



# Purification of Drinking Water

“New solutions through the use of ion exchange and adsorber resins.”

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something which is obvious at first sight. Further desirable, but less essential, characteristics are a balanced mineral content and an optimum degree of hardness, as this is desirable from the point of view of taste and also for household uses.

The availability of water is determined primarily by geographical / geological factors. In addition, economic and technical factors determine the quantity that can be drawn and its quality. Since the quality of surface water is generally inconsistent, reliable water supply has to start with the correct construction of a well and its responsible management. Further common steps in water treatment are the removal of iron and manganese and suspended substances by aeration of the water and subsequent filtration through sand filters. The water is then generally sterilised through the addition of chlorine or other disinfecting procedures.

## Chemical Impurities in Trace Quantities are of Increasing Interest

The treatment currently in use allows most spring water to be transformed into potable water. However, it cannot ensure that chemical impurities that are injurious to health are sufficiently removed from the water. Such substances may be present in the parts per million range (ppm = mg/l) or in trace quantities (ppb = µg/l or ppt = ng/l). It is these substances that are now increasingly the focus of attention among international and national health organisations. There is a recognised need for action in many places as a result of the continuous improvements in analytical methods, the more

### It Starts with the Drilling of a Well

People with access to clean drinking water, in sufficient quantity and at an affordable price, can consider themselves very lucky. Citizens of industrialised nations hardly give it a second thought. For them access to such water is taken for granted. However, the majority of people on the planet are not in this enviable position – when they turn on the tap there is no guarantee that water will flow, or they may be forced to walk long

distances every day to draw water from the nearest well. Alternatively, they may have no option but to drink dirty water and suffer the consequences or even lose family members through contaminated drinking water.

The purity of water is not defined simply through an absence of odor, its taste or its appearance. It must also be free of pathological micro-organisms and any toxic substances in concentrations that induce illness in acute or subacute forms. This is not

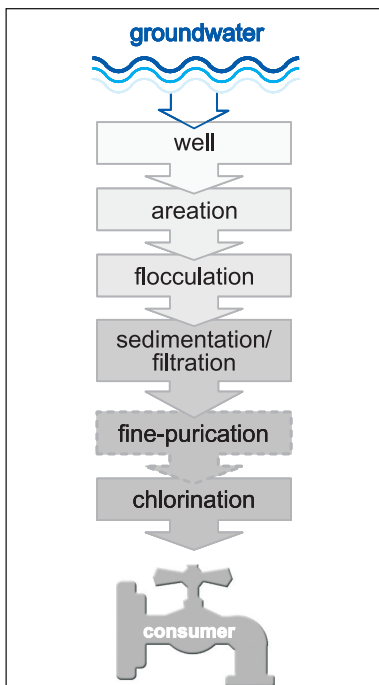


Figure 1: According to the state of the art well water is converted into potable water by aeration, flocculation, sedimentation/ filtration and chlorination. In particular cases an additional step for fine purification has to be integrated.

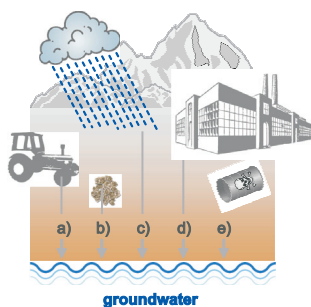


Figure 2: The contamination of groundwater with chemical trace impurities takes place on different pathways. Human activities are not always the cause.

