methodology for carrying out excursions on water management facilities

DRINKING WATER

Contents

Cover sheet .... **Chyba! Záložka není definována.**
1 General introduction 5
1.1 How to prepare for the excursion? 8
1.2 Preparation before the excursion 14
1.2.1 Be the Storyteller 14
1.2.2 The story of water 15
1.2.3 The story of matter and energy 18
1.2.4 The story of money 22
1.2.5 The story of people 23
2 Own excursion 25
2.1 Key questions 26
2.2 Water quality 26
2.3 Source of raw water 28
2.4 Description of technology 29
2.5 Water network 32
2.5.1 Water meters 33
3 Description of technologies 35
3.1 Chisel 36
3.2 Aeration 37
3.3 Sedimentation 38
3.4 Flotation 39
3.5 Clarification / coagulation / flocculation 40
3.6 Filtration 42
3.7 Ion exchangers 43
3.8 Sorption 44
3.9 Hygienic provision of water 46
3.9.1 Chlorination 46
3.9.2 UV radiation 47
3.10 Stabilization (calcium-carbonate balance) 51
3.11 Membrane technologies 52
3.12 Sludge management 53
4 After excursion 54
5 Links and additional information 55

6 Appendix: Form for obtaining information about the water treatment plant 56

Cover sheet

This document was created by a collective of authors: Helena Bakešová, Jakub Sochor, Jitka Czakojová, Martin Srb, Denisa Čadková, Lenka Procházková, Jindřich Procházka, Andrea Benáková, Eliška Maršálková, Jana Šmídková and Jiří Paul, as part of the project solution:

Financováno Evropskou unií NextGenerationEU
NÁRODNÍ PLÁN OBNOVY
Ministerstvo životního prostředí
STÁTNÍ FOND ŽIVOTNÍHO PROSTŘEDÍ ČESKÉ REPUBLIKY

Od kohoutku do záchodu

Tento projekt je financován Evropskou unií v rámci Národního plánu obnovy.

Projekt cílí na zlepšování kvality odborných exkurzí a odborných přednášek či demonstrací v oblasti vody. Primárně se zaměřuje na poskytnutí podpory a materiálů pro učitele, odborníky a pracovníky vodohospodářských společností, kteří provádějí exkurze.

Realizace projektu: únor 2024 – červenec 2025

The project manager is the Water Association

CzWA®

General introduction

Water treatment plants (and related water sources, reservoirs, pumping stations, pressure stations...) are the basic building unit of the water management and water supply system. Although few people are fully aware of it these days, each of us indirectly uses these systems, even every day. A person cannot last more than 3 days without drinking water, and he realizes its loss practically immediately.

Nevertheless, from our own student experience, we have to sadly state that during lessons, time is devoted to rather less essential topics (e.g. brewing beer or developing analog photos), which with regard to water management leads to a complete lack of elementary knowledge. An example is the classic and completely common confusion of the function of a treatment plant with a water treatment plant. We don't even want to hear the word "treatment plant" in connection with a wastewater treatment plant. After all, students and elderly residents do not know where the water that flows from their own faucet comes from. With a low level of information, we can't be surprised that ordinary people usually have no idea what this complex field entails, and then take drinking water for granted. And that is exactly what we would like to change with this methodology, and above all with the help of you, readers and current or future guides to water treatment plants and related infrastructure.

Because there are a relatively large number of regular interactive lessons in schools and the offer significantly exceeds the demand, we decided to use the biggest benefit that the nature of our field allows us - field trips with an emphasis on local information so that every pupil and student can imagine the path the water has to take before it flows out of the tap in his home.

To the credit of the few operators of water supply systems who already implement such educational excursions. However, these are mostly large cities; however, from our point of view, it is important not to forget smaller towns and villages, where schools do not have the opportunity to travel an hour by train for an excursion to a larger traffic. We therefore want to contribute to the fact that these excursions start to take place elsewhere and thus increase awareness of the functioning of the water industry in the Czech Republic with its regional specifics.

We have therefore tried to design the methodology that you are holding in your hands in such a way that it can be used from small processing plants with simple technology to large processing plants in regional cities with the most modern technological procedures. Because these operations are (for understandable reasons) diametrically opposed, our work was quite complicated. The result is that this document consists of many individual modules that are practically independent of each other - for the realization of the excursion at the given processing plant, you will therefore choose only those modules that are relevant to you. More detailed information about folding is provided directly with the given technological modules.

In the same way, the methodology is designed for primary and secondary schools, or even for the most curious participants of the excursion (for future students of technical universities). You can obtain the required level (amount and expertise) of information suitable for a given level of education by using only those parts of the modules that are relevant for the given level. However, we highly recommend that even in the case of an excursion "only" for elementary school, you quickly study the higher levels as well - sometimes you would not believe what questions the children are able to formulate and completely surprise the guide. Of course, we don't want to scare you with that.

At the same time, we also attach a water utility minimum booklet to this methodology, where the principles of individual technologies are described in more detail. So if you feel unsure about whether this tank is coagulation, flocculation or flotation, you can use this accompanying literature to refresh your school information and ensure that you are giving pupils and students the correct information.

In some places, the text uses the division of information for individual levels of education so that the interpretation is adapted to the content of the communicated information. The parts that are not colored in any way can be used as you like and are not intended for just one target group.

Primary schools – due to the teaching of chemistry and other subjects, pupils in the second grade of elementary school (ie approx. 11–15 years old) are primarily counted

Secondary schools - approx. 15-19 years old from various schools (gymnasium, industrial schools, apprenticeships...)

For the inquisitive - usable, for example, for field trips to elective seminars in chemistry or the environment in high school graduation years or for technical youth clubs and other institutions of interest and informal education. Or simply for the curious of any age.

However, please do not take this methodology as some dogma to be blindly followed. What about you, what about the editing room, what about the group, it's individuality and you need to keep thinking about it. You have to test yourself what works for you and how to work with different group of people. We know that you have no easy task ahead of you, but you have our admiration for going ahead and trying to have the best possible excursion. It makes sense!

Let's not forget that the excursion is a unique chance to speak to the public. Raise awareness of the field, attract attention and maybe even change something. Try to involve the children as much as possible, show what is possible, and perhaps become a myth buster. You can give the children common advice, such as: why it is better to give up a certain amount of water from the indoor water supply after the holiday, why you should regularly heat the boiler to a higher temperature at home, why you should drink tap water rather than mineral water, why and how much more expensive it is to drink bottled water, why not fill the pool in the garden with water from the line (you can find the answers at the end of the introduction). Who knows, maybe through the children you will contribute to changing the habits of the whole family. Let's not forget that we are speaking to a future generation that will likely one day raise the next generation. Let's pass on good habits while we can.

At the same time, don't be afraid to emphasize what problems operators face. For example, you can mention the microbial revival of water in the summer or the risk of reservoirs freezing in the winter months. As part of the excursion, attention should also be paid to the connection of water management with the entire society, emphasize the necessary professions, financial resources, the size and complexity of the necessary buildings, etc.

In conclusion (and in combination with the previous paragraph), we would like to shed light on another aspect of this methodology – as much as possible, we tried to come up with the text in the style of questions and answers. Not only because these questions can appear away from the participants during the field trip, but you can also use them "against" the participants to activate them.

❔ Question: Why should you give up a certain amount of water from the indoor water supply after a vacation?

💡 Answer:

During our absence, the water stands in the queue without movement, and after a few days the hygiene protection ceases to be effective. These factors provide a suitable environment for microbial growth in water, which can pose a health risk to us. Therefore, have the water from the line "replaced" with new (freshly treated) water.

❔ Question: Why regularly heat the boiler to a higher temperature at home?

💡 Answer:

Legionella thrive best in lukewarm water. Only by reaching a higher temperature, often stated to be at least above 60 °C (above 55 °C, bacteria no longer reproduce and from 70 °C they die rapidly), will we prevent their overgrowth in the boiler, thereby reducing the health risk of infection. Both the temperature itself and the time it remains at its value are important.

❔ Question: Why should I drink tap water instead of bottled water? How much more expensive will it be?

💡 Answer:

There are several reasons: lower price, more frequent quality control during production, lower burden on the environment. The price of tap water (also sometimes called tap water) of course depends on the area (you can determine the exact one for your region), but it is usually more than 100 times cheaper than bottled water. And what's more - it's often the exact same water, only the bottled one has been in a warehouse for a few months.

❔ Question: Why is it better to drink tap water than mineral water?

💡 Answer:

One might mistakenly think that it is good to drink mineral water every day, but this is not the case. Each mineral water has a specific chemical composition and usually does not (and does not have to) comply with drinking water legislation. Due to the high content and imbalance of ions, excessive and long-term drinking is not recommended.

❔ Question: Why not fill the pool with tap water in the summer?

💡 Answer:

The water line is not adapted to fill swimming pools, especially if several residents get the idea at the same time. High flow velocities in the pipeline can cause water to become cloudy (sediments from the pipeline are released into the water). In addition, the amount of water was not calculated, and therefore water may later be missing from the reservoir (water accumulation). It is equally important to mention the subsequent drop in excess pressure in the network, which ensures both water transport to consumers and protection against soil water seeping into the water pipeline, i.e. contamination. These problems can be easily avoided by ordering a tank from the water company.

For the inquisitive - plumbing series. Many people use the term plumbing regulations. This is not correct. The correct term is water line. The name comes from the word series

How to prepare for the excursion?

In order for the excursion to interest the visitors and at the same time to take away knowledge from it for the next life, it is necessary to prepare for it and adapt the interpretation to the audience, its age, experiences and interests. At the same time, it is a good idea to make the excursion as interactive as possible (which makes you different from other explanatory classes, e.g. tours of castles and chateaux).

Remember that excursions with a longer theoretical part are more suitable for secondary school students. Younger participants tend to have a significantly lower level of concentration, which is why it is necessary to think as practically as possible, even at the cost of a smaller volume of transmitted information.

- **In particular, it is good to know:**

How many visitors will come

- Not only with regard to the interpretation, as attention decreases as the number of participants increases, but also with regard to the technical layout - will the entire excursion fit, for example, in the handling chamber of the reservoir or in the control room? In both cases, don't be afraid to split the group into two if there are enough human resources.

How old are they and what school are they from?

- Students of an industrial school focused on automation will be interested in different information than students of a humanities-oriented grammar school, and those in turn will be interested in different information than future nurses; the excursion will look different for 6th grade elementary school students without knowledge of chemistry.

What is the purpose of the excursion?

- Whether to primarily impart theoretical knowledge about water engineering processes, or whether a theoretical lesson has already taken place at school and the aim of the excursion is to test the acquired knowledge in practice; or introduce the job description of the employees (career in the water sector)? Often the goal can be just to raise awareness that drinking water is not a matter of course and that there is a lot of work behind its production and at the same time its quality is also influenced by our behavior towards the environment.

How much time do you have for the excursion?

A typical time is two teaching hours, i.e. roughly 1.5 hours; however, it depends not only on the age of the participants, but also on the distance between the school and the treatment plant building - this aspect of the tour must always be agreed in advance with the teaching staff.

- It is a good idea to prepare general information about the water treatment plant in advance; the form you can use to do this is in the Appendix of this document.

Local history

- See chapter "Your own excursion"

How much water you produce per second, per day and per year

For a better idea, it is advisable to convert to some more accessible units, see the table below. **Unit**	**Volume**
Olympic pool (depth 2.5 m)	3 125 m^3
rural pond	on the order of thousands of m3
railway tanker	46 – 90 m^3
tank on chassis T815	9 m^3
tank on V3S chassis	3,5 m^3
bath	100 – 200 l
bucket	12 l
garden watering can	5 l

Where do you supply water, to which cities, municipalities, local areas

- Whether only to the immediate surroundings, or to more distant municipalities, or whether the treatment plant is connected to a group water supply. Feel free to take a map or an aerial photo of the area to help.

How many people do you supply water to?

- Of course, you don't need an exact number, rather an order of magnitude for an idea.

How long is the water supply network and what material is it made of?

- Again it is possible to zoom in, e.g. the distance from the place of the excursion, or from the center of the city/village of the participants to the city XY; how many reservoirs, gas stations and other interesting objects are there on it. You can use, for example, a map output from GIS, where (in a printed version) children can find where the water reaches their home. It is always better to have some visual material to talk about so that the children can better orient themselves. At the same time, children will probably be surprised at how long and complex the water supply network is.

How much electricity do you use to produce water?

- You can compare with the consumption at home - the average electricity consumption in the Czech Republic in 2023 for 1 household was 3,500 kWh/year, which corresponds to a TV turned on continuously for a year (and that is not a little - you can remind the children how their parents appeal to them to turn off the TV when they are not watching it).

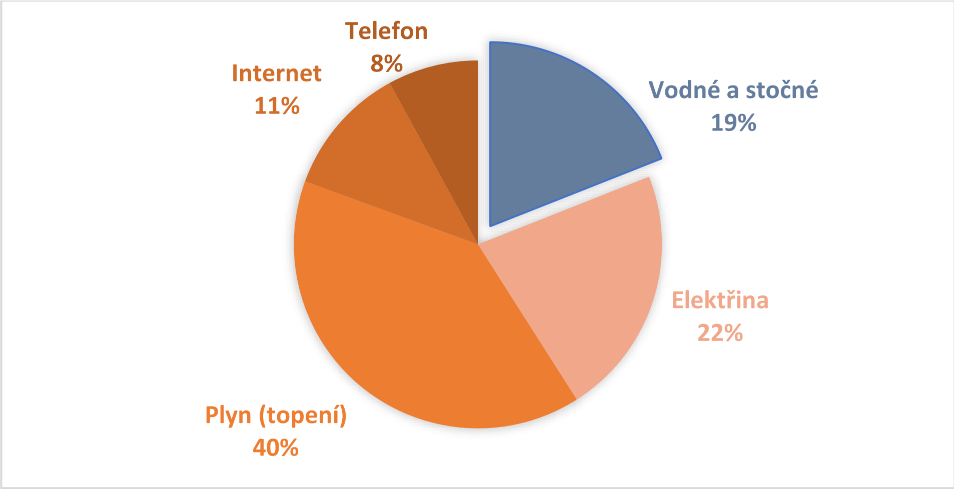
The price of water in relation to bottled water

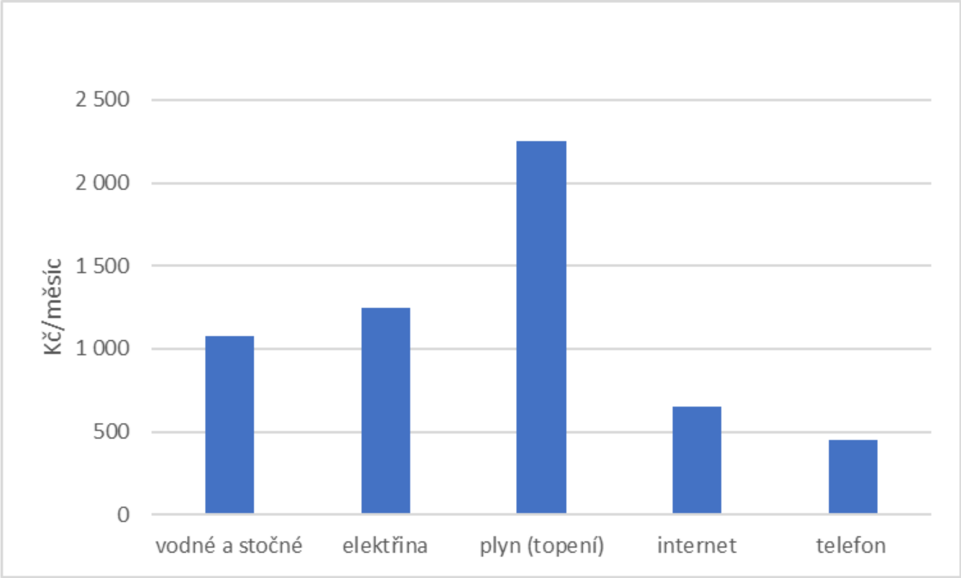
- For a better illustration, refer to 1.5 liters, when the price of a package is at least CZK 8; this roughly corresponds to the price of 1 m3 taken from the environment for treatment into drinking water (children usually have no idea that they also pay for this water). Alternatively, you can compare with other drinks such as cola lemonade. You don't have to reveal the price to the children right away - ask them what they often drink and how much they pay for a bottle. If no one dares, start it yourself. Then compare with produced water at the treatment plant.

