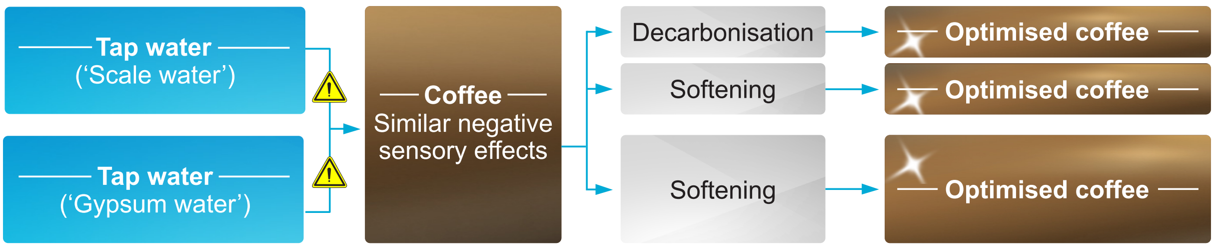

Figure 9: 'Scale water' and 'gypsum water' result in coffee with similarly unfavourable flavour profiles. Either decarbonisation or softening can be used to protect a coffee machine from limescale deposits, but they produce different results in sensory terms. The use of softening technology is essential with 'gypsum water'.

[7] In sensory science, the terms 'sourness' and 'acidity' are used interchangeably, but 'sourness' is much more common. This white paper employs the term 'sourness' when describing taste, and the term 'acidity' in chemical contexts.

[8] Caveat: both reverse osmosis or total demineralisation can be used to filter all kinds of water (except soft water and 'very soft water'). However, these two technologies aren't always the best choice. Due to their nearly universal usability, they are separately discussed in section 6.7.

Good to know

In hard waters with a high concentration of calcium, magnesium and hydrogen carbonate ions, it's the **hydrogen carbonate (HCO_3^-) that has the biggest impact**. This is because, in addition to directly affecting the perceived sourness, it also indirectly impacts other sensory attributes of the coffee. Why is this? It's simple: the perfect cup of coffee has a harmonious balance of multiple sensory factors such as **sourness, bitterness, various aromas and body**. Altering any one of these can also influence how the others are perceived. For example, while enjoying a cup of coffee you might notice a slight bitterness in addition to pleasantly fruity sourness. When using the same coffee beans in the same way but at a different location, greater hydrogen carbonate content (HCO_3^- → hard water) there may (directly) buffer most of the acids, therefore (indirectly) letting the bitterness and roasted aromas of the coffee's flavour profile come to the fore. The resulting taste may not appeal to every palate, however [1] [9].

Sourness, controlled by the amount of hydrogen carbonate, is just one of the most important factors which influence the balance of flavours. But altering one of them will also change the others. The causal relationship between hydrogen carbonate on the one hand and the development of sourness on the other is demonstrable, replicable and therefore controllable. Where other factors affecting the flavour balance are concerned, like aroma, body and bitterness, the link is often fuzzier and therefore harder to control. This is why sourness occupies a higher level in the graphic below.

