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Drinking Water Treatment and Water Quality Protection

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WATER QUALITY PROTECTION

Just as a considerable part of the human organism consists of water, about three-quarters of the Earth surface is also covered by water. 71% of the Earth surface is covered by sea and 2% by surface waters on the continents. A small part of usable fresh water can be found in the atmosphere in the form of clouds, fog and water vapour. The bigger part can be found subsurface (ground water) or as surface waters in the form of lakes and rivers, etc. In parts of the world without sufficient fresh water, desalination of sea water is used to obtain potable water used for drinking or cooking.

The need for water is increasing day by day. Water does not stop at borders; a good example for this is the Carpathian basin which is a single hydrological unit and 8 countries share it. Water abstraction in one country may have a dramatic effect on the other country's water resources. Therefore, it is necessary to examine and utilize hydrological and hydrogeological systems in their totality and manage the supplies. Under these conditions water management requires international cooperation and appropriate governmental and legal institutions.

As Hungary's waters are mostly downstream, over 90% of the country's surface water stock comes from abroad, therefore we do not have the power to regulate the water quality and quantity of our rivers. 24 water courses flow through boundaries, so only 5% of the water assets are of domestic origin reaching surface waters in the form of precipitation. Water arrives in the country through 24 water courses and leaves the country through three of them (the rivers Danube, Tisza and Drava). The 112 cubic kilometre water arriving from abroad flows through the country quickly, and the water quantity increases by 5 to 6 cubic kilometre, so we let more water out than flows into the country.

Rivers, streams and other water courses are not evenly distributed in the territory of our country. Water resources can cover the country's water needs at the moment. However, it appears as a problem that while 85% of water resources are connected to the water system of the Danube and 15% to that of the River Tisza, in terms of utilization 59% of needs are connected to the Danube and 41% to the River Tisza, and in extremely drought-stricken periods there may be water supply problems in the Tisza region. Furthermore, there would be great opportunities in utilizing rain water. The 56 cubic kilometre of rainwater is half of the 112 cubic kilometre of water arriving from abroad but 49 cubic kilometre of it is just left to evaporate.

In Hungary public utilities providing drinking water obtain over 90% of the water needed from various ground waters and 10% from surface waters. If the water discharge decreases, the riverbank filtration water supply that forms the basis of potable water in Budapest and the surrounding area will continue to decrease.

In two-thirds of Hungary, the water supplied in the water system is appropriate but the ageing of the system of pipes and the decrease of consumption pose problems. Water loss through the system must be calculated with 20-25% of loss due to leaking and because pipes tend to break. In Hungary about 2,3-2,5 million people live in areas where drinking water is contaminated to a certain degree.

Satisfying water needs sets an increasingly difficult task for water management experts. Whereas needs are increasing, water resources needed to satisfy these needs are not available in the required quantity. Needs in terms of quantity, quality, space and time do not always match available resources.

Residential water needs and factors influencing them:

Water need is determined by the product of two factors:

WATER NEED=Consumption unit (unit consumption) * specific water need

Determining the consumption unit of water need

Characterization of consumers:

The following consumer groups can be differentiated in a settlement:

Communal groups

- Households (residents)
- Basic public institutions
- Watering

Groups requiring individual examination

- Public institutions
- Trading
- Services
- Watering (streets, parks, etc.)

Industry (social and process water)

Agriculture (only the consumers connected to the drinking water system)

Other consumers not classified in the above, using water from public utility water networks (e.g. heating centres)

Water supply, drainage

The aim of water supply for settlements is to provide drinking water for the population and ensure household water needs, and also to provide drinking water for public institutions, the networks of service providers and smaller industrial plants.

Water supply may be drawn from:

- private wells
- public wells

- water plants owned by plants or institutions
- public utility water pipes

Drainage means the collection, purification and disposal of household (institution and industrial) waste water. In a wider sense drainage also includes the removal of precipitation falling or getting in the inner area of settlements.

Industrial water supply, drainage

To satisfy people’s health, food, clothing, transport, telecommunications, relaxation, entertainment, etc. needs, a large number of industrial products are necessary. Industrial production of these products uses a large quantity of water. Water is used for exploring, exploiting and processing raw materials in the following ways:

- cooling of production equipment, machines, products,
- washing, conveying and soaking of base materials of products,
- as base material for products.