The price of water in relation to other monthly costs

Prepare a graph that shows how much the average household in your region pays for water and how much for other utilities and services such as cable TV, Internet, and telephone. You will be surprised how low the cost share of a basic (perhaps even the most basic) human need, water, is compared to electricity, gas or internet connection.

Example of comparison to typical prices in 2024: Service	Average monthly cost	Percentage share
Water and sewage	**CZK 1,080**	**17,9 %**
Electricity	**1,250 CZK**	**20,7 %**
Gas (heating)	**2,250 CZK**	**37,3 %**
Internet	**650 CZK**	**10,8 %**
Phone (mobile)	**450 CZK**	**7,5 %**
Other heating	**variable**	**-**
In total	**CZK 6,030**	**100 %**





Which groups of substances are removed at the water treatment plant and which technologies are used for this

Removal methods and the significance of individual substances for the organism and the environment are detailed in the next part of this methodology. However, consider if the technology also focuses on removing something less common. For example, some groundwater may have higher levels of nickel or other metals. Elsewhere, the water may be rich in radon. Don't forget to emphasize to the children that this is something typical for the locality.

- **Think about:**

Where do you take visitors?

With regard to their safety, traffic safety, space capacity (for example, try to set aside a place where they can leave their backpacks - it is better if they do not walk around the whole processing plant with them), the time allowance of the tour and the distance between individual places.

Keep in mind that children have a lot of explanations at school, they go on an excursion primarily to see something (an hour-long lecture in a meeting room and half an hour in traffic is not exactly what would excite children). The proven method of the excursion route is to walk in the direction of the water flow at the treatment plant.

If you know you are going to a noisy place, try to explain to the participants what they will see there before entering the building. It is up to you whether you start a more detailed description before or after entering the place.

- Due to the complexity of some technologies, graphic diagrams can also be used to describe the process. Do not forget that children cannot stand a long explanation in one place. For this reason, it is recommended to explain what the children will see before entering, agree on what you will show them and in what order (first inlet, second outlet, third...), let them have a short look and then leave the building. You will then take the diagram in your hand and explain the process in more detail. Before moving on to the next station, ask the children if they want to look inside again to see the technology with their newly acquired knowledge.

What main information should participants take away from the excursion?

- This point might seem trivial, but don't skip it, please. What is the minimum that each participant must take away from your excursion? Think about it, write down a few points and plan your excursion accordingly. Feel free to take the paper with you on the excursion and keep checking to see if you forgot to mention something important from the list. Repetition is the mother of wisdom, so it's okay to mention something more than once. Feel free to repeat with the children between moves - ask them questions to see if they understood the information from the previous station.

What and where will you call them together with the time allowance for individual stops

Man is a creature with a bad estimate of how long things will last. Remember that sometimes less is more. If there is time left, you can attend to more questions from the children and repeat with them. It definitely feels better than giving a long monologue and you're pressed for time. In addition, children are able to take away more information from the excursion.

- Keep in mind that it is not your job to hammer all the information into the children during a short field trip. Your main task is to get the participants excited about the field. Give them some of your enthusiasm and motivation. After all, many of us are in the field because water is essential for life and our work really has a higher meaning.
- **What will you show and demonstrate to them, what can they try for themselves in your conditions**

What might they ask you?

- In each chapter, we tried to include a few typical questions on the given topic and also provided short answers. Specifically, we tried to answer in three sentences. Try to think the same way - do you have any other questions? If so, write them down and prepare short answers. After all, there is usually no time for more extensive answers during the excursion.

What you didn't understand at their age and would like to understand

- Think about what you think is important. What would you like to realize at a young age? Now is your time to explain it to someone else. Maybe he won't understand it right away, maybe it will take some time, but who knows, maybe he'll remember you for a long time and be happy for the knowledge he's gained.

What will you ask them?

Questions in order to make the tour more interactive and at the same time to find out the initial state of knowledge of the participants about the given issue. However, you don't have to test only initial knowledge. Don't be afraid to test the acquired knowledge during the excursion. This is a great form of feedback for you – did they understand the information from my presentation and where do they have gaps? Moreover, phased repetition is one of the best learning methods. Students have the opportunity to actively recall information, which will help them transfer knowledge from short-term to long-term memory. But keep in mind that we are now teaching, not testing!

Above all, ask questions and make sure they understand the things from your list of "What are the main things participants should take away from the field trip".

On the other hand, it must be said that some pupils do not like questions, or the answers to them at all, and this dislike increases with age; so it's not your fault if no one wants to answer you on their own. The "speech" question is also of didactic importance, which is followed by a short break, when the listeners usually think, even if the guide then answers, the listeners also tried to formulate the answer in their own words, which has a positive effect on understanding and remembering the material.

If you feel that you have come across a really shy group, try to start with very easy questions and give the participant a reward for the correct answer (candy, pen, other advertising item), perhaps to motivate them to be more active for future questions.

- **Ensure and prepare in advance:**
- **Necessary documents required by the facility operator (typically for example health and safety)**
- **Necessary safety equipment, if needed (gloves, helmets, safety vests...)**
- **Worksheets for visitors (after agreement with teachers)**
  Aids for illustrative examples
    - For example:
    - mobile hand-held tests (sometimes called droplet tests) - typically for operational measurements of chlorine, iron, manganese or pH,
    - tool,
    - water meter (ideally also disassembled),
    - sampling equipment for sampling water in individual technological stages (+ automatic sampler),

sample of filter material in a glass.

- We also recommend preparing a simplified technological diagram, either to hand out to the participants, or the second option – to regularly show the current location on a large format. We prefer the second option, because the participants probably won't keep the papers anyway (the more resourceful ones will lose them already during the excursion and you will have the opportunity to hunt for them, for example, from open sand filters). In addition, on a large format, children can see better when you show in bulk and you are less likely to lose their attention. After a few excursions the scheme has proven itself and if you have the opportunity, we recommend laminating the paper for its life.

Small rewards for visitors,

if available (for example company pens, candies...). We highly recommend this point. However, don't give anything away for free - for a correct answer, a good question (a very curious one - this will "buy" you some time to think if the question really catches you by surprise).

Preparation before the excursion

This part is about school preparation - what they should learn at school, what information to work with, preparation of worksheets, field trip assignments. But let's remember the limited time span they devote to it and the need for prepared materials that they will be able to use right away.

Due to the overall complexity of the issue and from a pedagogical point of view, it is advisable for the excursion participants to complete theoretical preparation before the excursion itself - the amount of memorized information will increase and you will not have to discuss basic issues such as the water cycle directly at the treatment plant. However, we know that, especially in larger cities, this is difficult due to the tight level of extracurricular activities in schools. It is therefore necessary to discuss the possibilities with a specific pedagogical worker who will be in charge of the excursion on behalf of the school. Talk to your teacher so you know what to expect.

1.1.1 The preparation at school can be done either by you directly (this option is better, of course, because you can combine the lecture with an excursion), or by a pedagogical worker; materials (presentations, worksheets, photos...) are prepared for both cases within this project and you can find them on its website.

Be the storyteller

Let's define what we want to say, where and to whom, what stories to project into the narrative. What we want participants to take away.

This chapter could be considered an extension, but we hope you find something interesting and inspired in it. The stories contribute to the revival of the classic excursion. Have you ever thought about how important the way you express yourself can be? Because how we convey information is just as important as what we say – often if not more so with children. Especially if you want to engage the participants.

Historically, storytelling has been the main way of transmitting information and experiences between people. It is still considered the most effective method of attracting people. Unlike "dry" facts, stories have a personal level, a specific plot and often evoke emotions in us, which help us grasp and process the information all the more. In addition, people usually remember stories longer and easier. And when they are told particularly well (the impact is "strong"), they can stay with us for a lifetime. We probably all carry some of that in us, don't we? Sometimes they even inspire us.

For a story to be good, it must be carefully thought out and prepared. Relying on something coming up on the spot usually doesn't pay off. In addition, we need to be careful not to betray our own body - it is said that more than 90% of communication is non-verbal. Therefore, pay extra attention to gestures and facial expressions. However, it is definitely not desirable to overdo it, especially if you are not used to it - you do not want to appear contrived. Don't worry, everything just takes practice. You will see that you will improve with each subsequent excursion. Remember that the most effective stories are those from your own experiences, so don't be afraid to "spice up" the excursion with stories from the field.

As part of this project, we thought about the possible stories for you and came up with three important story lines that will help illustrate the individual ongoing events and processes at the treatment plants – this is the story of water, the story of substances and energy, and finally the story of people. Which of the stories you promote more should depend primarily on the purpose of the excursion.

You should set the goal during a joint discussion with the teacher, long before the excursion itself. If a group of students who are not very familiar with the field arrive on the excursion, it makes sense to focus especially on the story of water - how raw water becomes the treated water that flows from the tap at home. However, when you are talking to older students who already have a basic knowledge of chemistry, it makes sense to include a discussion about energy, water prices, and the chemicals that are necessary for treatment, whether to use or specifically remove from water. For students who have shown a direct interest in the field, or who are researching the possibilities of future employment, it is offered to guide them through the story of people who work at water treatment plants. We analyze the individual stories in the following subsections. You can be inspired by our stories, combine them, or simply invent your own. You are the narrator.

In most of the sections described below, there are questions that you are likely to encounter - you can either "just" prepare to answer them, or directly incorporate these questions into your presentation.

The story of water

Water is practically everywhere around us - not only in the form of rivers, ponds and lakes, but also in snow, atmospheric and soil moisture; even we are full of water. About 60% of our being is made up of water - isn't that a good reason to have the best possible water for life? It might seem that then there is no problem with everyone having access to the water that is necessary for life. However, the opposite is true - the vast majority of water in nature is not intended for long-term direct consumption without negative effects on the human organism and it is necessary to treat it accordingly; and that's actually what the entire field of water engineering is about. So let's see where the tap water comes from. In other words, what must happen before we pour drinking water into a glass at home, which many not only children but also adults take for granted.

As a story of water, it is possible to start with a description of the water cycle, i.e. the evaporation of water from the oceans, its transport in the form of clouds and subsequent precipitation to us. Subsequently, the water somehow gets into the raw water source for the treatment plant and into the technology. However, the story does not end there and the used water is cleaned and returned to nature, where someone else can use it several times before the water flows back into the ocean.

❔ **Question: How much water is there on the planet and how much of it is potable/potable water?**

💡 **Answer:**

Water bodies occupy almost 71% of the earth's surface. Of the total volume of water, the vast majority is in the world's oceans and seas (97.7%), glaciers and long-term snow cover, for example, at the poles capture 1.7% of the world's water reserves. Only 0.6% is in the soil and in the soil environment (we call it groundwater) and 0.01% is retained in freshwater lakes, artificial water reservoirs and riverbeds (surface water), from both of these sources we treat water for consumption. So let's say we're working with roughly 0.61% of the total water on the planet - that's not even one percent!

❔ **Question: What percentage of us, humans, are water?**

💡 **Answer:**

About 60% of us are water.

❔ **Question: How long can a person last without water?**

💡 **Answer:**

On average, we can last 3 days without water.

A study from 1944 states that a person can survive without water in the order of units of days. However, it is necessary to realize that some part of the water is also in the food that one eats, and climatic conditions also have a great influence. According to the BBC, the record holder is a young Austrian mason who was locked up in a pre-trial detention cell by the police in 1979 and then forgotten about. He allegedly lasted 18 days without water.

❔ **Question: What forms of water do we know?**

💡 **Answer:**

In nature, we can meet water in three different forms (groups) – solid, liquid and gas, and even at the same time. When we say water, we most often think of its liquid phase, which flows to us in rivers, rains from clouds, and which we drink. However, water can also be gaseous - water vapor, which we see floating above tea and which evaporates when cooking food. The last form is, of course, solid water - the ice on which we skate in the winter and with which we want to cool down our lemonade in the summer.

❔ **Question: Where does our water come from?**

💡 **Answer:**

We'll probably find out it's going to rain. That's the right answer, but let's ask if it also applies to groundwater. And yes, the correct answer here too is that the groundwater was also rainwater. The difference between underground and surface is only in the length of the cycle and the time it stays here.

All water in the Czech Republic comes from precipitation, and all water from the Czech Republic gradually flows into the sea. So we are completely dependent on rainwater.

SŠ: Do you know that Pilsner beer has such an exceptional taste precisely because of the groundwater used? Therefore, even if someone brewed according to the same recipe, the beer would not taste nearly the same due to its different basic ingredient, water. Beer also has the great advantage that the water is boiled during its production, which helps to destroy any harmful microorganisms contained in the water. Historically, even children drank beer because it was safer than drinking water. This is also proven by the London water epidemic, when only the brewery employees did not get infected (since they mainly drank beer).

Curious: Did you know that water cannot be created by itself? This means that underground water can be tens of thousands of years old, and every water before us was already drunk by a huge number of people and animals.

❔ Question: What is the difference between surface water and groundwater?

💡 Answer:

Water from rivers, lakes and reservoirs, i.e. water visible on the surface, is surface water. Anything taken from the ground (from the subsurface) is already groundwater.