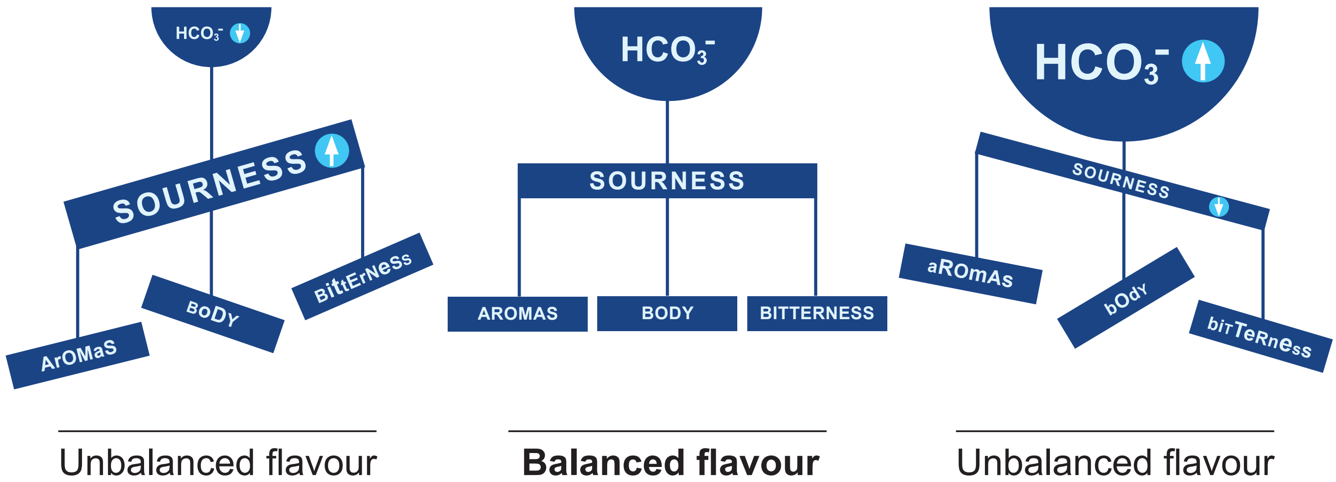

*Figure 10: **Balanced flavour:** The 'right' amount of hydrogen carbonate (HCO_3^-) results in coffee with a desirable balance of sourness, aroma, body and bitterness. To achieve it, the SCA recommends brewing with water that has a carbonate hardness of 2-4 °dH or total hardness of 3-10 °dH. Although this parameter plays an important role in achieving great-tasting coffee, it isn't the only one. **Unbalanced flavour:** Too little or too much hydrogen carbonate can increase or decrease, respectively, the coffee's sourness, which can in turn affect other flavour parameters as well. The influence on the sensory parameters of aroma, body and bitterness of other substances contained in water is significantly harder to predict.*

6.2.1 'Scale water' and decarbonisation

'Scale water' is characterised by a high concentration of calcium and magnesium ions in association with hydrogen carbonate ions. The high level of hydrogen carbonate in particular prevents the natural coffee acids from developing their sourness by converting them into substances that *don't* taste sour, resulting in coffee with low sourness and consequently an unbalanced flavour profile. As a result, the coffee tastes 'flat', 'chalky' and 'heavy' [1]

However, if the tap water is decarbonised first this unleashes chemical reactions which ultimately reduce the amount of hydrogen carbonate in the tap water *before* it can react with substances in the coffee grinds. As a result, the coffee acids remain intact and so does the flavour balance.

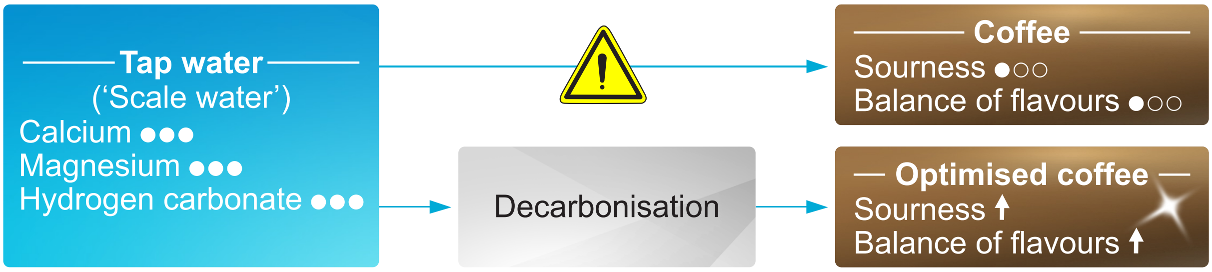

Figure 11: Decarbonisation of 'scale water' preserves the coffee's sourness and flavour balance.

6.2.2 'Scale water' and softening

If you want the coffee to taste 'typically Italian', in other words quite bitter with intensive roasted aromas and (unchanged) low sourness, this can also be achieved with 'scale water' by softening it first. The chemical process for this is described in somewhat greater detail in section 6.3. Coffee brewed with this water is quite popular with most consumers in Italy and other Southern European countries but less so in Northern and Central Europe.[9]

Figure 12: When dealing with 'scale water', a coffee flavour profile with pronounced bitterness and roasted aromas and (unchanged) low sourness can be achieved by softening.

[9] According to feedback that BRITA has received from customers.