Thermal water utilization

With the help of geothermal energy, the load of traditional energy resources can be lessened. The complex utilization of geothermal energies must be improved, including usage of such energy in communal, industrial and agricultural areas.

THE IMPORTANCE OF WATER / DRINKING WATER

European water sources are at risk, though Hungary has an advantage over Western Europe in terms of water sources and water quality. The stratified Pleistocene and Miocene sediments in the Hungarian Great Plain store a large quantity of fresh water resources that are of strategic importance, and they are recorded among the large water supply systems according to international classifications.

The protection of subsurface fresh waters has become one of the most important scientific and technical issues of our age because these waters will become the most important drinking water resources in the process of the survival of mankind.

With such manifold water needs it is crucial from what sources the population can get raw water that may guarantee safe drinking water quality after treatment and be conveyed to consumers through the public utility water distribution system. Water supply systems must undertake quality guarantee at consumers' taps.

In this study an overview is given of the suitable methods for producing drinking water from raw water. Major steps:

1. WATER ABSTRACTION, abstraction of water: drinking water for example, can be obtained from artesian water, karst water, rivers and lakes.
2. WATER TREATMENT PLANT where water treatment is carried out: e.g. raw water is let through filtering materials to purify it from organic and inorganic contaminants.
3. WATER POOL RESERVOIR: The treated water is stored in a pool reservoir and then it gets into a pressure booster station.
4. WATER DISTRIBUTION – pressure booster station – Water pressure is increased so that it can reach consumers. Water gets to the water tower through the water mains. Water towers are not only for storing water but they ensure the pressure needed to provide water for high buildings, too.

The concept of drinking water: Drinking water is an inevitable nutrient for the human organism. Water that meets the current drinking water standard can be considered drinking water.

In providing settlements with drinking water it is crucial to utilize ground waters first because they are less contaminated so treating them is more cost effective. Their quantity, however, is less than that of surface waters. Because of increasing demands, surface waters are exploited more intensely, even if their treatment is more expensive due to their contamination.

THE PROCESS OF PRODUCING DRINKING WATER:

NATURAL WATER – SEDIMENTATION (coarse sediment) – FILTRATION (fine sediment) – DEGASIFICATION (CO_2; O_2; N_2) - PRECIPITATION OF COLLOID PARTICLES (settling: $Al_2(SO_4)_3$; $FeCL_3$) – SEDIMENTATION, FILTERING (large-surface precipitation and adsorbed colloid particles) – STERILIZATION OF TREATED WATER (disinfection: chlorine, ozone, NaOCl, ultraviolet rays) - **DRINKING WATER**

If the surface water is raw water, coarse filtering is required (to remove ice, wooden chips, fish, etc.), however, it does not need to be used with water abstraction of ground waters. In the treatment of this latter water type, aeration is important, whereas with surface waters it is not a part of the process.

Surface waters are exposed to natural conditions directly, so our downstream rivers suitable for water abstraction are contaminated depending on the type of the resource. Their utilization requires treatment and, beyond this, flexible water treatment technology.

Subsurface waters, **ground waters** are contaminated because of natural conditions, and their physical-chemical and biological features make using them as drinking water more difficult.

There are huge resources of **phreatic waters** in the depth of the Carpathian basin accessible by deep-drilling, and in Hungary the abstractable quantity at the moment is about 6 million m^3 a day. Its quality is usually permanent and it is considered protected. In case utilization (abstraction) exceeds a certain degree, the leaking of contaminants may increase between the strata. These subsurface waters are usually of drinking water quality or can be made such by a relatively simple purification treatment method. It explains the fact that today in Hungary a considerable quantity of drinking water is provided by these waters. Most regional water plants are also built on these sources.

Besides phreatic waters, **riverbank filtration** waters provide a considerable part of subsurface water abstraction, thus it is a cardinal aspect that its quality depends on the quality of surface water. Rivers suitable for riverbank filtration are: the Danube, Raba and Drava. Domestic water use requires a significant quantity in quality drinking water in all three major areas (residential, industrial and agricultural use). The annual average use of drinking water in Hungary is about 1,6 billion m^3.

QUALITY PROTECTION OF RAW WATER RESOURCES

Definition of Raw Water: Raw water is the surface or subsurface water used as water resource by a water treatment plant to produce water of drinking water by water treatment methods (physical, chemical, biological).