❔ Question: How much water is produced in the Czech Republic annually?

💡 Answer:

In 2022, a total of 576 million cubic meters of drinking water was produced in the Czech Republic, which corresponds to less than two Lipno reservoirs.

❔ Q: What industries use treated water?

💡 Answer:

For sure, every industry uses water in its production. Whether it is one of the raw materials or just cooling water. We will give only a few examples here. Agriculture is undoubtedly at the top of the consumption ladder. It may surprise participants, but 70% of the world's fresh water (about 3% of the planet's water including frozen supplies; less than 1% for conventional sources) is used in agriculture. That's almost ¾ of the total! However, agriculture is not the only one. The clothing industry also consumes a huge amount of water. Not to mention that most of the clothes that are made are never worn. But that's probably a sad story for another time. In addition, water is used by the food industry - it often needs to regularly document satisfactory water analyzes for its activities. Surely the children have heard that the production of electronics is demanding on water - all those batteries are a big burden on the environment. With the age of electric cars, the demand for water is even greater. Even if we think about how much water is needed to put out such a burning electric car...

For the curious: The most demanding cultivated plants in terms of water consumption are cotton, sugar cane, wheat, corn and rice. Surprisingly, this also includes nuts, which are often grown in water-poor areas.

❔ Question: What is a watermark?

💡 Answer:

The water footprint tells us how much fresh water is used (directly or indirectly) to grow crops or produce a certain product. So it is a certain indicator that helps us learn the burden on the environment.

There are also certain types of water traces, but it is definitely not worth going that far on an excursion. But if the children take away the information that the water footprint exists and it is a good way to evaluate our behavior towards water, it will be partially won.

For the inquisitive: To give an idea, around 15.5 thousand liters of water are consumed per kilo of beef. The water footprint is therefore 15.5 thousand l/kg of meat. In comparison, for example, rice has around 1.6 thousand l/kg. So slowly ten times less than beef.

The story of matter and energy

If the children are already well acquainted with the story of water, or if they are older students with an awareness of chemistry, it is appropriate to include the story of substances and energy in the excursion. After all, water treatment is far from simple and free. This is probably one of the most mistaken assumptions in general. Everyone then has the feeling that there is plenty of water all around us and the water companies only want to extract money from people. And the opposite turns out to be true when we start to take an interest in water pricing. Few people probably know that there is a charge for raw water intake. In addition, we have to pump raw water and that energy also costs something. And when we talk about energies, we are leaving out one essential one here – human energy, without which the processing plant would definitely not do. Fortunately, that is discussed in the next chapter.

How much do the chemicals that we have to add to the water to treat it cost? A wide range of chemicals are used at treatment plants of both types of water and it would not be possible without them, because the water would not meet the requirements of the legislation and could endanger the health of consumers. However, it is not only about the substances that we add to the water, but mainly about those that we want to get rid of in the water.

❓ Question: What substances are found in water?

💡 Answer:

In general, we can distinguish between chemical and biological parameters that we monitor in water. Based on their size, substances in water can be divided into undissolved, colloidal and dissolved substances. Of course, the biggest ones are best removed (the undissolved ones). Substances can be inorganic or organic in nature. In general, we can talk about salts, metals, gases, micropollutants, pathogens, but also harmless microorganisms and substances beneficial to health.

Secondary school: The following part is intended primarily for secondary school students who already have a solid foundation in chemistry, because only then will all consequences and connections be fully understood. Na tomto místě jsou uvedeny parametry vody, které jsou důležité.

❓ Question: What concentrations will we be talking about?

💡 Answer:

You can ask the children what they think are the concentrations of individual substances in the water. They will probably be surprised that no substance in ordinary water exceeds the value of a quarter of a gram per liter. Some (iron or manganese) are at most in units of milligrams per liter, for heavy metals or pesticides we can go up to tens of micrograms per liter.

1 gram per liter is approximately 1 part of the substance per 999 g of water. A milligram then corresponds to a dilution of 1:1,000,000, and in the case of micrograms, then 1:1,000,000,000.

❓ Question: What substances and pollution can we normally encounter in waters?

💡 Answer:

iron and manganese – Both of these parameters are caused by the geological substratum and are a completely normal part of practically every groundwater. In addition, iron can come from older internal distribution systems directly in homes (so if you have rusty water flowing at home, it may not be a problem at the treatment plant). The good news is that in commonly found amounts (milligrams per litre), they are not harmful to health - however, they are a problem when cooking or washing, for example, where they can result in brown stains on clothes. However, high concentrations of manganese are suspected of having a negative effect on the nervous system.

nitrates and nitrites – Nitrogenous compounds enter the water through agricultural activity (fertilization) or seepage of organic material into the water. They are not a problem for adults, but for children it is necessary to monitor these parameters (that is why baby water is defined mainly by the content of nitrogenous substances). Nitrates are converted to nitrites in the human body, which irreversibly react with hemoglobin to form methemoglobin. Methemoglobin is no longer able to carry oxygen, which can result in suffocation of the child (in "lighter" stages, gradual turning blue).

radiological parameters - Perhaps this information will surprise you, but practically all water is radioactive, even drinking water. But you don't have to worry - the limits are set very strictly so that you are at risk of acute radiation syndrome (headaches, vomiting) if you drink 45 million m3 of water at once (about a sixth of VN Slapy). The most common source of radioactivity in water is (as well as in the air) radon-222, followed by potassium-40, uranium-235 and uranium-238. These are all natural radionuclides and contamination from, for example, Chernobyl is not a problem.

microbiological parameters:

This might also be interesting because every water contains a certain amount of microorganisms. However, the decree limits all unfavorable and dangerous microorganisms to zero and allows only harmless or dead ones in the water. There are tens of thousands of microorganisms in treated water and only a very small part is cultivable. In general, only 0.27% can be cultured from raw water, less than 0.01% in treated water. In other words, only such a small percentage can be isolated and subsequently determined by conventional culture methods.

There are many pathogens that can be found in water, and historically, the most important waterborne epidemics in the world were cholera (a dangerous diarrheal disease) and typhoid (sudden fever and life-threatening dehydration).

When assessing microbiological safety, the analysis does not look for specific harmful microorganisms (pathogens). Searching for individual organisms would be not only time-consuming, but also technically demanding, so we usually only focus on a specific organism during an epidemic investigation. Under normal conditions, group determinations of the so-called indicator system are carried out. This can be understood in the way that we always follow a representative that indicates whether we succeed in removing a certain group of microorganisms from the water. Faecal pollution indicators are used all over the world to look for bacteria commonly found in the intestines of warm-blooded animals. Typical indicators include Clostridium perfringens, Escherichia coli (E. coli) and enterococci.

Clostridium perfringens – indicates successful elimination of parasitic protozoa. The finding of such bacteria clearly indicates that the water has come into contact with faeces and may pose a health risk.

E.Coli – this is a commonly occurring bacterium in our intestines, but there are also pathogenic strains of this bacterium. The consequences of infection can range from bloody diarrhea to kidney failure (especially in small children).

Legionella - was discovered in 1976 thanks to a mysterious epidemic in the USA. Unlike the previously mentioned bacteria, Legionella infection is caused by inhalation. It is commonly found in all waters, but poses a risk in warm water and air-conditioned units where it multiplies in large numbers. This bacterium thrives best between 25 and 45 degrees Celsius. Globally, the rate of infection is increasing. With energy prices rising, people started saving in the wrong place and kept the home boiler at an insufficient temperature. This resulted in the bacteria multiplying in him to life-threatening concentrations. The infection manifests itself as a febrile illness that leads to severe pneumonia and, in weaker individuals, to death. Due to the financial and time-consuming nature of monitoring their occurrence in households, it is necessary to pay attention to prevention and sufficiently heat the boiler - to eliminate the bacteria, a water temperature above 60 degrees Celsius is necessary. The last representatives we will mention here are heterotrophic bacteria, natural and harmless bacteria in the aquatic environment. Heterotrophic bacteria are determined at two different temperatures, namely 22 and 36 degrees Celsius. This is one of the first historically investigated microbiological indicators, but these days they are no longer considered to be medically significant.

❔ Question: Which substances, commonly found in water, are beneficial for health and which, on the contrary, are harmful?

💡 Answer:

As the wise alchemist Paracelsus once said, "Everything is poison, everything is poison. It is only the dose that matters." it is no different in water. Yes, some substances are harmful even in very small amounts and their occurrence is undesirable. These can be the already mentioned pathogens, pesticides, pharmaceuticals and other biologically active substances. Others can be harmful in the long term, and some, such as the already mentioned minerals magnesium and calcium, can even be necessary for our health.

❔ Question: What kind of chemicals do we add to water when treating it?

💡 Answer:

We add many chemicals to the water depending on the technology and we also need different materials (eg filter materials such as granular activated carbon, sand, quartz, ground limestone, expanded clay granulate and many others). We will only give a brief summary here.

It is often necessary to harden the water, which means "artificially" adding calcium to the water so that the water is not aggressive towards the pipes (you can find more in the technological modules). To adjust the pH and calcium content of the water:

Soda – we know it from the household, but it is an integral part of (mostly smaller) water treatment plants. Soda is supplied in powder form, and an aqueous solution is used directly at treatment plants for dosing. The purpose of using baking soda is to increase the pH of the water (reduce its acidity).

Sodium hydroxide - at small treatment plants and is used to treat (increase the pH) natural slightly acidic waters. Just like soda, its aqueous solution is dosed.

Deacidifying filters - natural materials such as semi-burnt dolomite, marble or limestone are used. The water passes through the filter, dissolves the filter material, becomes enriched with minerals and increases its pH.

Lime hydrate – it might surprise some, but ordinary lime is used in treatment plants. It is not used to prepare mortar mixtures, but to increase the pH of water. It is added to water in the form of lime milk or lime water. At larger processing plants, you often encounter lime management, and milk of lime is prepared in a so-called lime choke.

Raw water (especially groundwater) contains increased amounts of iron and manganese. Although it is often stated that they are not harmful to health, this is not so certain about manganese. Some sources talk about a possible effect on the nervous system. We are particularly concerned about iron because it affects the sensory properties of water - you can show the children a sample of really iron-rich water so that we all know what we are talking about. It is also necessary to use chemicals or a certain material to remove these substances:

Potassium permanganate - although it may sound really strange, a compound containing manganese is used to remove manganese. Permanganate is a strong oxidizing agent that helps us convert manganese and iron into a removable form (from dissolved to undissolved), and after oxidation, a classic sand filter is enough to remove them.

Oxygen/air – used at elevated iron concentrations. Similar to permanganate, oxygen has an oxidizing effect and converts substances into an undissolved, easily removable form. You often encounter oxygen at large surface water treatment plants. You may notice that it is stored in pressurized bottles. Such treatment plants do not use oxygen for the normal oxidation of iron, but for the generation of ozone for ozonization of water. But more on that later in the document.

Sodium hypochlorite – hypochlorite is used in smaller treatment plants to oxidize and thus remove iron. But rather more about hypochlorite as a disinfectant. Almost everyone uses and knows SAVO well, it is a sodium hypochlorite solution. This is one of the possible means of hygienic protection against microorganisms. You will come across hypochlorite at every small processing plant in the Czech Republic. What is new is that even some larger processing plants are starting to produce it themselves and put it into operation.

❔ Question: How does regular SAVO differ from the hypochlorite used in treatment plants?

💡 Answer:

SAVO and regular sodium hypochlorite (NaClO) used in water treatment plants have the same active ingredient, which is sodium hypochlorite. Probably the biggest differences are in concentration and use. The SAVO we have at home is usually a 5% solution and is formulated this way especially for safety and ease of use for the average consumer. At home, we use it as a disinfectant for surfaces or as a bleach. However, at treatment plants, the concentration varies depending on the needs of the individual treatment plant. A certain purity of the hypochlorite is also expected, which will ensure a higher stability of the product and, above all, prevent unwanted by-products in the water during its use. At treatment plants, hypochlorite is used to sanitize water against pathogens, thereby ensuring safety for consumers.

For more polluted water sources, which means mainly surface water, other specific chemicals are needed such as coagulants, auxiliary flocculants and advanced oxidation processes.

Coagulant based on trivalent ions – so-called coagulants are used to precipitate really small (colloidal) impurities, which help to aggregate impurities into larger units, so they can be removed more easily (see the technology module for more information).

Ozone – Ozonization is one of the most effective forms of hygienic water security and a short contact time with the water is sufficient. A big advantage is that there is no formation of chlorinated disinfection by-products. Due to its low stability in the lower atmosphere, ozone must be generated directly at a water treatment plant and is produced from air or pure oxygen exposed to a high electrical discharge.

Granulated activated carbon - sorption on granular activated carbon is discussed more in the technology card. We will only briefly state that it helps to remove micropollutants, odor-causing and taste-causing substances from water. However, it must be regenerated once in a while to keep the technology as effective as possible. Today, unfortunately, pollution of underground sources with pesticide substances occurs with frequency, so filtration through granulated coal is being introduced more and more often also for underground sources.

Chlorine – Probably the most well-known organoleptic characteristic of supplied water is the smell, which is most often chlorine (after all, you can smell it in swimming pools, for example). Previously, it was necessary to have a non-zero chlorine content in drinking water in order to ensure microbiological safety; this has not been necessary for several years. However, the human sense of smell is very sensitive to chlorine, and the limit value of 0.3 mg/liter is already so noticeable that the ordinary smell of chlorine from the water supply is far below the limit.

❔ Question: Why must water be chlorinated if it has a negative impact on the organoleptic properties of water?

💡 Answer:

1.1.2 Most of the time, we always have something for something in life, and unfortunately it is no different here. Chlorination of water helps us to secure water for a longer period of time and a longer distance before the water reaches the consumer. In addition, the quality does not depend so much on the internal piping and its cleanliness, since free chlorine ensures disinfection even on the route. This is such an insurance policy for the operator, and few would take such responsibility on their neck. After all, if there was no guarantee of hygienic security, the occurrence of pathogens in water could have fatal consequences. We would go back to historical times of epidemics from water. And yes, some treatment plants (especially abroad) operate without chlorine, but for that you need a quality infrastructure. Let's answer honestly - do you think there is money to replace distribution lines with new ones everywhere in the Czech Republic? Check and repair pipes regularly? What about the part at the consumer? Do you regularly check the wiring at home? And how often do you disinfect your tap aerator at home?

The story of money

It is about money first and foremost, and therefore part of the explanation of the excursion (or the previous lecture) should be devoted to the pricing of water, because the lay public (which includes the participants of the excursions) has no idea what the price of water consists of. We have already come across the opinion that those hundred crowns per cubic meter, for example, all go as profit to the company, because water is free from nature, the infrastructure was built from the time of socialism and nothing else is needed. We probably don't need to tell you, as operational workers, that it's definitely not that simple.