6.2.3 'Gypsum water' and softening

When using 'gypsum water', as opposed to 'scale water', the only way to protect coffee machines from gypsum deposits is to employ softening as a filtration technology.[10]

In sensory terms, the results are comparable with those when softening 'scale water' (see section 6.2.2).

Figure 13: The only way to effectively protect coffee machines from permanent hardness is to soften it first. This results in a coffee taste with (unchanged) low sourness and pronounced bitterness and roasted aromas.

6.3 Softened water

For reducing gypsum deposits in pipes, fittings, water kettles, coffee machines and so on, some buildings have a central softening unit installed right where the water main enters. Softening is accomplished with a cation exchanger to which sodium ions (Na^+) are bound. Within the scope of the softening process, the calcium (Ca^{2+}) and magnesium ions (Mg^{2+}) in the water, which together with the hydrogen carbonate (HCO_3^-) are responsible for the deposits, are replaced by sodium ions in the cation exchanger.

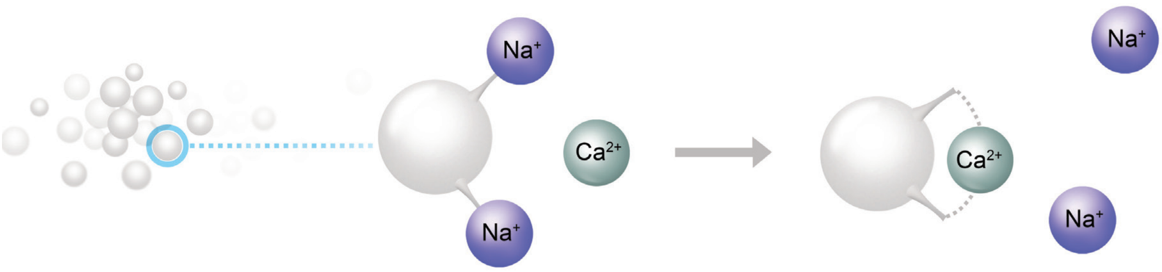

Figure 14a: A cation exchanger with two bound sodium ions (Na^+) exchanges these for a calcium ion (Ca^{2+}).

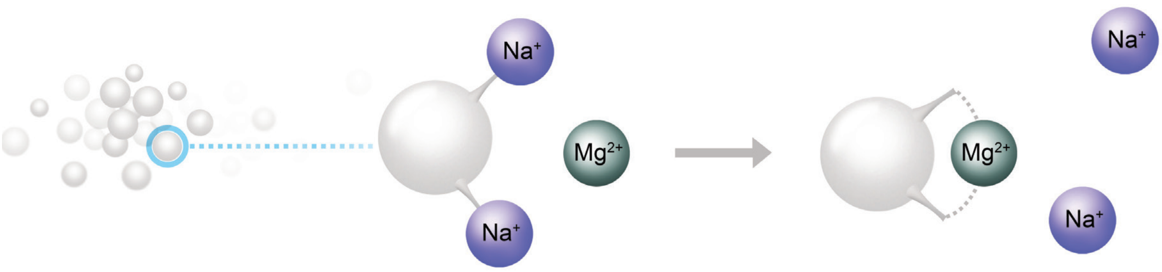

Figure 14b: A cation exchanger with two bound sodium ions (Na^+) exchanges these for a magnesium ion (Mg^{2+}).

[10] Caveat: both reverse osmosis or total demineralisation can be used to filter all kinds of water (except soft water and 'very soft water'). However, these two technologies aren't always the best choice. Due to their almost universal usability, they are separately discussed in section 6.7.

The still-high hydrogen carbonate content, which isn't affected by this process, can – together with the imported sodium ions – result in marked bitterness and intensive roasted aromas along with an (undiminished) low level of sourness in the coffee [10] [11]: when softened tap water is heated while making coffee, the sodium ions and hydrogen carbonate react chemically to form sodium hydroxide (NaOH), among other things. This markedly increases the pH of the wet coffee grinds and makes them swell, therefore slightly compressing them. The hot brewing water therefore takes longer to flow through them. This prolongs and intensifies the extraction process, with the water picking up more components that would otherwise resist dissolving. Afterwards the water still contains quite a bit of hydrogen carbonate, which buffers the coffee acids. The lack of sourness leaves room for both the bitterness and the roasted aromas of the coffee to dominate and be more prominently perceived. [10] [11] [12] Coffee prepared with this water tastes 'typically Italian' and is very popular with the majority of consumers in Italy and other Southern European countries.[11]