The concept of water resource protection has become increasingly widespread in the past few decades because the significance of water resources suitable for providing drinking water has increased. Water resource is defined by Act 57/1995 on water management: „*Water resource:*an area or subsurface area utilized by a water abstraction plant or designated for that and the abstractable water including the current or planned water abstraction plants. Based on this definition two types of water resources can be differentiated:

- the so-called **long-term water resources** for satisfying future needs,
- the so-called currently **operating water resources** ensuring water supply at the moment".

Long-term water resources are potential areas with good water supply conditions where water production plants have not been established yet.

Operating water resources are water abstraction locations satisfying current needs.

Water supply is the responsibility of local governments. According to the Act of Water Management (57/1995), protection of water resources is included in the responsibilities of the government and local governments as well. The preliminary securing and protection of long-term water resources serving to satisfy future water needs or replace potentially contaminated water resources will continue to be a government responsibility until particular user needs appear. The protection of drinking water resources utilized (operated) by water law permission belongs to the licensee's responsibility.

In order to prevent contamination of water resources, zonal protective areas (and subsurface protection zones) are designated by the competent regional water management authority in resolution both for the operating and the long-term water resources. We can differentiate **internal protective zones, external protective zones and hydro-geological protective zones (A, B, C zones).** The different zones have different functions but their overall purpose is to prevent or restrict existing and future contaminating activities.

Different restrictions apply to different zones with less strict restrictions as we go farther from the water abstraction place. Taking these restrictions into account is highly important during working out development plans of settlements. The potential of contamination of water resources is the lowest if designation of protective areas is done simultaneously with installing the water resource and putting the water plant into operation.

Tasks of water resource protection can be divided into 3 stages:

- assessment of water resources state (diagnosis)
- securing water resources
- safeguarding and safe operation of water resources.

Budapest Waterworks: Its major environmental protection task is to protect drinking water resources providing water for the capital and its agglomeration. Most of the so-called internal protective areas with the strictest regulations located in close proximity of the wells are managed by the Budapest Waterworks with about 6,600,000 m^2 of protective areas in Szentendre Island and Csepel Island. Another important means of securing water resources is taking record of the potential and actual sources of contamination in the protective zones. The continuous monitoring of the assessed agricultural, industrial and communal pollutant sources helps the detection of potential pollutions in time. The appropriately installed and regularly monitored observation well system allows for the forecasting of pollutions.

RAW WATER QUALIFICATION, QUALITY REQUIREMENTS

In order to satisfy water needs it is necessary to protect water resources both in terms of quality and quantity. Concerning protection of quantity, it means that the pressure loss of subsurface waters must be prevented and the regeneration of aquifers must be ensured, and the balance of water abstraction and replacement must be created in a way that the initial water table of subsurface waters is not reduced permanently below the natural multiannual average because of human intervention. Concerning protection of water quality, adverse quality changes cannot happen as a consequence of new hydraulic conditions due to water abstraction.

Concerning the designated water abstraction plant, Operation is obliged to conduct

- **baseline test** at least every 6 years,
- **regular baseline test** every year,
- as regards the **control test,** its frequency cannot be less than
    a) once a day with water abstraction from a river,
    b) twice a week with water abstraction from Lake Balaton and once a week for water reservoirs,
    c) one test in the half year following the regular baseline test for protected water abstraction plants,
    d) once a month at the network input points with water treatment including other than degasification and disinfection and for water plants over 5,000 m^3 / day.

Legal provisions

21/2002 (04/25.) KöViMRegulation	ON THE OPERATION OF PUBLIC WATER WORKS
201/2001 (10/25) Government Regulation	ON DRINKING WATER QUALITY REQUIREMENTS AND CONTROL PROCEDURE
65/2009 (03/31) Government Regulation	AMENDMENT TO 201/2001 (10/25) GOVERNMENT REGULATION ON DRINKING WATER QUALITY REQUIREMENTS AND CONTROL PROCEDURE
430/2013 (11/15.) Government Regulation	AMENDMENT TO 201/2001 (10/25) GOVERNMENT REGULATION ON DRINKING WATER QUALITY