1.1.3 The formation of the price of water is governed by the relevant legal standards and the regularly (annually) updated price assessment of the Ministry of Finance (which includes, among other things, the maximum price of water for a given year for individual regions of the Czech Republic, the so-called socially acceptable price, and the maximum percentage of the operating company's profit, the so-called reasonable profit). The owner of the infrastructure, most often the relevant municipality, which approves the price calculation compiled by the operator, plays an important role in the creation of the price. The price calculation then includes cost items that arise during the production of drinking water. The costs start already with the withdrawal of raw water, for which a fee needs to be paid (the fee has a different amount and a different target organization in the case of surface and underground water). Water collection is often pumped and requires electricity. After all, it is also needed to power other technologies. Electricity thus becomes an important item of the so-called water supply. Furthermore, chemicals are used in water treatment. In addition to electricity and chemicals, there is a need for laboratory control and technology operation (in general, human resources related to the operation of not only the technology, but also the company as such). Often the most significant item of water is the costs associated with the renewal and maintenance of water assets. Every building and technology has a limited lifespan, and from every m3 produced, it is necessary (by law) to generate finance for their renewal. The water fee also includes other items related to accompanying services, maintenance of analytical devices, waste disposal, costs for readings, calibration and replacement of water meters, administration of the entire operation and, if necessary, costs associated with possible loans and the like. The price of water must then be high enough so that there are enough funds to cover all expenses. The waterworks operator also usually makes a profit, which is the main motivation for his activity. The amount of profit is heavily regulated, controlled and cannot exceed 7%, which is a very low figure compared to other fields.

The story of the people

If the subject of people and professions in the water industry is brought up, every tour participant is likely to think of the operations personnel checking the canals (even if it is not actually related to the water industry as such). This stereotype and at the same time the decreasing interest in professions related to water led us to include this topic in the tour. It is not necessary to reserve one separate stop for these stories, but rather to convey this information gradually at times when it will be useful (when introducing yourself, when visiting the operational laboratory or the control room). So you can mention the listed occupations and professions. At the same time, it must be said that not everywhere the profession has the same name, or the scope of the work performed may differ.

❔ Question: What positions (people) could the treatment plant not do without and why?

- 💡 Answer:
- **Treatment plant operator – a person who takes care of the normal day-to-day running of the facility. His duties vary according to the specific facility and location. It may only be about replenishing chemicals and maintenance, but duties may also include (especially for small operations) chemical analyses, system setup, sampling, minor repairs and adjustments, mowing the grounds around buildings, and the like.**

- **Dispatcher – at larger processing plants, they monitor the operation and settings of the processing plant non-stop. They work closely with the technologist.**
- **Foreman of the treatment plant – at larger operations; coordinates people, ensures orders and supplies of material and communicates closely especially with the treatment plant operator and technologist.**
- **Operational fitters – ensure network functionality and repair faults.**
- **Sampler - takes samples both at the treatment plant and at the water supply network and at customers.**

Laboratory technician - processes samples, either operational or accredited.

- **For the curious: With accredited laboratories, you can be sure that the methods used, statistical processing, error rates and the quality of the chemicals used are in accordance not only with legal regulations, but also with generally accepted laboratory practice; this is regularly and very strictly controlled by the accreditation institution.**
- **Electrician - provides maintenance and repairs of electrical equipment.**
- **Water manager – provides administration related to water withdrawals, communication with authorities, water management balances.**
- **Technologist - a very important profession. This is a person who is responsible for the quality of the supplied water. Among his competencies and tasks are the correct setting of the technological line, determination of the correct doses of chemicals, planning of sampling and evaluation of analysis results. A technologist should be a trained chemist (preferably directly in the field of "water technology", although unfortunately this specialization is severely lacking).**
- **Customer department - mediates communication with customers, concluding contracts, invoicing, complaints, commenting on networks and the like.**
- **Prevention - usually troubleshooting - here you can talk about your company's troubleshooting methods.**
- **Other professions – water management operations may also have other employees who provide, for example, GIS, investment planning, storage, technical support, drivers.**

Management – like any company, operational water companies must have managers, internal auditors, HR and other related positions.

❓ Question: How many people work here?

💡 Answer:

Probably the most common human resources question you can get from field trip participants. However, we can't help you with the answer and you have to ask yourself (for small municipalities, where you may be the only worker in the water department) or your superiors (for operating companies).

❓ Question: What do I have to study to work here?

💡 Answer:

If you get this question, we will be very happy - because one of the secondary goals of this document and the entire project has been fulfilled, namely to arouse interest in the study of water engineering fields in the participants of the excursions. If we are talking about drinking water technologists, then they can be studied directly at the Faculty of Environmental Protection Technology at the University of Chemistry and Technology in Prague and at the University of Technology in Brno. Related fields can also be found at the Faculty of Science of Charles University in Prague, at the Czech University of Life Sciences in Prague and at the University of Mining and Technology in Ostrava. However, it must be said that this position is open to all scientifically and technically educated applicants.

As for other professions, it depends on the specific position - it is difficult for a person to perform the position of a laboratory technician if he has a plumber's training certificate and vice versa. Regarding "career advice", we refer to the platform Young Water Professionals Czech Republic (www.ywp.cz), which brings together water professionals under the age of 35.

Own excursion

Opening words

It would be a good idea to start by discussing the terminology with the children – the words you will use often to make sure they understand everything. Try to start a little communication with them in this way and increase their interaction. Ask them in the form of questions - do they know this word and how would they describe it?

Health and safety during the excursion

A short occupational health and safety training is the first mandatory part of every excursion. For specific content, we refer to your internal company guidelines, or to a separate document from a series of methodologies, which is specifically devoted to OSH training. Please do not underestimate this part, even though it may seem redundant or unnecessary.

Story line

A good excursion can be supported by an interesting and well-targeted story. The story line should be engaging and should guide the participants through the entire excursion. After previously discussing the purpose of the excursion with the pedagogical support, you can choose one of the story lines suggested by us or you can invent your own. However, if you decide to use ours, we would like to refer you to the previous chapter as well as the additional material: Self-excursion – overview (Appendix 2). He could make your job easier. In addition to the story lines, here we also present suggestions for tasks for children and a key question at each station that you should answer with your children.

Local history

We recommend including the issue of local history (from the point of view of drinking water supply) as a thematic introduction for the excursion, which will naturally be followed by other areas of interpretation. If you do not have information about this area, try to contact representatives of the local government or senior employees of your organization. For a basic orientation, let us state that the first water mains in smaller municipalities (where we assume a more likely lack of information) began to be built between 1910 and 1930 (in the case of border areas), or in the 1960s and 1970s as part of the so-called Action Z. Both construction styles are easily distinguishable from each other, as well as constructions implemented as part of state subsidy incentives, or EU in recent decades.

Elementary school: From a pedagogical point of view, it is not appropriate to include the participants in the data excursion; a discussion of the approximate time of construction, or more fundamental construction or technological reconstruction, is completely sufficient. Instead of dates, we recommend using the wording "XX years ago..." and relating it to generations (e.g. "The water supply system started to be built in our country at the time your parents were born; therefore, your grandparents did not yet have a water supply system and had to take all their water from a well").

It is better to "wrap" history in a story, for example: "...as the city grew, our ancestors had to deal with the lack of water and decided to build this treatment plant..."

Secondary school: Information similar to that of primary school students. It is possible to point to historical, especially local historical events with a similar dating to the water supply itself, if possible to link this dating with the state of the water supply (distribution network material, possibly technology).

Inquisitive: If, for your further education or deeper interest, you would be more interested in the issue of the history of the water supply system in a given locality, we recommend that you turn to the local chronicle (nowadays they tend to be digitized), or the local state district archive, specifically to the funds of specific municipalities (before 1945) of local national committees (after 1945). Relevant links can be found at the end of this methodology in the links and other educational materials chapter. A basic overview of the history of water supply in most regions is contained in the book Jaroslav Jásek: Water supply in Bohemia, Moravia and Silesia.

❔ Question: And what are you doing/cleaning here at the cleaner...?

💡 Answer:

Unfortunately, in our practice we regularly encounter the fact that the lay public does not know the difference, or does not recognize drinking water treatment plants and wastewater treatment plants. With such a question, it is therefore appropriate to draw attention to the diametric difference between these two buildings, not only in terms of primary purpose, but also technology.

- ## Key questions
- **Question: Is drinking water a matter of course?**
- **Q: What can contaminate water?**
- **Q: What role does the order of technologies play and what do they remove?**
- **Question: What would be the impact on society if there was no reservoir on the network?**
- **Question: Can water treatment be done without continuous control?**
- **Q: What happens if the water does not meet the limits?**
- **Question: Every production has its own specific waste - what is the water supply waste?**

Question: How to save water?

- Saving water at home is a great way to reduce costs while helping to protect the environment. A few tips for participants:
- Shower instead of filling a full bath
- Make sure you have two-phase flushing at home (two different volumes of water)
- Use the dishwasher at home instead of washing the dishes (run it full!)
- Buy energy-saving appliances (consider water consumption when choosing)
- Check and repair faucets and toilets for leaks regularly
- Collect rainwater and use it, for example, for watering, or bring it home to flush toilets
- Turn off the water while brushing your teeth
- Do not let the water run empty when washing dishes

Water quality

The whole process of water treatment technology is actually nothing more than removing unwanted substances from water. If the water is rusty or with a strong smell of chlorine, the consumer will immediately recognize it and his trust in tap water will decrease; and we are not even mentioning the legislative aspects - in short, operators must be very careful about the quality of the supplied water.

❓ Question: What are the basic characteristics of water?

💡 Answer:

pH – perhaps the first parameter that comes to mind for the participants (high school students); de facto it is the acidity of the water (correctly it is the negative logarithm of the activity of oxonium ions). Drinking water can be slightly acidic to slightly alkaline, while the specific value depends on the properties of the raw water and on the necessary changes during the treatment technology (each technological step needs different conditions).

hardness - this term is probably confusing - how hard can water be? It's a liquid though. Water hardness is nothing but the content of calcium and magnesium in the water. This is a widely discussed topic among the lay public and two interests come into conflict. Harder water (that is, the one with a high content of calcium and magnesium) is tastier and supplies the body with important elements. On the other hand, such water deposits scale in kettles, washing machines and boilers and thus causes problems in these appliances.

odor - odor degrades water, even if it is otherwise suitable for drinking; it is also probably the first thing the consumer will recognize. In practice, you can most often encounter a chlorine smell (at pH 7 the threshold value is 0.156 mg/l), which is usually caused by higher doses of hypochlorite in the case of poorer raw water quality or when disinfecting pipes after a malfunction. Each consumer perceives smell differently, as well as taste (see below).

taste – just like smell, taste is a parameter that every consumer takes as a reference value for the quality of water, even if, for example, the water complies with the regulation despite the worse taste. In practice, you can mainly encounter an iron taste, which, however, may not be caused by poor-quality treatment, but by poor-quality wiring in the house, which the operator of the treatment plant cannot do anything about. The taste of water is most influenced by the concentration of calcium and magnesium (de facto, i.e. hardness), possibly also by pH.

turbidity – tells us about the amount of undissolved substances in the water.

conductivity – gives us information about the content of ions in the water (the more ions, the higher the conductivity). By itself, however, it does not provide information about whether the water is drinkable. Water with a high ion content (mineral) is not suitable for long-term drinking.

❓ Question: What does it mean that water is potable?

💡 Answer:

Probably the first thing that comes to mind for pupils is that water is colourless/transparent. However, color is a separate parameter and does not tell us anything about the content of, for example, nitrates or pesticide substances, i.e. substances invisible at first glance.

European legislation currently does not recognize the term drinking water - it has been replaced by the term "water intended for human consumption" and is defined as "water that is harmless to health, which does not cause illness or health disorders even when consumed permanently due to the presence of microorganisms or substances affecting the health of natural persons and their offspring through acute, chronic or late effects, whose sensory properties and quality do not prevent its consumption and use for the hygienic needs of natural persons".

Pro zvídavé: Limity pro pitnou vodu jsou definovány ve vyhlášce č. 252/2004 Sb. "Decree establishing hygienic requirements for drinking and hot water and the frequency and scope of drinking water control", which has undergone eight amendments during its existence (until 2026) (primarily addition of other parameters). Radiologické parametry jsou však definovány ve vyhlášce č. 422/2016 Sb. „Vyhláška o radiační ochraně a zabezpečení radionuklidového zdroje“.

This legislation distinguishes between (among other things) three limits - the so-called DH, MH and NMH. Recommended values (DH) are, for example, for water hardness, while their fulfillment is not mandatory. Threshold Values (MH) indicate limits, the exceeding of which must be addressed, but do not represent an acute health risk (for example, manganese or iron); the third type is the highest limit value (NMH), when exceeded, the water is automatically marked as unsuitable for consumption and must be immediately addressed by taking corrective measures.

Every customer has the right to know the quality of the water they are consuming. If the water supplier does not publish it on the website, the customer can contact him and the supplier is obliged to provide the information. In the same way, the customer has the right to see part of the so-called risk assessment and management document, where all the risks of the given water supply can be seen (regardless of the quality or quantity of supplied water).

❔ Question: What does it mean that the water is baby water?

💡 Answer:

From our own experience, we have to say that a very common argument of residents distrustful of tap water is that their well water is infantile. This term was mainly spread by the marketing of companies selling bottled water. Other limits do apply to this type of water, mainly in the parameters of nitrates, nitrites, conductivity (practically the content of dissolved substances) and sodium, but mostly well water does not really meet these conditions, even if people think so.

❔ Question: How often must drinking water be analyzed?

💡 Answer:

1.3 Here it is impossible to say in advance what the tips of the excursion participants will be. The frequency of sampling is determined by the decree and ranges from one sample per year for small treatment plants to several samples per month for larger ones (find out the frequency of samples on your water supply system before the excursion and enter it in the table in the appendix of this methodology). In addition to these statutory analyzes (which are reported to hygiene stations), most operations also have so-called operational analyzes that are carried out for specific parameters of interest (typically chlorine, pH, manganese or iron). If this frequency seems low to the participants, try to follow up with a supplementary question about how often they do analyzes from their own well at home.

Raw water source

The basis of drinking water supply is, of course, the source of raw water, while raw water can be surface (watercourse / reservoir) or underground water (deep or shallow circulation).

For the excursion, prepare basic information about the quality of the water compared to drinking water - i.e. that the water has, for example, excessive amounts of iron, manganese or nickel, or unsatisfactory quality in terms of microbiological parameters. In this way, you will actually justify the existence of the entire water treatment, and the participants of the excursion will be able to better imagine why the individual steps are included in the technology.