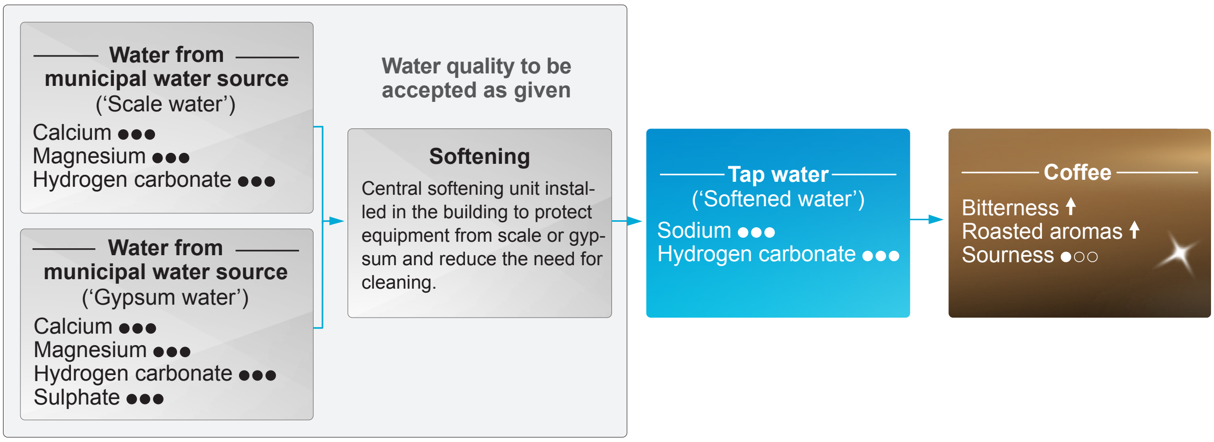

Figure 15: In this case, the result of pre-treating the initial (municipal) water with an in-house central softening unit is assumed to be the tap water quality. Water treated by a central softening unit contains a lot of sodium ions and hydrogen carbonate. When this water is heated during the brewing process ***and*** *passes through the coffee grinds, chemical reactions occur that can result in marked bitterness, intensive roasted aromas and an unchanged low sourness of the coffee.*

In Northern and Central Europe, most people aren't fans of this 'typically Italian' coffee flavour.[12] One way to temper bitterness and roasted aromas in the coffee is to pass the softened water through a decarbonisation filter. This lowers the still-considerable amount of hydrogen carbonate contained in it. The acids in the coffee are therefore buffered less, letting them develop better and taking the edge off the bitterness and roasted aromas. The coffee's taste profile becomes more balanced and harmonious as a result.

Figure 16: Too much hydrogen carbonate in the water can reduce the coffee's sourness, which has the effect of amplifying its bitterness and roasted aromas. In Southern Europe, many consumers prefer coffee that is prepared with this kind of water. In regions where this 'typically Italian' coffee taste profile is less popular, the undesirable sensory effects can be mitigated by decarbonisation.

[11] According to feedback that BRITA has received from customers.
[12] According to feedback that BRITA has received from customers.

6.4 'Salty water'

In some coastal regions, and more rarely in places with geothermal water (like from hot springs) and areas where potassium salts are or have been mined, the use of tap water increases the risk of corrosion. This can happen for various reasons. Most commonly, it is due to large amounts of dissolved chloride, sulphate and nitrate ions, with chloride ions posing the greatest risk. Apart from the absolute quantity of these ions, a role is also played by their relative amounts compared to other ions in the water, such as hydrogen carbonate. Although BRITA includes waters of this kind in the category of 'salty water', which is considered harmful to coffee machines, in most cases it doesn't cause either tap water or coffee made with it to actually taste salty. In exceptional cases, when the amounts of sodium and chloride ions in tap water exceed both the ceilings set by the European Drinking Water Directive **and** consumers' personal taste tolerances, the tap water may taste salty, and possibly also coffee made with it despite its intense and complex flavour.