	REQUIREMENTS AND CONTROL PROCEDURES
12/1997 (07/29) KHVM regulation	ON DEGASIFICATION OF PRODUCED AND PROVIDED WATERS
38/1995 (05/05) Government Regulation	ON PUBLIC DRINKING WATER SUPPLY AND WASTE WATER DRAINAGE
123/1997 (08/18) Government Regulation	ON THE PROTECTION OF WATER RESOURCES, LONG-TERM RESOURCES AND WATER INSTITUTIONS PROVIDING DRINKING WATER
6/2002 (11/05) KvVmRegulation	ON POLLUTION LIMIT VALUES OF WATER RESOURCES DESIGNATED FOR ABSTRACTING DRINKING WATER AND SURFACE WATERS ENSURING LIVING CONDITIONS FOR FISH AND THEIR CONTROL
43/1999 (12/26) KHVM Regulation	ON THE CALCULATION OF WATER RESOURCE FEE
47/1999 (12/28) KHVM regulation	ON FEES TO BE PAID FOR DRINKING WATER PROVIDED BY STATE OWNED PUBLIC WATER WORKS AND FOR THE USE OF STATE OWNED PUBLIC DRAINAGE SYSTEM

The following water resources can be utilized for water abstraction serving water supply, depending on local conditions:

1. Subsurface water: (ground water, artesian water (underground water), karst water, riverbank filtration water, spring water)
2. Surface water: water course, water of lakes and reservoirs
3. Precipitation
4. Recycled water

<u>General description of the drinking water treatment process:</u>

The aim of water treatment is to transform raw water into quality water meeting consumption needs. The water abstracted from wells, rivers, lakes is drained to water treatment plants where contaminants are removed through multi-stage filtering. During the treatment various methods are used to remove non-desirable materials from the water or to transform them into tolerable materials. The quality of initial raw water is very different and therefore water treatment technology is also diversified.

1. Grids, drum filter (removing scums)
2. Desanding, hydro-cyclone, settling (removing suspended, easy-to-settle solids)
3. Deacidification (removing carbonic acid)
4. Removing iron and manganese (oxidation/filtering)
5. Removing nitrate (ion exchange)

6. Salts dissolved in water that cannot be removed by filtering (water softening)
7. Sterilization (filtering/oxidation) and disinfection (chlorine, ozone, potassium permanganate)

WATER ABSTRACTION / WITHDRAWAL

To satisfy water needs the following options are available depending on the availability of water:

1. Surface water: water course, lake, natural reservoir, artificial reservoir
2. Subsurface water: ground water, riverbank filtration, karst water, artesian water, spring

Water abstraction methods and equipment

Methods of surface water abstractions are:

- suction piping
- water withdrawal from a well
- dam water withdrawal
- filter dam withdrawal

Structures of subsurface water withdrawal:

Water abstraction from porous aquifer medium is done using the beneficial purification effect of filtering. From hydraulic aspects, the basic structures are: well and gallery. The combinations of these two are collector well and a special shaft.

From the point of view of installing structures:

- water withdrawal structures for little depth, such as: dug well, sunken well, driven well, drilled and pipe wells, galleries, collector wells in little depth,
- deep-drilled wells.

Subsurface water abstraction plants are grouped according to the type of water produced:

- installed on ground water
- riverbank filtration
- artesian water
- fed through fissure and karst rocks
- water withdrawal plants fed by springs

SAFETY MANAGEMENT OF KARST WATERS AND RIVERBANK FILTRATION WATERS

Safety management of riverbank filtration waters

Wells with riverbank filtration can be established at the banks of rivers embedded in sandy, pebbled stratum. The water of riverbank filtration well, depending on the water level, is provided partly by the outside ground water and the river flowing into the stratum. In Hungary, running water withdrawn by riverbank filtration is classified as ground water.

Safety management of karst waters and spring waters

Karst waters are best for residential water supply. They are less used for agricultural purposes, they originate from the subsurface catchment of porous limestone mountains covered with forests, and they are usually available by proper water withdrawal. A considerable part of Hungary's subsurface water supply consists of karst waters.

The quality of spring waters **originating not from karst areas but other stone strata** varies between wide ranges; we can find a lot of carbon-dioxide, iron and manganese ion and (di)hydrogen-sulphide. Springs like this can mostly be found in the volcanic area next to Lake Balaton, and the mountainous areas of Matra and Zemplen.