> We know that in many cases the source of raw water is at a considerable distance from the water treatment plant and there is no time available to visit the source as part of an excursion. In that case, we recommend printing several photos of the resource in sufficient quality and size so that the participants can see this technological part as well. But if it were possible, it would definitely be better to visit it with the children.

SŠ: You can point to the architectural dimension of the source (primarily in the case of underground sources) - in the border areas you will encounter sources from the beginning of the last century made of bricks, which contain integrated technological devices such as ventilation cascades, while inland, concrete rings from the 1970s, often built as part of Action Z, will be more likely.

> Do not forget to mention that there is a strict ban on the entry of people near water sources, of course the ban on littering and unauthorized handling of the sources themselves. This not only endangers the health of the person himself, but of all consumers of the given water supply network. You can find more about the topic of the water resource protection zone in the accompanying materials of the project.

SŠ: An elevated source of raw water in the middle of a field is not the right place for evening consumption of alcoholic beverages with friends, as we could witness in one unnamed village in the Pilsen Region, and the gap in the concrete rings certainly does not serve as a trash can.

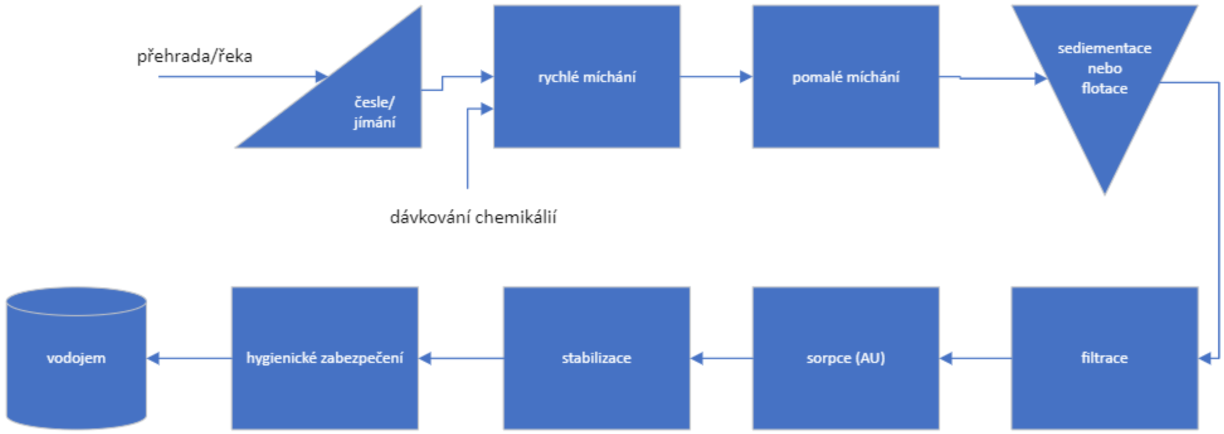
1.4 At the end of this post, it is appropriate to point out the distance of the source from the treatment plant, the material of the pipe connection (the reasons for pointing out the material are mentioned in this methodology in the chapter on the distribution water network) and the method of transport (gravity / pressure line).

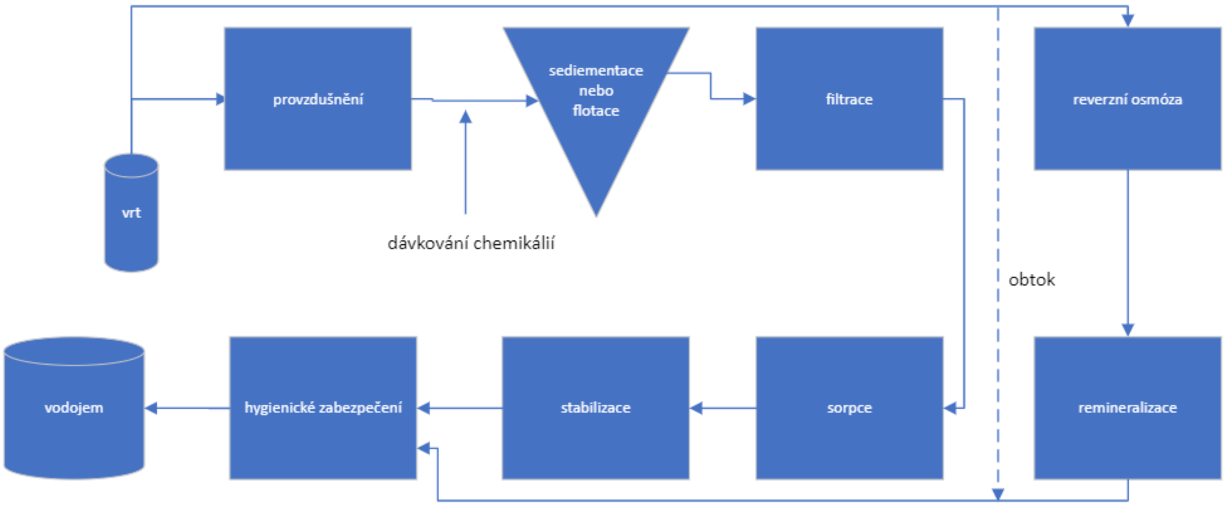
Description of technology

Just as the quality of the raw water source varies, so must the technology used. There isn't one universal scheme of technology that we could present here, and that's why we decided to focus more on the types of technology and create some kind of modules from them, from which you can put together information for your own modification shop.

In general, however, it can be said that groundwater is of significantly better quality than a surface source and treatment usually has, if at all, a maximum of 2 separation stages. In addition, there are certain characteristics for groundwater. Compared to surface water, underground water is a very chemically stable source (in terms of substance content and physical properties of water). One of the typical ones is the content of carbon dioxide, which underground water has a significantly higher amount than surface water. Another gas that is usually dissolved in groundwater is radon or sulfane. Gases can be removed using a technology called aeration. Of the metals, a higher content of iron and manganese is common. Unlike manganese, iron is more easily oxidized, when a part is already oxidized during the aeration itself. The remaining part is usually removed at the first separation stage, which is usually open or pressure filters, and the filling of the filters can vary across treatment plants. The oxidizing agent is, for example, sodium hypochlorite, and then there is a second separation process where it is desirable to get rid of the manganese. The stronger oxidizing agent potassium permanganate is used for this. Sand impregnated with manganese oxide (burel) can also help ensure removal. It is not unusual to encounter, for example, an increased amount of nickel, which needs significantly higher pH values for its removal. The soil environment and the low pH of the water will cause the leaching of rocks, which also results in a higher mineral content in the water. This tends to be positive, but overly mineralized water is also undesirable. In addition, other substances such as arsenic can be leached. Everything is influenced by the rock environment.

Sample technological line – diagram and example of a possible excursion (surface / underground)





Raw water very often contains substances that are harmful from a health point of view, are unsuitable for long-term consumption, or are harmful to technical equipment (dishwashers, washing machines, pipes, etc.). Even otherwise harmless substances that manifest themselves sensoryally (color, taste, smell) can be unacceptable to the consumer and must also be removed. Here you can ask visitors if any objectionable substances attack them, or why they are unsuitable for consumption - information about specific substances and their negative effects can be found a few subsections further down.

- <u>We can use different strategies to remove substances that are undesirable in water:</u>
- **Sedimentation (for solids that settle well with high density - eg sand)**
- **Filtration (for undissolved substances, we convert dissolved substances into undissolved substances, which can then be removed by filtration; the filter material is mostly siliceous waterworks sand)**
- **Venting (for gases – for example carbon dioxide or radon)**
- If we cannot use the conversion of dissolved substances into undissolved substances, we can use ion exchange (ion exchangers) or sorption (for example, activated carbon).
- Biochemical transformations of substances with the help of bacteria can also be used, this is only rarely used today, as more reliable technologies are available. In the past, this was a relatively common method of water treatment, so-called slow filters. Currently, however, this technology is starting to develop again abroad, albeit in a completely different technological arrangement.

Hygienic protection (for microorganisms; typically the use of sodium hypochlorite, i.e. SAVA; alternatively, however, ozone, UV lamp, chlorine dioxide, etc. can be used)

You can have fun with the children about which substances are easy to remove and which, on the other hand, make our lives hell. Include them in the issues that every treatment plant operator faces. What do the participants think - is it technologically easier to remove a dissolved or undissolved substance from water? Complain about what monsters micro-organisms are and how they multiply in our water again and again when we give them room to do so. But don't forget to mention that many microorganisms are completely harmless and naturally occurring. Unfortunately, there are also harmful pathogens among the good ones.

As already mentioned in the introduction of this methodology, due to the large number of possible technological solutions of individual treatment plants, this stage is solved in a so-called modular way. In the next chapter, you will find descriptions for individual technological stages, which please combine to describe your water treatment plant. Individual modules are mutually independent. During the excursion, it is important to emphasize what happens in which phase, why and in what sequence the steps are (for example, permanganate is dosed here to oxidize dissolved substances, which are then separated on a filter).

❔ **Question: How long does it take for the water to be treated?**

💡 **Answer:**

Here, following the example of Standa Pekárka, we offer to answer the question with a counter-question - how much water are we talking about? The general answer to this question is very individual depending on your technology (for example, whether you have included slower units of the sedimentation type), so prepare an answer to such a question individually based on your technology.

❔ **Question: What about microplastics?**

💡 **Answer:**

The issue of microplastics not only in the environment, but also in drinking water was very much discussed a few years ago, as they get into the water with practically everything - from bottled water and shampoos, to washing jackets and wiping down surfaces. Unfortunately, technologies that could fully prevent the entry of microplastics into drinking water are not yet widespread; current technology can only remove a fraction.

❔ **Question: What about hormones / pesticides / drugs / other bioactive molecules? water?**

💡 **Answer:**

Just like microplastics, bioactive molecules are also present in water – with the help of analysis of wastewater from cities, information can be obtained, for example, about the number of users of hormonal contraception, users of this or that drug, people sick with the coronavirus, and the like. In most cases, these molecules are not removed at the wastewater treatment plant and thus continue not only into the environment, but also into drinking water. Recently, however, technology accessories (typically UV lamps combined with advanced oxidation methods (so-called AOP) with activated carbon filters) are beginning to be installed at larger water treatment plants, which also remove these unwanted substances from the water.

❔ **Question: I heard that fluoride is poured into the water. Is it true?**

💡 **Answer:**

1.5 Is, or it was true. During the second half of the 20th century, fluorine compounds were added to water (for example, cryolite; the so-called water fluoridation) in order to supply a sufficient dose of fluorine to consumers - fluorine is an essential part of, for example, tooth enamel. In the 1990s, however, this practice was abandoned mainly for economic reasons. Today, water fluoridation is being reintroduced, for example, in Great Britain.

Water network

> The pipeline alone in a small village can reach several kilometers; the total length of networks in the Czech Republic was 82,034 kilometers in 2022 (approx. a fifth of the distance between the Earth and the Moon).

Secondary school: So-called the pipe network can be connected in a branch, circuit or combined manner (the last two methods have the advantage that one fault does not shut down, for example, the entire district from the supply, as it is possible to supply it from another direction). We can also distinguish water supply systems according to the size of the supplied territory into local (supplies only one municipality), group (several municipalities or perhaps an urban agglomeration) and regional (contains not only water supply systems, but also several water treatment plants, which can help each other, for example, in the event of shutdowns or malfunctions).

The material of the water supply network has a fundamental influence on the way it is operated and, in extreme cases, it can have an impact not only on water losses in the network due to leaks, but also on the quality. Depending on the time of construction, we may encounter the following materials: cast iron, steel (including stainless steel and galvanized parts), plastic (typically PVC - polyvinyl chloride, PP - polypropylene, fiberglass, HDPE - polyethylene), reinforced concrete, copper, brass (primarily couplings and other smaller components), glass, asbestos cement, glass concrete or lead (the last three materials are replaced as much as possible due to health or technical risks).

SŠ: Why is asbestos a problem not only in water management, but also, for example, in the construction industry during the reconstruction of older buildings? Asbestos are fibrous silicates that were used, among other things, because of their non-flammable nature. However, when the structure is broken (for example during repairs and demolitions), small fibers penetrate into the lungs, where they lead to scarring of the alveoli and the possible development of cancer.

SŠ: Another interesting material that can be encountered (albeit very rarely) is glass concrete. This material was used after the Second World War, when there was a shortage of iron for the water sector; on the contrary, there was plenty of glass, especially in the border areas. These are glass pipes that are embedded in concrete.

The time that the water spends in the pipes is definitely not negligible, and can reach up to higher units of days (extremes are up to 14 days). It is necessary to pay attention to this when setting the dose of the disinfectant (most often chlorine); therefore, homes near the treatment plant/sink can smell much more chlorine than the farthest collection points. The issue of disinfection and general hygienic protection of water in the distribution network (typically with hypochlorite) is part of the chapter dedicated to individual technological units of the treatment plant system.

In order for the water to flow after opening the tap, it is necessary to create pressure in the pipe (which, after all, can be seen, for example, in movies, when a geyser of water occurs when a pipe bursts, or when a hose is connected to a hydrant). This can be realized either by automatic pressure stations on the network, or by placing the reservoir on a high place in the vicinity (or on a tower) so that the pressure is sufficient at all points of the network (the so-called pressure zone). Have you ever wondered how skyscrapers are supplied with water?

ZŠ: There is no point in explaining all the items. It is important to mention that you also need to pay for taking water from nature, which they often don't realize. Also mention items like electricity, employee wages, chemicals and property restoration.

Secondary School: Here it is possible to discuss more broadly, for example asking how much a m3 of water costs (either it can be a homework assignment, or you can find out the degree of orientation of students in financial literacy by guessing), what are the monthly costs of water and compare them with the costs of electricity, telephone, Netflix (see the table below, which you may or may not use); at the same time compare the costs of tap water and bottled water (see the first chapter of this document).

1.5.1 Inquisitive: It is very difficult, due to constantly changing prices (and inflation, which the country is struggling with at the time of writing this document), to write a comparison table of the price of water and other services or benefits. On the other hand, it is not necessary to have an absolutely exact comparison, but only a kind of guide; the following table therefore compares individual monthly expenses using multiples, where 1 = monthly payment for water (used average consumption in the Czech Republic of 89.4 L/person/day, i.e. 2.7 m3/person/month with an average price in the Czech Republic of 100 CZK/m3):

Water meters

Of course, water meters are essential for water connections. We rate it as very beneficial if, as part of the excursion, you explain and illustrate even such a common device as a water meter, or even mention methods of remote reading. The participants of the excursion will probably see him for the first time in their lives. Here it is suggested to mention how one should take care of the water meter at home (especially in winter).

