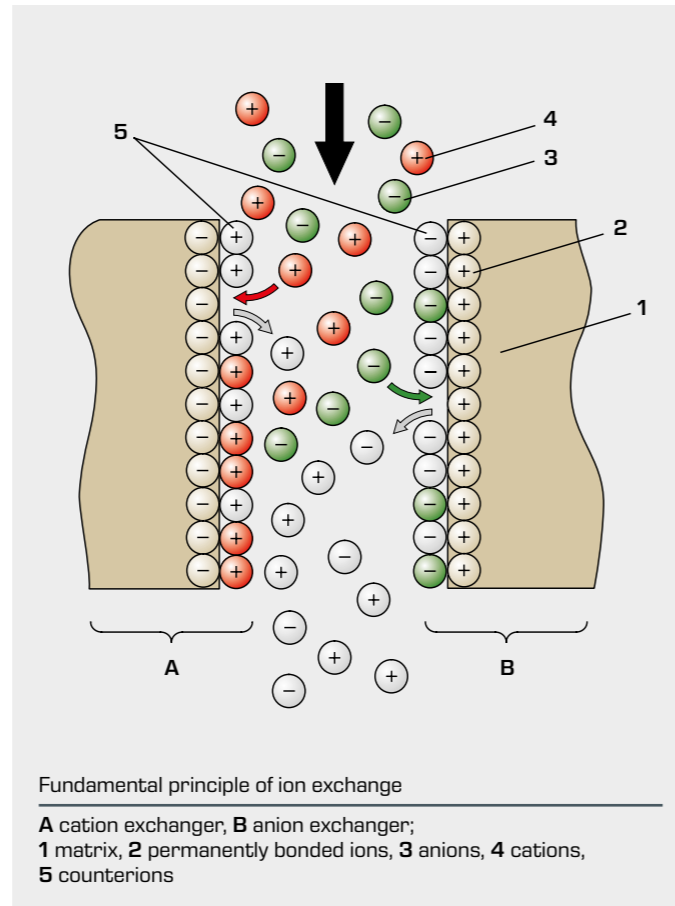


## Basic knowledge

## Ion exchange

Ion exchange is a physical / chemical process in which a solid absorbs ions from a liquid and, in exchange, discharges an equivalent amount of identically charged ions to the liquid. Positively charged ions are known as cations, and negatively charged ions as anions. Ion exchangers may be natural materials (such as zeolites) or synthetic resins (such as polystyrene or polyacrylate).



An ion exchanger consists of a matrix with permanently bonded ions and oppositely charged counterions. The counterions are exchanged with the ions being removed from the water.

Ion exchange is based on the principle that the higher the valence (ionic charge), the more strongly the ions are bonded to an ion exchanger. This means divalent ions are capable of being exchanged for monovalent counterions. Ion exchangers can only exchange a certain quantity of ions. When the exchange capacity is exhausted, the ion exchanger is regenerated. This utilises the fact that ion exchange depends not only on the valence of the ions involved, but also on their concentration. So a large number of ions with a low valence can displace ions with a higher valence. In regeneration therefore, the exhausted ion exchanger is converted back to its original form by a high concentration of the original counterions. In the case of cation exchangers this is done with acids, and in the case of anion exchangers with caustic.

## Applications

## ■ Desalination

When removing salt (sodium chloride: NaCl), Na<sup>+</sup> ions are exchanged for H<sup>+</sup> ions by a cation exchanger. In an anion exchanger, the Cl<sup>-</sup> ions in the salt are then exchanged for OH<sup>-</sup> ions. The released H<sup>+</sup> and OH<sup>-</sup> ions combine to form water (H<sub>2</sub>O).

## ■ Softening

When hard water is heated, lime deposits form. These can lead to damage in pipes and equipment (for example steam generation and in households). In the softening process, calcium ions (Ca<sup>2+</sup>) and magnesium ions (Mg<sup>2+</sup>) are removed from the water by cation exchangers.

## ■ Detoxification

Industrial wastewater can contain toxic substances such as heavy metals, cyanides and chromates. These substances are normally present in the form of ions, and can be removed from the wastewater by ion exchange.

## Basic knowledge

## Precipitation / flocculation

Precipitation and flocculation are two different processes, though in practice they are often combined. In precipitation, dissolved substances are converted into undissolved solids by a chemical reaction. This is achieved by adding a precipitant.

The solids can then be removed by means of mechanical processes such as sedimentation. However, the resultant

solids (precipitation products) usually have a low density and sediment very slow. The object of flocculation is to produce larger solids with better sedimentation properties.

An important area of application for precipitation and flocculation is the removal of dissolved metals (e.g. iron).

## Precipitation

A frequently used form of precipitation is **hydroxide precipitation**. This makes use of the fact that the solubility of many metals diminishes with increasing pH value. A common precipitant for hydroxide precipitation is caustic soda (NaOH). Hydroxide precipitation can be illustrated simplified in the following example:

Wastewater to be treated contains trivalent dissolved iron (Fe<sup>3+</sup>) and has a pH value of approx. 2 to 3. Fe<sup>3+</sup> ions are only soluble at very low pH values. By adding caustic soda (precipitant) the pH value is increased to approx. 8 to 9. The OH<sup>-</sup> ions (hydroxide ions) of the caustic soda react with the Fe<sup>3+</sup> ions and form insoluble iron hydroxide: Fe(OH)<sub>3</sub>.

## Flocculation

The particles often are charged identically and repel each other. Therefore the particles can't aggregate into larger flocs (coagulate). Consequently, the electrostatic repulsive forces between the particles must first be eliminated. This is done using inorganic coagulants, such as metal salts. The individual particles can then aggregate into micro-flocs. This first phase of the flocculation process is termed **coagulation**.

In the second phase – the actual **flocculation** – flocculants are added into the wastewater. These agents are organic polymers. They adhere to the micro-flocs, enabling them to be interconnected. The resultant flocs are termed macro-flocs.