Artesian water is still considered safe. At the same time, the upper 10-20 meter layer of the ground may be so much contaminated that using it directly as drinking water cannot be considered safe.

In contrast with this, the organic and nitrate contamination of water layers under the first impervious layer is insignificant. It is rarely risky for direct use.

Safety management of waters in deep drilled artesian wells

The water of deep drilled wells originates from the sandy, pebbled permeable stratum located between the far-stretched impervious layers. These waters are fed by precipitation leaking from the surface, but the water remains so long in the ground or travels so long in the layer to the well that it is basically perfectly filtered during this journey.

WATER QUALITY PROTECTION OF WATER RESERVOIRS

Water reservoirs are essential parts of water management. Apart from playing an important role in preventing water scarcity, droughts and floods, they are suitable for producing energy and irrigation, and their significance in nature preservation is also important. Storing drinking water is necessary because household water consumption is fluctuating by parts of the day and also by seasons. Water abstraction, however, is permanent and to avoid water shortage in peak times, water is stored in water reservoirs during lower consumption periods.

Water reservoirs, artificial lakes

Water reservoirs are artificial stagnate waters created in natural terrain features, blocking rivers from one or more sides. The largest artificial lake in Hungary is Lake Tisza.

The water-holding basin system in Gellert Hill

The largest drinking water holding basin of the country is the Gruber József Basin System in Gellert Hill with its 110,000 m3 capacity.

Water towers, "hydroglobes"

Water towers are large water containers made for providing water for water networks. They are placed so high that the hydrostatic pressure due to gravitation is sufficient to operate the network. After lifting the water high, it moves on by the principle of interconnected vessels.

The globe-shaped water tower built from metal is called hydroglobe. Its function is the same as that of water tower.

Treatment of water in dam reservoirs

There are several smaller dam reservoirs in Hungary. Their depth, compared to their surface, rarely exceeds 10-15 meters, so these reservoirs are shallow lakes from the water biological point of view. Biological life in lakes changes depending on weather conditions and the quantity of nutrients arriving in the water flowing into the lake. The quantity and quality of biological organisms in the water are different in the different parts of the lake even at any given time, and they are also different in different depths. Therefore, it is practical to make sure to take water samples from different depths.

PRODUCING DRINKING WATER FROM SURFACE WATERS

Providing water supply for several settlements - for example the capital, several riverside towns and holiday-maker population in summer at Lake Balaton - is impossible or only partly possible from water resources (e.g. karst water, artesian water).. In this case, appropriately treated water of stagnant waters and rivers can also be used for pipe water supply.

Factors influencing the quality of surface water

- origin of water, conditions at catchment
- water flow speed, turbulence
- strength of waves

- water depth, water level
- water temperature
- precipitation
- strength and duration of sunshine

Factors influencing water quality change primarily according to seasons but within this there may be different variants. Therefore, the quality of surface waters (lakes, rivers) changes between wide time ranges. Apart from natural conditions, the quality of surface water is influenced by the quantity and quality of communal and industrial waste water flowing into it. Producing drinking water from surface water is conducted by pre-treatment, slow filtering or rapid coagulation filtering.

REMOVING MICRO CONTAMINANTS AND RESIDUES FROM DRINKING WATERS

Micro contaminants are materials in waters in microgram/liter concentration that can reduce or stop conditions of vital processes and usability of water for humans. Micro contaminants can be classified in two groups: **organic** (*crude oils and their derivatives, polycyclic aromatic hydrocarbons, phenols and their derivatives, pesticides, detergents, trihalo methane (THM)* and **inorganic** micro contaminants (heavy metals, barium, arsenic and cyanides).

In our domestic surface waters the concentration of inorganic micro contaminants does not reach the limit values stipulated in drinking water standards, so the technology of removing organic micro contaminants during surface water treatment is described in the following:

Apart from adsorption, ozone treatment proved to be effective in removing organic micro contaminants.

Summarizing post-treatment technologies used for removing organic micro contaminants:

- Oxidation [O3; O3+UV; H2O2+UV; Fe(VI)]
- UV + TiO2 catalyser
- Sonolysis + TiO2 catalyser
- Water radiolysis with ionizing radiation
- Adsorption on activated carbon
- Reversed osmosis, Membrane (ultra, nano) filtering

About drinking water arsenic content and its health effects

As a result of EU law harmonization, a significant aggravation has been introduced concerning the permitted arsenic content of drinking water: the former 50 mg/l limit value was reduced to 10 mg/l

(201/2001 Government Regulation). The aggravation affects over 400 settlements, the water supply of which is typically based on small water plants.