SŠ: Currently, there are water meters in test operations that automatically report values to the operating company's system (for example) once an hour, and thus it is possible to better organize production (in the form of machine learning on a digital twin) or to detect leaks and thus save money and natural resources.

Something that is not well known to the lay public is the loss of water during pipeline transport - in the Czech Republic, these losses are an average of 15% (that is, 1 liter of about 6 liters of treated water flows into the ground unknown), while in some extremes (abroad) this value can reach up to 80%. The global average is around 40%. A novelty that can help detect water losses are water meters with acoustic noise measurement. A crack in the pipe will cause a certain noise, which makes it easier to find.

Water losses below 5% can be considered extremely low and their further reduction is very difficult. Here we are getting into the area of inaccuracy in measuring the flow and amount of water. At the same time, very small leaks or leakages at the joints of pipes and fittings, which are practically impossible to measure and locate, also contribute to water losses at the level of lower percentage units.

Description of technologies

Basic information about technologies – facts and interesting facts, which will make up your own excursion.

As has already been written several times above, the following part of the methodology is modular and the individual parts do not follow each other; please choose the technological units relevant to you and compile your own excursion program from them. Even though we tried to include all common technologies in Czech countries, it is possible that we missed some. In that case, please ask the technologist / professional representative to create a description similar to the descriptions here.

SŠ: What is currently beginning to be emphasized in the Czech Republic in connection with technologies and the security of water supply processes is cyber security. There have already been several acts of terrorism (abroad) where, for example, chemical dosages were changed or water supplies to the network were stopped due to a hacker attack. Although it seems like a small thing, increasing the pH of the water to 11 implies caustic damage to the digestive system.

Inquisitive: To increase attention, you can go through the Wikipedia page entitled Terrorism directed at drinking water supply infrastructure, from which you can select some cases (or on the English version of the same page) and mention them at the appropriate moment in your interpretation. The so-called true-crime stories are popular and popular among today's youth and will definitely bring you plus points.

Chisel **Importance**	Protection against ingress of dirt, mechanical damage to pumping equipment and clogging of pipelines
Principle	A mechanical barrier capturing material on its surface
Captured material	Coarse and fine dirt (depending on the distance between individual combs) e.g. branches, cones, leaves, fish, frogs

Part of the receiving facility for surface water (this technological step is not required for groundwater, as the nature of the source does not assume the presence of such large parts). The equipment must be adapted for easy cleaning. In small processing plants, this cleaning is done manually with a rag. In larger operations, the combs have continuous mechanical wiping.

ZŠ: Children can imagine a comb as a grid or a comb. Like combs, combs can be fine, with a high density of teeth (combs very close together), medium and coarse, which have teeth far apart. Put together with the children what we can float on the comb (examples are mentioned in the captured material above). Children will no doubt be creative. The mechanical combs can be brought closer to the escalators, which lead the dirt up until the dirt ends up in the container. Since the raw water is not nearly as dirty, the waste from the combs is usually exported only a few times a year at most.

Then ask why they think combs are needed in the treatment plant at all (protection against clogging, damage to important equipment)

Secondary school: For high school students, you can go into more technical matters, such as the distance between the combs (and the gaps between them), etc.

1.6 Inquisitive: At one West Bohemian water treatment plant there is a technological stage "Fish Catcher", where it may seem that it has the same reason for inclusion as combs. But the truth is that the fish catcher is located behind the pump system, and the chopped fish remains would have nothing to catch in the break tank (as the correct name sounds).

Aeration

Importance	Ventilation of gases (e.g. radon, sulfane, free CO2,...) Mechanical removal of carbon dioxide - deacidification of water, thereby reducing the corrosive effects of water Enrichment of water with oxygen - oxidation reaction (removal of iron)
Principle	Mixing water with air. An increase in the surface area of the water-air interface will intensify the gas exchange between water and air.

Affected material	Gaseous unwanted substances (passes into the air and further into the atmosphere), oxidized substances (mainly iron – it is further separated in undissolved form)

Previously (historically) cascades were used, when it is formed by several overflows. The energy obtained by the overflow helps to mix the water with the air, thereby enriching the water with oxygen. Other technical solutions are Bubla and Fuka aerators, which are horizontal or vertical columns where air is blown in using fans.

Above all, underground waters are rich in manganese and iron, contain higher concentrations of carbon dioxide and lower concentrations of dissolved oxygen compared to surface waters. In some areas of the Czech Republic, there are also higher concentrations of radon, in connection with the geological subsoil. For these reasons, the aeration process is particularly important for groundwater treatment (although it is also encountered in some surface water treatment plants, where it is not used due to the removal of radon).

ZŠ: There is definitely no need to go into great technical details; a completely sufficient description is that, thanks to blowing air into the water, the gases that are present in the water are vented.

SŠ: If we ventilate radon, we can mention its relatively short half-life, about 3.6 days, as an interesting point, and as a method of removal you can also use a long accumulation of water, where radon naturally decays. However, this does not get rid of radioactivity as such, as radon further decays into unstable isotopes of polonium and lead (the so-called uranium-radium transformation series).

Curious: We can refer to Henry's Law (see equation below) and say that different gases have different willingness to transfer between water and air. For example, radon is very well ventilated. In the case of carbon dioxide, it depends on the overall composition of the water.

$$p_1 = K_1 \cdot x_1$$

In the equation described above, p is the vapor pressure of the solute above the solution, x is the mole fraction of the solute in the solution, and K is the Henry's constant performing the function of the constant of proportionality.

It is interesting that the release of such vented radon into the atmosphere is not subject to any permits from state authorities (in this case the State Office for Nuclear Safety), as it is naturally occurring.

Sedimentation

Importance	removal of settleable impurities
Principle	heavier suspended solids fall towards the bottom of the tank due to gravity
Captured material	removal of a significant proportion of insoluble substances

The principle of most methods of removing common pollutants from water is their conversion to an undissolved form and its subsequent separation. This separation step is usually filtration. However, filtration is demanding on the surface area of the device, the filter needs to be washed and monitored. Prioritizing sedimentation before filtration can significantly reduce the cost of filtration, or even the size of the filter; on the other hand, it significantly increases the time required for water to pass through the treatment technology.

In the operation of treatment plants, sedimentation is preceded by coagulation, the formed flakes subsequently sediment. As flakes of different sizes are formed, they settle to the bottom at different speeds. The technology often does not provide the time or the length of the vessel to settle all settleable substances, and therefore sedimentation is always followed by filtration, thanks to which even smaller flakes can be removed.

Sedimentation is also partly used for the settlement of undissolved substances in wastewater from the water treatment process in the so-called sludge management (see one of the other sub-chapters in this document), or in the wastewater treatment process (see other documents created as part of this project).

ZŠ: Raw water contains a lot of undissolved substances, which we are able to remove with or without the previous use of chemicals, and only with the help of time and calmness. Gravity works reliably and for free. Dirt particles fall slowly towards the bottom, where they settle. The water freed of impurities then overflows from the top of the tank and continues to the next level of treatment, usually filtration.

SŠ: Due to the action of the force field, as a result of the different densities and sizes of the particles, the particles sink to the bottom. Larger particles sink to the bottom faster. A very important factor is to calm the water as much as possible before it enters the tank.

1.7 Curious: The sedimentation efficiency should be around 80-90% in order for the sedimentation separation stage to be declared functional. For example, bore walls, additional partitions (so-called lamella sedimentation) or the addition of milk of lime (suspension of calcium hydroxide) can be used to improve efficiency, which pulls undissolved particles down.

Flotation

Importance	separation of suspended particles and biological recovery

Principle	bubbles of dissolved air carry pollution to the surface
Captured material	hydrobiological pollution, secondarily also other substances

Flotation is another separation step in water treatment, which in the vast majority of cases precedes filtration, and which serves to separate suspended or flocculent particles or organisms from the liquid (i.e. treated drinking water) using air bubbles. According to the method of creating bubbles, we can divide flotation into electrolytic, mechanical or pressure, while in the Czech basin we only encounter the last variant.

The principle of the method is that particles (for example, formed by coagulation) combine with blown air bubbles, which as a result are lighter than water and rise upwards. This creates a layer of sludge on the surface, which is swept into the waste, and water is drained from the bottom of the tank for further technological steps (mostly filtration) - i.e. the opposite of sedimentation.

It is important to note that flotation itself only works on undissolved substances, but not on dissolved substances - in that case, coagulation must precede, when flakes are formed, which are then carried out and removed. Therefore, coagulation is practically always preceded by flotation.

Flotation as such is not a very widespread technology in the Czech Republic and is mainly used in large processing plants, where it is assumed that a technologist will help you with the chemical and technical description; therefore, only simplified basic information is provided on this page.

ZŠ: Formed flakes with attached impurities, possibly cyanobacteria, algae and other biological components of the water are carried to the surface with the help of many millions of air bubbles, where they are collected as waste. Water for further treatment is then collected at the bottom. Many bubbles look like a milky color to the water from a distance.

SŠ: Compressed air dissolves in water according to Henry's law (see technology sheet on aeration). When water is saturated in a closed volume, many microbubbles with a size of 30 and 100 micrometers are formed, which are then discharged into the flotation space, which then brings undissolved substances to the surface.

Flotation as such is not only used in the treatment of drinking water, but also, for example, in the treatment of wastewater or in the treatment of ores, where it works on the same principle.

Inquisitive: In the literature, you can come across the abbreviation DAF, which comes from the English dissolved air flotation, which indicates pressure flotation. In Czech conditions, it was only used for the treatment of drinking water at the beginning of the 21st century (in 2005).

1.8 *Instead of dissolved oxygen, this technology can also use oil (historical method, no longer used today), or ozone (very little widespread, rather a theoretical possibility).*

Clarification / coagulation / flocculation

Importance	accelerating the removal of fine suspended and colloidal substances (normally difficult to settle)
Principle	fine particles are converted into larger clusters formed larger particles sediment faster binding agent – coagulant and flocculant
Captured material	colloidal substances, microorganisms

This is an important technological process used primarily for the treatment of surface water, where, along with subsequent filtration, dissolved (typically high-molecular organic substances, such as humic substances) and colloidal substances are removed, which cannot be removed by themselves by sedimentation or flotation. Clarification is a demanding process for management and design, as it is influenced by many parameters of both the treated water (pH, temperature) and technological parameters (mixing speed, shape of agitators, dose of coagulation agent).
With the use of positively charged particles of iron or aluminum metals (typically sulfates or chlorides in the form of hydrates), larger clusters of so-called flakes are formed, which can then be removed by sedimentation, flotation or filtration. The positive particles then attract impurities like a magnet.

ZŠ: We add a reagent to the water, which causes the substances we don't want in the water to start to precipitate and accumulate in the form of flakes. The resulting flakes, which are significantly larger than the impurities themselves, can then be easily removed by filtration and sedimentation. Demonstration Tip: We can show these flakes and compare the water before and after coagulation.

SS: Coagulation, or clarification, is an important process that can convert dissolved substances in water into undissolved ones. The addition of the agent causes otherwise stable dissolved substances, such as humins, to begin to clump together to form a precipitate with the coagulant. The process requires the use of a suitable reagent, the setting of the correct dose of the reagent and the correct conditions, such as pH in particular. These things cannot be reliably designed "from the table" and before any major change, so-called glass coagulation tests must be performed in the laboratory.

Curious: Colloidal substances are stabilized in water by the electric charge on their surface. Adding a reagent changes the charge and thus destabilizes them and allows them to clump together (like magnets).

Humic substances - humic substances or other substances of natural origin are often removed by coagulation. These in themselves are not harmful to human

health, but cause sensory problems, especially brown discoloration. Another reason for their removal is to ensure the long-term stability of the water, when these substances could serve as a substrate for the growth of bacteria. Another reason is their possible reaction with the chlorine used to ensure hygienic water. Potentially dangerous chlorinated substances could be produced (so-called disinfection by-products, for example chloroform).

In practice, the terms flocculation, coagulation and clarification can be encountered, which terms are often (incorrectly) confused. Coagulation is the formation of clusters of particles (it could also be described as destabilization), flocculation (also aggregation) is the formation of visible flakes from these clusters; clarification is then generally mixing without further follow-up to the formation of flakes. Coagulation, unlike flocculation, is not reversible.

Filtration

Importance	a key step in the removal of suspended solids in water
Principle	capture of large particles (oxidized, flocculated) on sand particles
Captured material	oxidized dissolved substances, coagulated particles (for example, colloidal substances, microorganisms, hydrated oxides of iron and manganese, clay particles)

A filter is probably the most traditional technology used in water treatment and you can probably find it at every treatment plant in the Czech Republic. There are several types of filters depending on the filling. Various fabric or sail filters that trap material on their surface (as high school students may know from, for example, chemical laboratory exercises), are not used much in the water industry and are more likely to be used in other fields, or in home swimming pools, for example. In the water industry, filtration through a layer of granular material is widespread, when the material is captured in the volume of the filter filling; typically it is sand, or chemically modified sand having different modified layers on it.

At first glance, you can also see the difference between a pressure filter and an open filter. The appropriate type is chosen mainly with regard to the remaining technology and space requirements - pressure pumps are significantly smaller than open ones, but they also consume the electrical energy of the pumps.

In principle, it is the same filtration that children are likely to imagine: the particles are guided by a layer of granular material in which they are captured. As the filter is gradually clogged, the pressure drop increases and less water passes through, or the pressure needs to be increased to maintain the flow (at the cost of greater energy consumption and at the same time greater stress on the technology). When the pressure loss is too high or the suspended suspension begins to penetrate the filter, it needs to be washed. Washing uses reversing the flow of water through the filter and increasing the flow to cause expansion of the cartridge (the cartridge is "fluffed"). Washing is often intensified with compressed air, which facilitates the release of trapped material from the filter.

The filter material can be sand with a grain size of approx. 0.6 to 1.8 mm (there are different grain sizes with different ranges). Or other materials, such as anthracite, or industrially produced filter materials with special properties. A special form of filter is the so-called deacidification filter. However, its purpose is not filtration, but adjustment of the carbonate balance, and will therefore be described in another chapter.

<u>Guide Tip: Prepare a filter cartridge in a beaker or other container and send it to the kids to touch (some technology companies outright offer these sample kits as promotional items). Such an illustrative demonstration will renew the attention of the participants of the excursion.</u>

Ion exchangers

Importance	Removal of unwanted cations or anions from water
Principle	high molecular substances (ionex) containing functional groups capable of capturing an ion with the opposite charge
Captured material	dissolved substances in an ionized state (positive or negative charge)

Water treatment with ion exchange is very effective. Ionexes, or ion exchangers, primarily target inorganic water pollution, but if organic substances carry a charge, they can also be captured. Ionexes are usually found in the form of small balls. In general, these are high-molecular substances carrying functional groups in their structure. These groups have a certain charge, which determines which group of substances it will attract. We distinguish two types of ionex, negative and positive. People often get their names confused, but like electrodes, ionex are always named according to the type of charge they attract - catex exchanges cations and anex exchanges anions. A whole range of natural and synthetic substances have the ability to exchange ions. Zeolites belong to the best-known ion exchangers of natural origin. Nowadays, however, substances of synthetic origin, mainly based on polymers, are most often used.