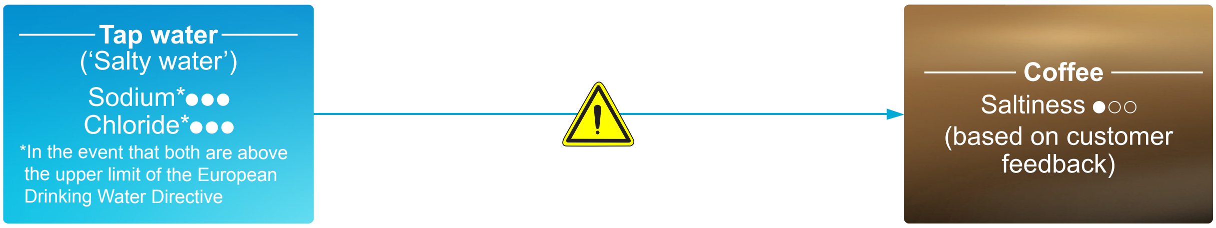

Figure 17: Salty-tasting water contains quite a bit of sodium chloride, which can in exceptional cases also give coffee prepared with it a salty flavour.

In these (rare) cases, the large amount of dissolved sodium chloride responsible for the salty taste can be reduced by reverse osmosis or total demineralisation. Regardless of which technology is chosen, either the equipment used should include a special mineralisation filter or else part of the tap water should be added unfiltered via a bypass to ensure the minimum amounts of calcium, magnesium and hydrogen carbonate ions required for the flavour to develop. In both cases, water that has been subjected to reverse osmosis or total demineralisation should be filtered with activated carbon to reduce any potential off-flavours.

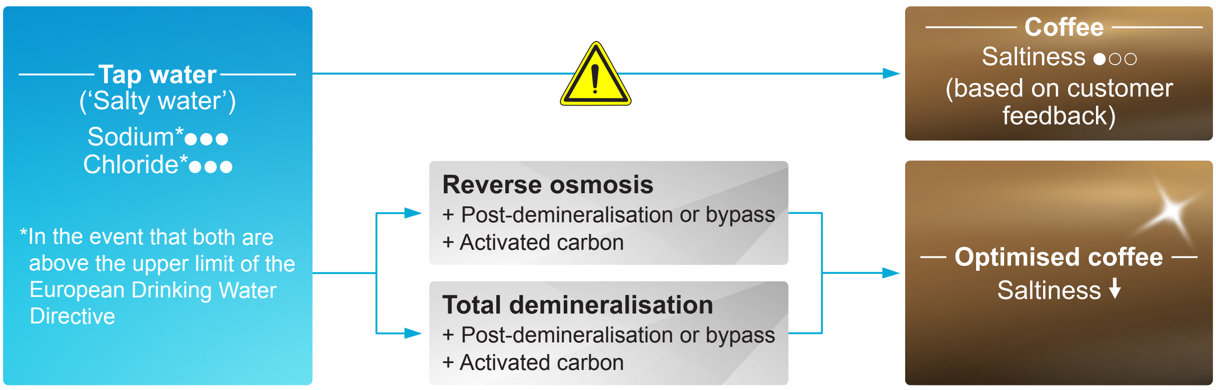

Figure 18: Too much dissolved sodium chloride can make coffee taste salty. This can be mitigated by reverse osmosis or total demineralisation.

6.5 'Very soft water'

This type of water contains very few calcium, magnesium, and hydrogen carbonate ions. However, a certain minimum of calcium and/or magnesium ions and hydrogen carbon is required in order for the coffee flavour to develop while preventing excessive sourness. [1] [8]

Figure 19: 'Very soft water' contains hardly any calcium and magnesium ions and hydrogen carbonate. This can result in coffee with extreme sourness and an unbalanced flavour.

Calcium and/or magnesium ions and hydrogen carbonate can be intentionally added to tap water to mineralise it. This tempers souness, bringing out the bitterness and roasted aromas of the coffee's flavour profile. The bottom line is a more balanced coffee taste.

Figure 20: To prevent 'very soft water' from resulting in extremely sour coffee with an unbalanced flavour, the water can be mineralised. For this purpose, controlled amounts of calcium and/or magnesium ions together with hydrogen carbonate are released into the water to enhance the extraction of coffee flavours and to offset the coffee acids. The result is an improved balance of flavours.