The currently available arsenic removal technologies can be divided into three big groups:

- traditional technologies (coagulation, removal of iron-manganese, lime softening),
- sorption methods (ion exchange, activated aluminium),
- membrane technologies (reversed osmosis, nano-filtering, micro- or ulta-filtering).

CHEMICAL AND ELECTROCHEMICAL METHODS AND THEIR APPLICATION FOR PRODUCING DRINKING WATER

Removal of dissolved harmful contaminants that are over the limit value is carried out by water treatment and water purification technologies. The use of chemical methods generates chemical processes due to the use of chemicals. In water and waste water technology chemicals are mainly used for improving the effect mechanism (intensification) of physical (mechanical) procedures and for oxidation (e.g. disinfection) and removing dissolved inorganic contaminants (precipitation, ion exchange).

The grouping of chemical methods:

1. CLARIFICATION

   The aim of clarification is to remove colloid size (smaller than 10^{-4} mm) suspended materials from the water (especially from surface waters) that cannot be settled (or only with low efficiency). Apart from this, clarification during drinking water production helps to reduce turbidity, colour and the quantity of organic material content and dissolved contaminants.

2. PRECIPITATION (removing iron, manganese, precipitation softening, removing phosphor)

   Precipitation is the process when dissolved contaminants in the water are removed by transforming them into water insoluble precipitation by adding the appropriate chemicals. Depending on the quantity or quality of precipitation it can be done by phase separation, sedimentation and/or filtering.

Group 1 and 2 are jointly referred to as coagulation methods.

3. ION EXCHANGE
4. OXIDATION

In many of the water treatment technologies adding oxygen to raw water is an important method because it reacts with a part of dissolved harmful substances and by oxidizing them it transforms them into filterable compounds. (e.g.iron, manganese, arsenic, etc.)

There are several ways of adding oxygen to raw water which have changed over the years as the quality of materials to be oxidized, the development of technologies and efficiency were changing:

- introducing oxygen available in the air is a traditional oxidizing method,
- introducing air under pressure,
- introducing air without pressure
- Depending on the quantity of contaminants to be oxidized introducing air is mainly suitable for removing contaminants in weaker bonds.

As the efficiency of technology improved and it became necessary to remove contaminants in stronger bonds, stronger oxidizing agents became more important:

- disinfection - chlorine (the most widespread oxidizing agent.)
- chlorine-dioxide,
- ozone
- potassium-permanganate (efficient oxidizing agent to remove manganese).

There are two common methods of electrochemical disinfection:

Direct electrolysed cells allow direct contact with the water to be treated.

Indirect, mixed action oxidizing agent generators produce anolit from concentrated salt solution, which is a combination of free chlorine, hypochlorite, chlorine-dioxide, hydrogen-peroxide and other strong oxidizing agents containing short-lived radicals.

BIOLOGICAL ORGANIC MATTER REMOVAL DURING THE PREPARATION OF DRINKING WATER

Biological processes in the water distribution network:

To reduce the microbiological processes occurring in the network, the modernizing of the technology of drinking water treatment plants consists of the following steps:

- minimizing the number of particles leaving the plant,
- minimizing the quantity of particle, colloid and dissolved iron, manganese and aluminium compounds (because microorganisms may adhere on their surface),
- minimizing biologically available organic matter content (they may serve as nutrients for microorganisms),
- taking the material of the distribution network into account, reducing the corrosion potential of water leaving the plant (to reduce corrosion of the pipe),
- reducing the quantity or materials influencing the concentration of residual disinfectants,
- determining the concentration of disinfectants remaining in the network with regard to local conditions and temperature,
- establishing monitoring system on the water distribution network

UP-TO-DATE WATER SOFTENING METHODS – ION EXCHANGE AND REVERSE OSMOSIS

Softening the water is always necessary when steam is produced but it is also needed in certain technological processes (e.g. pharmaceutical production).