Analogous to sorption on granular coal, there is only a limited amount of functional groups on ionex. Therefore, if all places are filled, regeneration is necessary. The biggest obstacle in the operation of ion exchangers is the disposal of regeneration solutions. Waste disposal is usually the limiting factor in deciding whether this type of treatment technology will be introduced at all. Due to the amount and nature of the waste (significant salt content), the technology is used more for small treatment plants.

Primary school: Show the children a sample of what such an ionex looks like. Let him go around and when he comes back to you, ask the children what he looked like - how would they describe him? Emphasize that the principle of the technology is ion exchange. Do children know what an ion is? Now that you understand the concept, how could ion exchange work? It follows that the balls (ionex) they saw will carry some kind of charge. What do the same charges do, repel or attract? You can demonstrate it to them on magnets. When you come to the fact that opposites attract, explain why cathexes and annexes are called the way they are. In conclusion, summarize that ionex helps us pick up a certain type of ions according to the charge they carry. Once in a while, the ionex needs to be flushed so that it gets rid of everything it previously caught and can continue to do our work again.

Inquisitive: The degree of ability to hold the substance depends on the properties of the ionex used and the ion itself. Certain types of substances can also bind irreversibly to the ionex and thus disable it from operation. Such ionex can no longer be regenerated and is treated as waste.

Sorption

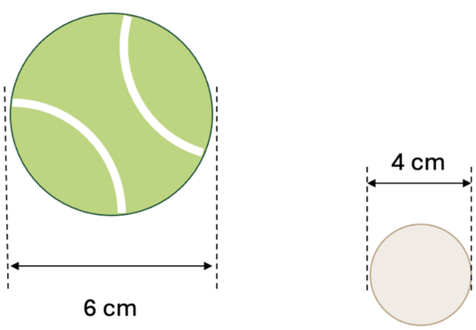
Importance	effective method of trapping micropollutants positive effect on the taste of water protection after ozone application
Principle	capture of substances on a large surface (adsorption) of granules
Captured material	taste and odor-causing organic substances organic and inorganic micropollutants (pesticides and pharmaceuticals)

Activated carbon is made from coal, wood or peat and has a porous structure with a large internal surface. The specific surface of activated carbon is usually around 1000 m2 per gram, but can reach up to 3500 m2 per gram. To give you an idea, the Eden football stadium in Prague has around 7,000 m2, which corresponds to 7 grams of activated carbon. You can find how much the football field in your area has, or even better, the field in the city/town where the visitors came from and compare the amount of activated carbon. You can weigh the amount and keep it for field trips in a container - the children will see what the activated carbon looks like and better imagine the amount you are talking about.

Sorption on activated carbon is the most frequently used means for removing organic substances in water, especially micropollutants such as pesticides. For pesticides, removal efficiency generally ranges from 50 to 95%, depending on the type of activated carbon and the type of adsorbed substance. Activated carbon is mainly used for its high efficiency and easy application. In the water industry, we most often encounter its granular form, but powdered activated carbon is also often used. Larger treatment plants keep powdered activated carbon in reserve in case there are problems with the functionality of filters with granular activated carbon, or if water quality suddenly deteriorates. In general, it can be said that powdered activated carbon is mainly used for seasonal deterioration of water quality (taste, smell, runoff from fields) and the application is usually classified before filtration. The disadvantage of the powder form is that it washes out after application, so this form is more expensive and less used for normal operation. If the quality of raw water continues to deteriorate, treatment plants use granulated activated carbon filtration. It is important to mention that with time the adsorptive capacity of coal decreases and after time it is necessary to regenerate it, i.e. restore its efficiency.

ZŠ: Harmful substances are captured on the surface, not only the outer one. The effort is to make this surface as large as possible. The appearance can be misleading, because the surface that brings together the inside of the material in activated carbon is many times larger than the external one, which we usually notice. Ask the children if they have ever read Ferda the Ant with their parents, or if they have seen an anthill behind glass - lots of paths, different lengths and twists. This is probably how it could look like in an activated carbon granule. The substances then penetrate deep into the interior of the grain and are then captured in all these paths.

SŠ: We dare to say that the concept of a specific (measured) surface is not completely easy to introduce. For this reason, it is important that more attention is paid to its explanation. It is the surface area of a solid substance per unit mass. In other words, how much surface area in square meters does one gram of a substance have. Why are we even interested in this, what makes the surface so important to us and why do we go to the trouble of determining it? Simply put, this is one of the most important parameters of adsorption, because adsorption is the process of accumulating a substance on a surface. Simply put, the larger the surface, the more space there is for trapping substances. I see! But how do I get a larger specific surface area? Please allow the children to think for a while. For example, you can show them a tennis ball and demonstrate what its surface is. But how do I increase the surface area to weight ratio? Counterintuitively, one would say to use larger particles, because then the surface is larger Particle surface is yes, but not specific, because this also increases the mass of the particle. One option is to have smaller particles (ping-pong ball). If they don't believe you, you can show them a simple calculation:



ρ = konst. = 1 g/cm³

Tenisový míček	**Ping-pongový míček**
d = 6 cm => r = 3 cm	d = 4 cm => r = 2 cm
$S = 4\pi = 113\ cm^2$	$S = 4\pi = 50\ cm^2$
$V = \frac{4}{3}\pi r^3 = 113\ cm^3$	$V = \frac{4}{3}\pi r^3 = 33\ cm^3$
$m = \rho V = 113\ g$	$m = \rho V = 33\ g$
$a_M = \frac{S}{m} = 1\ \frac{cm^2}{g}$	$a_M = \frac{S}{m} = 1{,}5\ \frac{cm^2}{g}$

The second more fundamental change is the porosity of the particle. Do children know what pores are? Let them imagine a cube of cheese they like, for example edamame. And now next to that cube of really leaky Emmental. Which one has the larger specific surface area? Pores can increase the specific surface area. Activated carbon is an excellent adsorbent precisely because of its high porosity, which is created by its production.

1.9 ***Curious: In general, we distinguish between two types of adsorption – physical and chemical. Substances can be bound on the entire surface by physical adsorption, the bond strength is usually weak and desorption occurs all the more easily. Physical adsorption takes place most often due to van der Waals forces, and multilayer adsorption can also be observed. In contrast, chemical adsorption works with the help of so-called active sites, and many factors influence the course of substance capture. The mixture of substances in water will also cause a competition of substances for active sites, as some substances will have a greater affinity, a desire, to bind to the sites of the adsorbent. The adsorbent also has a limited amount of these sites and when they are filled, further adsorption cannot work. Fortunately, the process does not end with the exhaustion of the sorption capacity, coal does not have to be thrown away after exhaustion, but it is possible to regenerate it (in the case of reversible bonding processes). In other words, it is possible to restore the sorption capacity of activated carbon. As with adsorption (bonding of a substance to a surface), the opposite process also works, i.e. detachment of the substance from the surface of the sorbent. Thermal desorption is most often used for this. The material is heated to a very high temperature (up to 1200 degrees Celsius), when adsorbed substances are removed from the coal. However, we should not forget that there is also oxidation and abrasion of the coal itself, which can lead to up to 15% material loss.***

Hygienic provision of water

Importance	hygienic provision of water in terms of microorganisms
Principle	oxidation and chlorination effects limiting or disabling important processes of microbial cells, which they destroy as a result
"Captured" material	microorganisms

Hygienic provision of water is often a controversial topic, but it is necessary to realize that finding a connection between some diseases and water quality and subsequently ensuring the microbiological quality of water has significantly extended the average age of the population.

ZŠ: Natural waters contain bacteria. Even treated water is not completely free of bacteria. Most bacteria are not dangerous for humans and the human body can deal with them. However, it is important to keep their numbers low and especially to ensure that the bacteria present in the water are not dangerous. The best treatment technology cannot ensure the absolute elimination of bacteria, but most importantly, it cannot ensure that bacteria will not multiply in the water network. For this reason, disinfectants are added to the water. A minimal amount of these is added, mainly due to their price and limiting the effect on the smell and taste of the water. From the point of view of the water consumer, it is far better for the water to contain a certain minimum amount of disinfectant than to contain dangerous microorganisms.

1.9.1 Curious: It is possible to tell the story of how the connection between water quality and the spread of disease was discovered. John Snow was conducting research on the connection between infectious diseases and water sources in 1854 in Broad Street, London, and found that people who had an outbreak were often linked by a common water source. He recorded cases of illness on a map, and the connection with the water source was quite obvious. An interesting fact was that there was also a monastery in the center of the epidemic, but no disease was recorded in it. Ask if anyone knows why this was. The correct answer is that the monks did not drink water, but beer that had undergone heat treatment.

Chlorination

Water chlorination is a process in which elemental chlorine or its compounds are used to ensure the hygiene of water. Several types of chlorine-based disinfectants are used. However, the dosage of gaseous chlorine, sodium hypochlorite, or chlorine dioxide is most often used. Chlorination is one of the most widespread methods of disinfection in the water industry.

Interpretation tip: Chlorination is not the correct term from a chemical point of view. Chlorination means that chlorine is chemically bound somewhere. Since the goal is not to bind chlorine to the water, a much more correct term is water disinfection. In addition, not all chlorine-based agents have a chlorinating effect on substances present in water. For example, chlorine dioxide is only oxidizing.

Chlorination primarily helps with microbial activity in water. The biggest advantage of chlorination is the so-called secondary disinfection. This means that it protects water quality even during its distribution through the networks to the final consumer. In addition, it is an easy way to ensure disinfection even at water reservoirs, thereby maintaining water quality in the longer term. A big disadvantage is the by-products of chlorination and the negative effect on the sensory properties of water. These are the reasons why many states eventually backed away from chlorination. Larger treatment plants use chlorine gas, which is fed into the water. Sodium hypochlorite is most often used on small ones.

Three basic forms are distinguished in water – total chlorine, free and bound active chlorine. By adding the bound and free, we get the concentration of total chlorine. Bound, or combined, is chlorine reacted with ammonia to form chloramines. Chloramine is particularly important for secondary disinfection because it has a long half-life and thus protects water quality from contamination by microorganisms entering the pipe network. Free chlorine is measured at every treatment plant, whether large or small. It protects the water from contamination and is a great indicator of whether the water is still hygienically safe. When discussing free chlorine, it is appropriate to demonstrate its determination to children. It is also suggested to have samples prepared with different values of free chlorine so that the children can see how the saturation of the color is related to the concentration of chlorine.

Elementary: Ask the children what they know about chlorine. Do they know its state and color? They will probably know it as combat gas, or remember the pool. If they remember the pool, you can tell them to try to recall its smell.

This gas and some of its chemical compounds have significant disinfecting effects. After mixing with water, these substances effectively destroy microorganisms that *threaten us in water. Children will definitely know sodium hypochlorite under the name SAVO.*

SŠ: Chlorine in water is also consumed by residual organic substances, so it is necessary to chlorinate the water as clean as possible. As with other disinfection methods, it is advisable to chlorinate only at the last stage of water treatment. The reason for the frequent use of chlorine is its great bactericidal effectiveness, which it retains even in small concentrations. The size of the dose of chemicals always depends on the quality of the incoming water and the disinfection limits. The effectiveness of chlorination is extremely dependent on the pH of the water. At treatment plants, we always try to maintain a certain level of free chlorine in the water.

Inquisitive: Chlorine-based disinfectants are also well-suited for removing iron, manganese, hydrogen sulfide and some organic substances, especially odorous and tasteful, thanks to their oxidizing effects.

UV radiation **Importance**	Hygienic provision of water
Principle	it is based on the natural biocidal effect of sunlight mercury lamps emit UV radiation with harmful wavelengths, causing a change in structure with subsequent destruction of microbial cells
"Captured" material	Microorganisms (bacteria, viruses) and theirs

This is a physical way of securing water for consumers. The advantage of using UV lamps is the prevention of the formation of by-products and at the same time it is a very effective method of disinfection. In addition, it is an environmentally friendly method. Another advantage is ease of operation and maintenance compared to other technologies. On the contrary, the disadvantage is the energy requirement of lamps, their susceptibility to overheating, but mainly the influence of water quality on the effectiveness of disinfection. The efficiency of the radiation is greatly affected by the turbidity of the water, because it causes a reduced permeability of the radiation in the volume of water. The water should therefore be completely transparent, and in addition, a thin layer of water must be transparent. However, the biggest disadvantage compared to chlorination is that the water will not remain hygienically secured in the water supply network. In other words, UV radiation only works at the point of exposure. Direct measurement of the dose of UV radiation is also not possible.

UV lamps are mainly used for the disinfection of drinking water in larger consumption areas. It is also increasingly used for decentralized water treatment. E.g. in boarding houses, private houses. However, UV radiation is also used in some countries to disinfect water in trains and ships.

Primary: Ask the children what they think of when they say waves. He will probably think of the sea. Point out to them that there are other waves, namely light waves. The sun emits waves of different wavelengths – short wavelengths of ultraviolet

radiation, visible light (color) waves, and long wavelengths of infrared radiation. We cannot see the mentioned short lengths, but they are the strongest in the fight against microorganisms. Surely the children have seen their grandparents or parents hanging their washed clothes outside. Sunlight not only dries clothes, but also rids them of bacteria and odors (organic substances). UV lamps emit exactly such radiation and help us ensure that the water is biologically safe. However, it always depends on the intensity of radiation and the duration of exposure. Children certainly know the feeling on their skin when the sun is very hot - this is related to the intensity of the radiation. And if the sun heats up this strongly and they run outside for a long time, in other words, they will be exposed to its effects for a long time, they will burn nicely. When microorganisms in water are exposed to radiation at a high intensity and for a long time, they will not survive.

Well, and because UV radiation is not only dangerous for microorganisms in the water, but also for humans (although we are not so small and we can tolerate a significantly higher dose of radiation), parents often appeal to us to apply sunscreen creams honestly.

SŠ: UV radiation is a natural component of light, namely short wavelengths. The natural source of UV radiation is therefore the Sun. Here, its source is mercury quartz lamps, in which there are (high-pressure or low-pressure) mercury discharge lamps. When we hear discharge lamps, we probably imagine that they need a larger dose of energy and at the same time they will heat up quickly. Therefore, water must constantly flow around them to cool them. Lamps must also be handled with care during maintenance because they contain mercury, which is hazardous to health.