6.6 Soft water

This water is ideal for making coffee. [1] [5] It contains enough hydrogen carbonate to take the edge off the intense coffee acids, while the amount of hydrogen carbonate present isn't large enough to excessively neutralise the acids and take away the desirable degree of sourness. In addition, the amount of calcium and magnesium ions in the water is just right for extraction and achieving a balanced flavour.

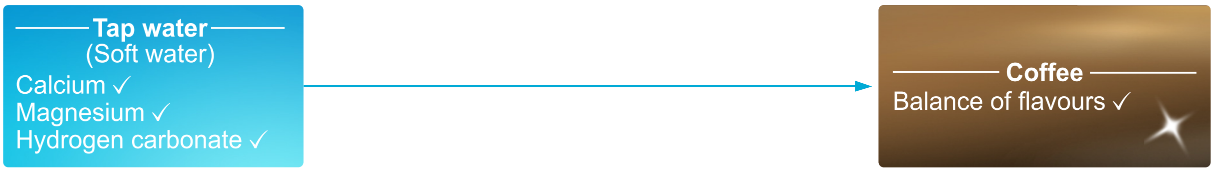

Figure 21: Soft water only contains small amounts of calcium and magnesium ions and hydrogen carbonate. As a rule, this results in a balance of flavours in which no single attribute stands out excessively.

The coffee associations make very similar recommendations on the best water for making coffee, deviating only very slightly from one another. By way of example, this table compares those of the SCA and the DKV:

Characteristic	**Specialty Coffee Association** (SCA) [1]	**German Coffee Association** (Deutscher Kaffeeverband, DKV) [5]
Total hardness	50-175 ppm $CaCO_3$ 50-175 mg/L $CaCO_3$ 2.9-9.8 °dH	54-143 ppm $CaCO_3$ 54-143 mg/L $CaCO_3$ 3-8 °dH
Alkalinity (SCA) also sometimes called carbonate hardness (DKV)	40-75 ppm $CaCO_3$ 40-75 mg/L $CaCO_3$ 2.2-4.2 °dH	54-107 ppm $CaCO_3$ 54-107 mg/L $CaCO_3$ 3-6 °dH
pH	6-8	6.5-8.0
Chlorine	None	None
Organics	None	The DKV has no specifications on this.
Odour	None	None

Conversions: ppm (parts per million) is equivalent to mg/L (milligrams per litre)
1 ppm of $CaCO_3$ corresponds to 0.056 °**dH** (**d**eutsche **H**ärte = German hardness)
1 °dH equals 17.9 ppm of $CaCO_3$

Even when soft water corresponds to the coffee associations' recommendations regarding calcium and magnesium ions and hydrogen carbonate, in practice it may still need to be filtered. This is because even water whose mineral composition makes it optimally suited for preparing coffee can consistently or occasionally contain chlorine and/or organic compounds. The deleterious effects of these on the flavour of coffee were described in section 6.1. As even tiny amounts of these can result in an undesirable deviation from the intended aroma profile, tap water should always be filtered with activated carbon.

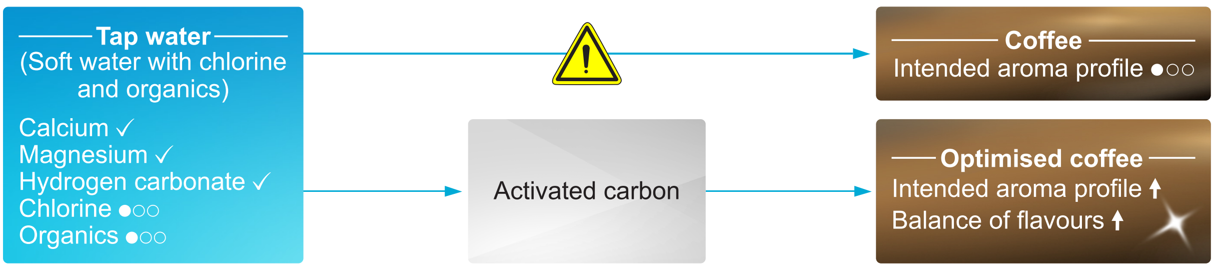

Figure 22: Even soft water that contains appropriate concentrations of calcium, magnesium, and hydrogen carbonate ions, and therefore ought to be ideal for making coffee, may also consistently or occasionally contain chlorine and/or organic compounds. Even minute amounts in the tap water can impair or alter the development of the desirable aroma profile. For best sensory results, soft water should therefore also be filtered with activated carbon.