There are two basic methods for softening water:

1) removing salts causing hardness by thermal, chemical or ion exchanging processes (the first two are jointly referred to as precipitation softening).
2) preventing precipitation of salts causing hardness by using chemicals

Ion exchange, reverse osmosis

Cation exchangers used in water treatment preparation contain either sulpho- or carboxyl groups, whereas anion exchangers contain amino-groups. The structure of synthetic resin is sterol-devinyl-benzol copolymer.

THEORY AND PRACTICE OF UV DISINFECTION IN DRINKING WATER TREATMENT PREPARATION

Ultra-violet radiation can act efficiently as a disinfectant only in a water layer of a few centimetres. Radiation can disinfect only during the radiation so it cannot prevent the proliferation of microorganisms in the pipe network. Therefore, in water treatment supply, it can be applied as a disinfectant, just like ozone and chlorine-amine, combined with other agents. UV disinfection may take place in an open or closed system, depending on water discharge.

Summarizing the advantages of UV disinfection:

- it neutralizes microorganisms physically
- no side products harmful to health are formed
- short contact time

Disadvantages of UV disinfection:

- lack of residual disinfectant
- effect of water quality on the efficiency of disinfection (iron, magnesium, calcium sedimentation, biofilm formation, light absorption, effect of particles)

Disinfection and mains water supply

With waters produced from any type of raw material, posterior chlorination (chlorine-oxide) may be necessary for safety reasons. It prevents proliferation of microorganisms and thereby production of potential contaminants and their infectious effects. Each residential water supply system is equipped with an appropriate sized water-holding system to balance uneven consumption. Safety disinfection is to ensure healthy conditions of water-holding systems.

WATER DISTRIBUTION, DIAGNOSIS AND FAST TROUBLESHOOTING OPTIONS

In Hungary each settlement has public drinking water supply. 95% of the population use drinking water from water mains. The remaining 5% get drinking water by individual water supply. In parallel with the water fee rise, water consumption has reduced in the past few years in Hungary. According to 2011 figures, it is about 100-110 litres/person/day on average but there may be significant differences between the different regions. In neighbouring Austria it is 150 litres/person/day, whereas in Switzerland it is 250 litres/person/day.

Safe water plan

The aim of safe water plan (SWP) is to ensure risk management and reduction methods for drinking water providers. Operating the Safe Water system aims to reduce public health risks but apart from daily operation, it includes the management of extraordinary occurrences. SWP is based on the applicable WHO directives and includes the whole water supply system, such as water production, water treatment and water distribution. Thus, the system ensures performing water supply responsibilities in a documented form with an integrated approach and to continuously improve service quality. The most important advantages of developing and using a Safe Water Plan is the thorough and detailed risk exploration and analysis and the already operating and planned monitoring system built by results of control tests. It is an organized and structured system aiming to minimize dangers and control failures in an ever changing environment. The procedures increase safe water supply consistence and prepare for managing unexpected events and emergency situations safely and efficiently.

AS A CONCLUSION it can be stated that drinking water management is a complex task that can be performed successfully if conditions are taken into account. Based on this, surface drinking water management means jeopardy because of its operation, technological reliability and public health expectations. Water quality largely depends on environmental exposure and contaminants.

UV treatment of chlorine resistant microbes is more efficient than chlorinating. However, it has a high public health risk because it acts only at the place of treatment and surviving microbes may proliferate after the treatment and posterior chlorination can be omitted only in really small networks.

Membrane technology is the most appropriate method from the point of view of public health, environmental protection and work safety. However, it is still not widespread because of its high installation and operation costs.

CASE STUDY: LÁZBÉRC WATER TREATMENT PLANT

The water resource of Lázbérc Water plant is the Lázbérc water reservoir.
The nominal water producing capacity of the water plant is: 24,000 m3/day
The maximum usable water quality from the reservoir is: 30,000 m3/day

From the reservoir the raw water gets to the water works through an abstraction structure in gravitation raw water pipes. In the raw water pipe, a potassium-permanganate oxidizing agent is added to the raw water to pre-oxidize the organic matters in the water. Then, using a static mixer, , , BOPAC (poly-aluminium-chloride basic flocculating agents) clarifying agent is added to the raw water pre-oxidized with potassium-permanganate. In the technological line clarifying is followed by the use of membrane-technology based ultra-filtering equipment. Ultra-filtering is followed by 3 open, gravitation activated carbon adsorbents (GAC). Activated carbon filtering after ultra-filtering is necessary for retaining dissolved organic matters, mainly thrihalo-methane (THM) precursors. An additional aim is to reduce the quantity of odour and taste destructive matters.