- a) Agriculture, b) Leaching of minerals, c) Draw in from atmosphere, d) Inappropriate industrial activities, e) Illegal waste disposal

a brown color as well as carboxylic acids and polysaccharides. Contaminants that are clearly the result of human activities include those from farming, for instance the use of fertiliser and crop protection agents and the disposal of sewage sludge and liquid manure to soil. These result in increased levels of nitrates in groundwater, along with heavy metals and pesticides, as well as their degradation products. Other contaminants from human activities include those from industrial production, from workshops or logistic centers such as for the storage and distribution of fuel.

systematic and increasingly widespread use of testing and the growing knowledge of the effects of the substances on the health. The World Health Organization (WHO) has reacted to the new findings by reducing the recommended limits for trace substances in water. These values are being adopted in the national legislation and regulations governing substance limits. The onus is on public and private water suppliers to ensure that the water they supply meets these requirements. Surprisingly, human or industrial activities are not always the cause of contamination of drinking water with chemical substances. In many cases these substances have a natural origin. This is particularly the case if the water has come into contact with minerals underground, from which chemical substances have been dissolved. Examples of such substances are the elements arsenic, fluorine and antimony, as well as the heavy metals nickel, radium, uranium, lead, thallium and mercury that enter springs through natural routes. A further substance - boron - is present in seawater in appreciable concentrations and is sufficiently removed in the reverse osmosis process used to remove salt from seawater. In addition to these inorganic substances there are also substances of organic origin. These include the wide range of humic substances that give water

Examples of these are various poorly biodegradable detergents (wetting and cleaning agents), solvents, impregnating agents and fuel additives (such as the anti-knocking agent MTBE). In addition, all of the above-mentioned heavy metals from natural sources may also enter water from human activities.

### The Choice of a Suitable Filter Material is Decisive

Not all spring water is contaminated with chemical substances. Whether contamination is present or not, its nature and whether upper limits of relevance to health are exceeded are entirely dependent on the geographical position of the well. The previous agricultural and industrial activities in the area and the surrounding watercourses are also a factor. Each well therefore has to be considered individually and requires study by a qualified institute.

If traces of contaminants are found, their removal can present problems. The abovementioned substances differ in their chemical properties therefore there is no uniform strategy for their removal. A further complicating factor is that there may be different background concentrations of other substances in the water that modify the behavior of the contaminants present in trace quantities.

In many cases activated carbon filters are used in addition to the conventional water treatment methods described above. However, such filters can only remove certain substances and in some cases the desired removal capacity or service life is not achieved.

The use of filter materials based on mineral substances, such as zeolite, iron oxide or aluminum oxide is just as limited. However, there are now new treatment options in the pipeline that have considerable potential and are of increasing importance. These are filter media based on ion exchange and adsorption resins that use porous plastic beads with diameters in the range 0.3 to 1.2 mm. One of the most important manufacturers of these types of materials is the LANXESS group which produces as globally sells ion exchangers and adsorber resins under the brand name of LEWATIT® and IONAC®.

These materials have chemically reactive anchor groups (= ion exchange resins) or are



Figure 3: The removal of chemical substances in trace quantities can be carried out by means of additional filters that are equipped with selective filter materials



Figure 4: Ion exchangers are made of microscopic polymer beads with specific chemical properties: Quality check in an application test laboratory at LANXESS Deutschland GmbH

manufactured without them (= adsorption resins). There are a few dozen types of such materials that differ in terms of the nature and porosity of the plastic bead and in the chemistry of the anchor group. Variation of the substance parameters yields several hundred products.

The large number of materials can be used in a modular manner to allow customised solutions to be developed to deal with almost all types of

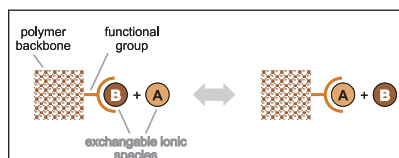


Figure 5: Ion exchange reaction: A particular pollutant A is fixed to a functional group and thereby is exchanged by a non-toxic species B.