6.7 All kinds of water

With the exception of soft water and 'very soft water', all of the discussed water types – specifically, water containing chlorine and/or organic compounds, 'scale water', 'gypsum water', softened water and 'salty water' – can be improved with reverse osmosis or total demineralisation. Both reverse osmosis and total demineralisation remove nearly all of the ions in the water (regardless of their types and quantities). Independently of which technology is chosen, either the equipment used should include a special mineralisation filter or else part of the tap water should be added unfiltered via a bypass to ensure the required minimum amounts of calcium, magnesium and hydrogen carbonate ions. This is important to take the edge off the intense coffee acids while, in the vast majority of cases, leaving just the right amount of ions in the coffee water for extraction and achieving a balanced flavour.

At first glance, both of these filtration technologies may seem simple and therefore quite tempting, as they can be used with all kinds of tap waters (except soft water and 'very soft water'). In order to make the best choice in a particular case, it's naturally also important to consider initial and subsequent costs, space requirements, time required for installation and maintenance work and other factors. In the case of 'scale water' – in other words, water with excessive carbonate hardness for making coffee with a balanced flavour profile – a decarbonisation filter is overall an effective and economic solution while taking all relevant aspects into account. An experienced customer service representative can generally be counted on to provide sound advice.

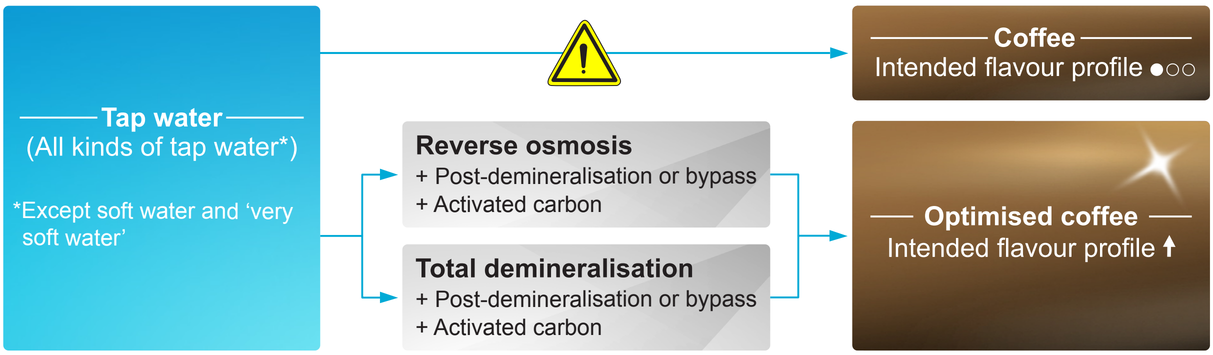

Figure 23: Almost any tap water can be turned into water that's excellently suited for making coffee: with either reverse osmosis or total demineralisation, in each case followed by post-mineralisation or addition of untreated tap water via a bypass and activated carbon filtration as the final step.

7. Conclusions

The substances that occur in tap water can vary greatly, impacting the flavour of coffee in equally diverse ways. Although its taste ultimately depends on many factors, there are a number of verified causal relationships between the chemistry of water and the sensory experience of drinking coffee made with it. The most important substances that need to be monitored and adjusted are ions (calcium magnesium and hydrogen carbonate), while chlorine and organic compounds should always be minimised as much as possible. Depending on their type and concentration, they can alter the overall flavour profile or, worst-case, turn drinking coffee made with it into a disappointment despite use of the best beans and careful preparation.

As there is no single, universally preferred coffee flavour, it's also impossible to provide a generally valid water specification. Despite this, the recommendations of coffee associations, experts and companies define ranges for relevant substances for preparing coffee that tastes good to many people. Those who are familiar with how certain constituents impact the flavour of coffee can additionally adjust the water to get even closer to the flavour that they personally prefer.

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BRITA SE (Headquarters)
Heinz-Hankammer-Strasse 1 | 65232 Taunusstein | Germany
Tel. +49 6128 746-5765 | professional@brita.net | www.brita.net