Slurry and leachate formed during treatment and contaminants washed out during cleaning filters run through a joint tube to 2 lengthwise flowing sedimentation basins. Slurry spreads in the sedimentation basins, it gets settled and the settled water is channelled through a lock-gate to the Bán Stream.

CASE STUDY - BAKONYKARSZT CPLC.

BAKONYKARSZT Water and Drainage cPlc. was founded on 01 January 1996 aiming to supply piped drinking water and waste water drainage and purification.
Bakonykarszt cPlc., as a major public water provider in Veszprém County, operates its drinking water network in 121 settlements (provides drinking water for 220,000 inhabitants) and sewers in 71 settlements. Their operational area includes 103 water abstraction plants. 82% of water resources are karst waters of excellent quality delivering drinking water from water resources directly to drinking water networks, 11% is artesian water and 7% is ground water.

The city of Veszprém obtains 100% of its drinking water from karst water. Unlike in the town of Balatonfüred, surface water abstraction here is not necessary. For this reason, water treatment takes place only in special cases.

Based on their locations, wells and galleries providing water for Veszprém can be divided into four water resources. They are the Aranyos-völgy (Aranyos Valley) water resource, Sédvölgy (Séd Valley) water resource, Gyulafirátót water resource, Kádárta water resource.

Water producing plants delivering water for the town:

- Aranyos-völgy (Aranyos Valley) galleries and wells,
- Séd-völgy (Séd Valley) drilled wells,
- the Laczkó karst shaft,
- the Lőtér drilled well,
- Gyulafirátót drilled wells,
- Kádárta galleries,
- Communal well.

It is an open karst area so the increased protection of subsurface waters is needed, because due to disadvantageous hydrological conditions, the karst water is highly susceptible to contaminants originating from the surface. For this reason, Bakonykarszt cPlc. designated a zonal protection area. Moving away from there, restrictions on the use of the area become less strict. In the immediate proximity of wells no farming activity is allowed.

The depth of drilled wells is 150m, and pipes are driven with perforated sides in the depth of the pervious layer specified by preliminary geological tests. The diameter of thinner pipes is 20-25 cm, and the thicker ones are 40 cm. Electric diving pumps abstract the water from the wells. Water abstracted from wells is delivered through pumping plants, water reservoirs, water towers, pressure intensifier power plants and pipe systems to households, plants and institutions. Required water pressure and reserve water quantity for varied consumption even within a day is ensured by water reservoirs and water towers.

To increase efficiency of wells, pipes are also laid sideways, so they can abstract more water within the same time period; it is called collector design.

Floating wells are drilled by water flush. In case of floating wells, the bottom of the well is in the pervious layer. Due to the suction effect of wells, a depression develops at a point of the water surface. Then, because of the depression, water movement starts towards the suction in the total width of the layer.

The ultimate host of precipitation feeding karst waters is Séd Stream which is also the drain of produced purified waste water.

Wells must operate evenly and it is solved by water-holding basins. It ensures consistent operation so that diving pumps do not have to be overloaded during daily peak times.

<u>In Veszprém, three pressure zones are formed:</u>

- **Édász Basin:**

  This pressure zone lies at the lowest point, it provides water for Veszprém's city centre. The Édász water reservoir consist of two arched basins, and two pumps with 150m3/h capacity and three pumps with 200m3/h capacity work in three equipment lines. Its absolute height is: 280-290m Bf.

- **Látóhegyi Basin:**

  It provides water for the area surrounding the centre.

- **Cholnoky Housing Estate water tower:**

  It provides water for a part of Cholnoky Housing Estate and a part of Szabadságpuszta. Absolute height: 346m Bf.

An interesting feature in Veszprém is that the 20-storey building in the centre is out of the pressure zone so a standalone water lifting installation was built on the top of the building. The lower 8 floors are connected to the general water network, but the upper 12 floors get water through the lifting pump.

The quality of produced water is influenced by the location on the water catchment, water usage, hydrogeological factors and potential contaminant sources and their distance. Especially nitrogen and its forms cause problems, mainly nitrate because its enrichment may be significant in less used water resources or shallow karsts. (e.g. Kádárta).