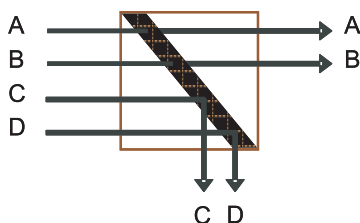


Figure 6: The principle of a selective filter: Particular valuable potable water ingredients (e.g. calcium) are allowed to pass through the filter whereby harmful substances (e.g. heavy metals) are arrested. The variety of commercially available ion-exchange materials allows the consumer to find the most suitable filter material for the prevailing trace impurity

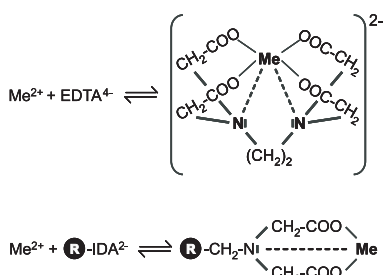


Figure 7: One specific type of ion exchanger (see reaction scheme) possesses a functional group that has a strong affinity towards heavy metal ions. Heavy metal ions are bound via a mechanism that is also known from the chemistry of complexing agents, such as EDTA (see reaction scheme at the top). This so called IDA-resin originally was developed for the purpose of metal winning or wastewater treatment. Aside from the IDA-group, there are a variety of other functional groups available, which allows arresting chemical substances by other specific binding mechanisms.

contamination, depending on the quality of the drinking water. In some cases a combination of materials is also conceivable.

The general approach to the customised filter is to choose a material with the highest selectivity for the substance that has to be removed from the water. This enables the natural composition of the water to be left very largely unchanged and to only remove the substance that is undesirable in the water. The loading capacity of the filter can be optimally exploited since the centers of the ion exchange material can take up substances from the water and are only exhausted by a single substance.

Furthermore, important minerals that the human body needs are left in the water.

### The Principle is not New, but the Application is Still in an Early Stage

Some of the selective ion exchange resins that are available for use with drinking water were originally developed for use in chemical manufacturing, metal extraction or the treatment of wastewater. Their possible use with drinking water was only recognised in the course

of the above applications. This means that the basic materials have been in existence for some time and are produced commercially and therefore already on the market.

However, modifications are necessary in some cases to meet the differing requirements for use with drinking water.

The use of ion exchange resins to remove traces of substances from wastewater is still in its early stages and the technology is being developed further. Treatment plants have recently come on stream for this purpose - for example there is one in the south of Germany and one in the north of Italy to remove nickel. A plant has commenced operation in Cyprus for the removal of boron in the course of desalination of seawater. Plants are already in operation in the USA for the removal of uranium and radium, as well as perchlorate and nitrate from groundwater. Other applications, such as the removal of arsenic, fluoride and human substances, are in pilot phases at various points around the globe.

Ion exchange resins have a cost advantage because of their regeneration. The substances removed by them can be desorbed using suitable regeneration chemicals and converted to forms that are suitable for landfill once they are rendered inert. The costs are therefore lower than for filter materials that can only be used once.

### Individual Filter Solutions - A Modular Approach

It is apparent from the above that it is difficult to achieve a high degree of purification of drinking water, but it is possible with the corresponding technology. Ion exchange resins and adsorption resins based on plastic beads are a suitable modular system for the removal of chemical contaminants, enabling an individual filter solution to be developed for every well. However a completed water analysis is the best base to identify the ion exchanger that is most suitable for a specific water contamination case.

Applications specialists of LANXESS AG are eager to help their customers to develop a tailor made technical solution. They are accompanying the projects starting from first lab tests and if necessary through pilot tests and the commissioning phase.

#### About the Author



Dr Stefan Neumann is working as Technical Manager on Ion Exchange Applications at LANXESS Deutschland GmbH since 2005. He has studied chemistry at the University of Cologne, Germany. He has earlier worked for University of Leipzig (HTWK), Germany, and Bayer Technology Services. He is currently head of Ion-Exchange - application laboratory for planning, coordination and evaluation of tests related to above mentioned working fields. He also works on marketing strategies to promote ion exchange products, technologies and applications. With over 100 products, LANXESS offers a range of ion exchange resins that can be used as a modular system to create individually tailored solutions.

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