Regarding the effects against microorganisms, UV radiation shows the highest germicidal effects at a wavelength of 200-300 nm, it is most effective at a wavelength of 254 nm. UV penetrates their cells, changes their structure and thus destroys them. Other substances that strongly absorb UV radiation include organic substances. Therefore, in order to make the disinfection as effective as possible, radiation is applied as the last step of treatment, when the water contains the least amount of them and the full dose is captured by the microorganisms that we are trying to get rid of in the water.

Curious: History - The germicidal properties of sunlight were discovered by Downes and Blunt in 1887. Although major advances were made in the first half of the last century, the low cost of chlorine and operational problems with early UV disinfection systems limited the use of UV radiation for drinking water disinfection. Radiation was first used for disinfection in the French city of Marseille, but the first reliable application for disinfection of urban drinking water did not occur until 1955 in Switzerland and Austria. With the discovery of chlorinated disinfection by-products, UV disinfection became popular especially in Norway and the Netherlands.

Technical – UV radiation with a wavelength of 200 to 300 nm destroys not only bacteria, but also their spores, which are normally very resistant forms of bacteria. The most effective is UV radiation with a wavelength of 254 nm at a minimum effective dose of 400 J per m2. The mentioned wavelength is related to the absorption maximum of nucleonic acids, which UV radiation decomposes. Ordinary glass absorbs UV radiation, so it is necessary to apply pure silica glass. High-pressure discharge lamps emit more effective UV radiation, but they are also more energy-intensive. UV lamps are most often oriented perpendicular to the water flow, this has the advantage of a much more even distribution of UV radiation intensity inside the device.

Ozonation **Importance**	hygienic provision of water, oxidation of organic substances
Principle	ozone = "active oxygen" a strong oxidizing agent
"Captured" material	substances negatively affecting the smell and taste of water microorganisms

Ozonation is one of the most effective forms of hygienic water security and a short contact time with the water is sufficient. A big advantage is that there is no formation of halogenated disinfection by-products (with the exception of bromine). Another advantage is its ability to break down otherwise problematic substances such as drugs and pesticides in water. Unlike chlorine, it also does not change the taste of the water. Due to its low stability in the lower atmosphere, ozone must be generated directly at a water treatment plant and is produced from air or pure oxygen exposed to a high electrical discharge. The disadvantage is its energy-intensive production, distribution into water, low stability of the resulting gas and its corrosively aggressive effects. In addition, it is not a suitable disinfectant for waters with a high content of bromide anions (formation of carcinogenic bromates).

1.10 Curious: Operation of the water supply system without dispensing disinfectant. Especially in Western Europe, but also on some water supply systems in the Czech Republic, operation without a disinfectant is starting to appear. This approach is possible and required by customers. However, it requires a certain change of approach. The treatment plant, water supply network and water storage must be in perfect technical condition, equipped with air filtration and other measures to prevent water contamination. At the same time, it is advisable to increase the intensity of traffic control. Most of the water mains in the Czech Republic were built more than thirty years ago and their technical level corresponds to that time. This does not mean that the water is in any way objectionable, but a slightly higher level is necessary for "chlorine-free" operation. Here it is necessary to realize that drinking water is not a sterile environment and if microorganisms find suitable conditions for their growth, for example, suitable pipe material, a place where water stagnates, a place with sediments, they will start to multiply and can reduce the quality of the water. Disinfection will reliably prevent this. The second option is a complete renovation of the network and its adaptation to current standards.

Stabilization (calcium-carbonate balance)

Importance	water stabilization in pipelines
Principle	dosing of calcium in order to achieve calcium-carbonate balance
Affected parameter	calcium, hardness, KNK

This part of the treatment is usually only part of large water treatment plants and is not well known among the lay public, even though it is one of the most fundamental steps from a technical point of view. The calcium-carbonate balance determines how aggressive the water will be towards the pipeline (secondary contamination of the water with iron from the dissolved material of the pipeline can occur) or, on the contrary, how CaCO3 (calcium carbonate, limestone) will encrust in the pipeline. This is the final fine-tuning of the water quality, which is why we only encounter this step at the very end of the technological line.

The calculation of this balance itself is rather demanding, as it consists of 6 independent equations, and technologists mostly use computer programs. If equilibrium is reached, the water is said to be stable.

At this point during the excursion, you can also tell information about the hardness of the water and its influence, for example, on the taste and fouling in technological devices, as mentioned in the chapters above.

ZŠ: There is calcium, carbon dioxide and its forms in the water, which must be in balance - if the balance is disturbed, either the water dissolves the pipes or, conversely, limestone precipitates on the walls of the pipes, which results in technical problems in the pipes.

SS: At water treatment plants, you can meet two methods of dosing lime - milk of lime and lime water. Both are solutions of calcium hydroxide Ca(OH)2, but the first one is in the form of a suspension (it is not a true solution, but undissolved colloidal particles of hydroxide in water, lime water is really a solution (it occurs in so-called chokes). You can use the difference between these two terms as a question for the participants of the excursion. We can also encounter a simple pH adjustment using sodium salts, or even sodium hydroxide.

Inquisitive: Milk of lime can also be dosed at the beginning of the technology, as it can help with sedimentation (thanks to the heavy colloidal particles, other insoluble particles become heavier and they then sediment faster and more efficiently).

Membrane technology	
Importance	Modern highly efficient separation method Depending on the size of the membrane pores – removal of a wide range of substances (colloids, ions, microorganisms)
Principle	Mechanical filtration, where a semi-permeable membrane serves as a physical barrier The pressure difference across the membrane (above and below) is the driving force behind the separation
Affected parameter	A filter cake containing impurities that did not pass through the pores of the membrane.

Membrane processes can be divided into many categories, but pressure membrane processes are particularly important for the treatment of water for drinking water. As a rule, there are four types of technologies: microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO). The principle is the same for all technologies, what differs is the size of the pores, which is also related to the size of the applied pressure. Smaller pore size means higher water quality. However, the smaller the pores, the more force (pressure) must be applied and, above all, the membrane becomes clogged more quickly (the greater part of the dirt is retained). When the membrane becomes fouled, backflushing becomes necessary. The frequency of washing is influenced by several factors, mainly the quality of the inlet water and the age of the membrane. Membrane separations are often preceded by other mechanical pretreatments that help improve water quality before entering the membrane, as well as protecting against mechanical damage.

ZŠ: What do children imagine under the word membrane? Where have they heard this term? How does our skin work? Try to put together a definition of a membrane (a material that forms an interface between environments and thus separates them - a physical barrier). Think further about the skin, have children heard of pores? What exactly are pores? The membrane used here also has pores, thanks to which certain substances can pass through. Specifically, substances that are smaller than pores. The smaller the pores, the longer it would take for water to flow through the membrane. But we use a pressure force that helps us push the water through faster. The membrane works like a sieve and what doesn't pass through accumulates on it. In order for the membrane to function properly, it is necessary to wash it often to wash off the adhering substances.

SŠ: What do children imagine under the word membrane? What do children know about the cell membrane? What about our skin? Analogous to what is learned in biology, here, too, the membrane allows only certain substances to pass through. Try to put together a definition of a membrane (a material that forms an interface between environments and thus separates them - a physical barrier). Think further about the skin, have children heard of pores? What exactly are pores? Have fun thinking about what substances membrane pores let through.

Curious: Membranes can be inorganic (ceramic) or organic (synthetic). Organic membranes are most commonly used, and not all membranes are porous. It is also offered to emphasize the importance of membrane technologies using the example of seawater desalination by reverse osmosis. One of the countries dependent on the mentioned technology is Israel. Israel gets about 3/4 of its drinking water from the sea.

Sludge management **Importance**	Thickening of sludge (impurities) from the water treatment process Sludge disposal
Principle	Gravitational (settling) or mechanical (machine) removal of water from sludge.
Affected parameter	Thickened water sludge

There is no need to devote a large amount of time to the issue of sludge processing as part of the excursion, as it is more of a Cinderella of waterworks processes. However, it would be appropriate to emphasize that even water treatment is not without waste, which must then be properly disposed of. In addition, it is good to emphasize that the character of the sludge is significantly different from that of a wastewater treatment plant, which they may know from another excursion. So it's not sludge like sludge.

Inorganic components predominate in water sludge. In addition, water sludge contains up to 99% water, and therefore the effort is to remove at least a proportional part of the water before further handling of the sludge. The sludge is either processed directly at the water treatment plant, or the sludge is discharged together with the wastewater through the sewer system. If sewage is used, it is disposed of at the nearest wastewater treatment plant.

2 Sludge lagoons are a generally used solution for processing sludge directly at treatment plants. These are tanks with a long residence time, where sludge settles. Most treatment plants use two such tanks in stand-by mode, i.e. one is filled and sedimentation takes place undisturbed in the other. The water after sedimentation in the sludge lagoons is discharged into the water course and the sludge is further processed. Nowadays, the need for chemicals for treatment is significantly higher, and with this comes a greater amount of generated waste - sludge. As a large part of treatment plants have a long history, the tanks are often not sized for this change. For this reason, new and more creative solutions had to be found. In connection with ÚV Želivka, our largest processing plant in the Czech Republic, the concept of so-called storage tanks was created. And in cases where it is not possible to choose a simpler solution, mechanical drainage is used.

After the excursion

How to work with information from the excursion. Evaluation of tasks, repetition of some knowledge and revitalization of findings, placing the excursion and information in a wider context.

The realization of other school activities after the excursion is very demanding - school study plans and other extracurricular activities are so full that any follow-up program is practically impossible. Even so, in some schools, part of the excursion includes a subsequent "Excursion Record", where students write down basic information. In secondary schools, it is possible to follow up by offering seminar and graduation papers in the field of water management (we recommend asking the teaching staff directly – there are very few meaningful topics, especially in regions outside of Prague), in the case of vocational schools, the possibility of practice or an internship (mandatory in many cases).

Summarizing the basic information that the students should take away from the excursion should be done at the end of the excursion itself, while the participants are oriented and have the opportunity to ask questions. However, this applies not only to teachers. What excursion providers can contribute to consolidating new information is a short repetition at the end. The use of the treatment scheme is offered here to repeat the story of water and what is removed at what stage and why it is necessary to get rid of these substances. Further questions and ambiguities may arise from participants during repetition. It's also a good idea to ask participants follow-up questions to make sure they're getting the point across.

If filling in worksheets was part of the excursion, it is of course necessary to evaluate these worksheets - however, this part is more up to the teaching staff at the school, to whom you will provide the correct answers for your specific operation.

However, your reflection on the excursion itself and its further possible improvement should not be forgotten. You will receive the first feedback on the spot - are the participants paying attention? Do they enjoy any part more than others? Would they like to look at the water source, even if it's quite far away and you didn't want to go there in the first place? It is necessary to realize that the program is implemented mainly for the participants, and even if you do not convey as much information as you would like, but it will be more fun for them, it is necessary to modify the program. Each group is diverse and it is good to work with it, perceive it and react adequately. Sometimes we can't avoid improvisation.

Of course, the use of classic feedback questionnaires is also a certain possibility, although its use for this purpose may be debatable. It is better to direct the question directly to the pedagogic worker who will be present on the excursion, because he or she knows this target group best. It is necessary to realize and possibly change what the students knew, what they didn't know, what surprised them and what interested them the most - whether funny stories from practice were interesting or not.

At the same time, we recommend cooperation with the PR department of your company, if it exists - an article on the website and social networks about the excursion will not only improve the opinion of the company, but can also inspire other schools in the vicinity to become interested in the possibility of an excursion.

Links and additional information

Although we have tried to write this material in such a comprehensive way that it is not necessary to search for general information further, it is possible that due to the range of possible technologies we have not explained some in full detail, or you may want to learn something more about some part. On this page, we want to provide you with a guide to other information sources.

- **General resources**
- Water management dictionary (for example https://www.pmo.cz/cz/o-podniku/vodohospodarsky-slovnik/ or elsewhere on the Internet)

Hygienic minimum for workers in the water industry (current version on the website of the State Health Institute)

- **Sources of expert information on technologies and substances in water**
- Hydrochemistry, author: Pavel Pitter (in many editions), available at the Digital Library

Methodological recommendations and opinions of the State Institute of Health (National Reference Center for Drinking Water)

Sources of information about specific systems

- We know from our own experience that in many cases there is not enough information about water sources, treatment plants or reservoirs and water pipes, and the guides cannot inform the participants about the specifics of the given place. For understandable reasons, we cannot provide you with a list of resources for every municipality in the Czech Republic, but below we present documents that you can go through and draw from:
- operating regulations of the water supply system (mandatory document for each system)
- operating regulations of the water treatment plant
- information within the PRVaK, PRVAK and PRVK systems (Plan for the development of water supply and sewerage systems), which is processed by each self-governing region and is freely available on the Internet
- information on the geoportal of the locally relevant region (for water resource protection zones), alternatively you can use the map services of VÚV TGM, v. v. i. or Farmer's Portal
- documents in the locally relevant state district archive (mostly the Water Management Fund)

locally relevant chronicles (pay attention to the merger and division of municipalities during history, especially in the 70s and 80s of the last century!), which are in many cases accessible on the Internet

Attachment: Form to find out information about the water treatment plant

<table>
<tr><td colspan="5">This form can help you prepare information for the excursion and contains fields for all the information that should either be heard during the excursion or will very likely be in the questions of the participants.
name of the water treatment plant</td></tr>
<tr><td>year of construction / reconstruction of the Central Office</td><td>water production per second</td><td>water production per day</td><td>water production per year</td><td>percentage of water losses in the network</td></tr>
<tr><td colspan="2">the number of inhabitants supplied</td><td colspan="3">supplied municipalities</td></tr>
<tr><td>the number of employees at the Central Office</td><td>number of company employees</td><td>electricity consumption per 1 m3</td><td>electricity consumption per day</td><td>electricity consumption per year</td></tr>
<tr><td colspan="2">price of water per 1m3</td><td colspan="3" rowspan="2">length of water supply network and material</td></tr>
<tr><td colspan="2" rowspan="2">problem parameters of raw water and technological steps to solve them</td></tr>
<tr><td colspan="3">description of resources (for wells, depth, type, declared protection zones)</td></tr>
<tr><td colspan="2"></td><td colspan="3">list and concentration of dispensed chemicals</td></tr>
<tr><td colspan="2">sludge management solution style (lagoons, sewers, recipient...)</td><td></td><td></td><td>number of subscriptions a of water samples per year</td></tr>
<tr><td colspan="5">information about the owner and operator of the water treatment plant and the water supply network, in the case of companies, the country of origin of the company</td></tr>
</table>

On the other side of the sheet, prepare a technological diagram of the water treatment plant and a diagram of the entire water supply system (including the size of the reservoirs), possibly also a sketch of the route where you will lead the excursion, including the time frame and any important information.