CTB3365x – Introduction to Water Treatment

D5a – Direct Surface water treatment

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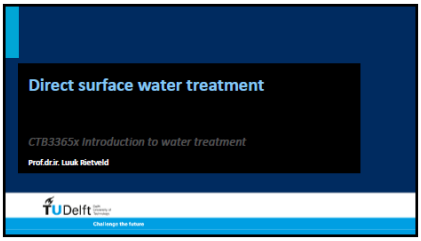
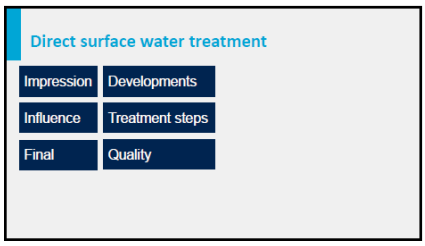
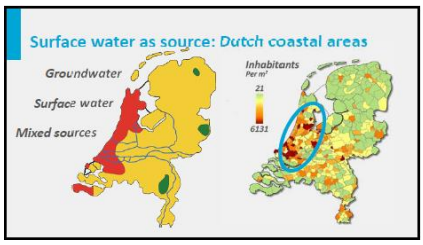
Although surface water is mostly contaminated, we need this source for drinking water production.



Welcome! Today I will give an introduction to the direct treatment of surface water for the production of drinking water.

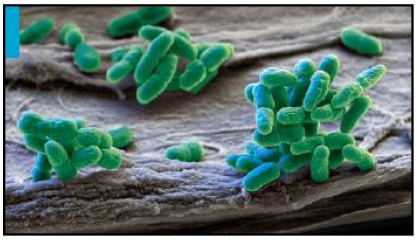


After this lecture you will have an impression of the developments in direct surface water treatment and the influence of the different steps on the final drinking water quality.

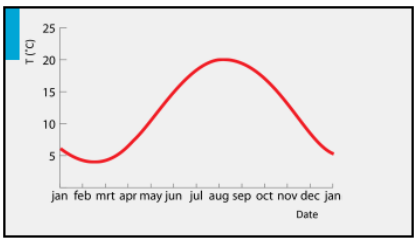


Surface water is one of the sources for drinking water production and is used when sufficient fresh groundwater isn't available.
In the Netherlands this is the case in the densely populated coastal area.
Here large rivers and lakes can supply sufficient fresh water, while groundwater abstraction on a large scale, would result in the up-coning of brackish and salt water.

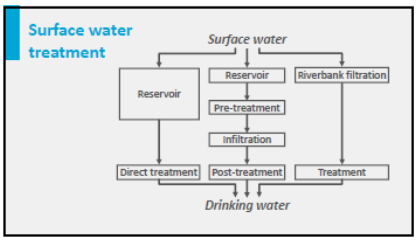
However, disadvantages of surface water as source for drinking water production are the contamination by solids, resulting in turbidity;



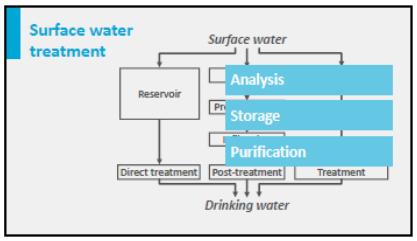
by pathogenic micro-organisms and chemicals, such as heavy metals, pesticides and pharmaceuticals.



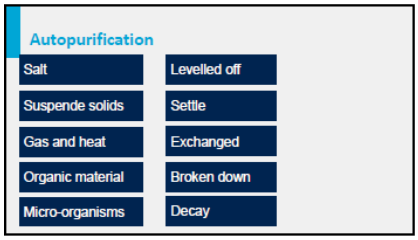
In addition, the water quality, including the temperature, is varying over the year and is sensitive to calamities.
Therefore, surface water needs extensive treatment, including storage in reservoirs and disinfection.



Surface waters can be treated in three different ways.
During direct treatment the surface water is taken in, stored in a reservoir for several months and then passed through a treatment plant.
An alternative is that the water is first pre-treated, to remove turbidity, infiltrated in an aquifer and then post-treated.
Finally, water can be taken in from the river banks, abstracting indirectly the water from the river.
This river bank groundwater is then treated to produce safe drinking water.

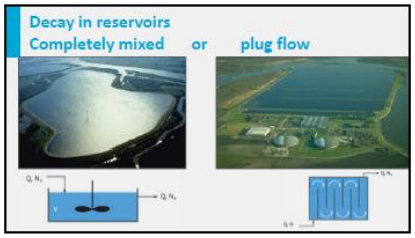


Today we will focus on direct surface water treatment.
Direct treatment of surface water is preceded by storage in reservoirs. These reservoirs have different functions.
First they are needed for analysis.
When river water is contaminated some time is needed to measure it in the laboratory. After feed-back the abstracted river water can be discharged without contaminating the rest of the stored water.
Second the reservoirs have a storage function.
As long as the river remains contaminated, the stored water can be used without interrupting the drinking water supply.
Obviously, during this period, the level of the reservoirs will drop.
Finally, the reservoirs have a purification function, so-called auto purification.

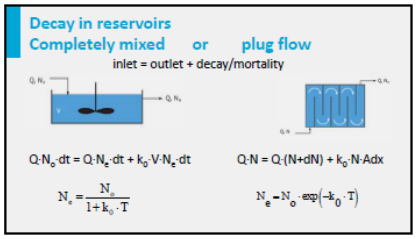


High salt concentrations will be levelled off due to mixing, suspended solids will settle, gas and heat will be exchanged with the atmosphere, organic material will be broken down and anthropogenic pathogenic micro-organisms will decay.

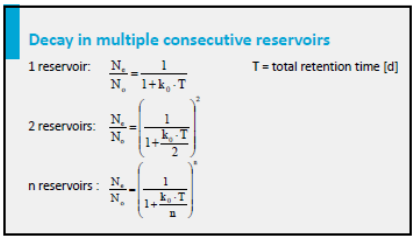
From the water quality table, it can be concluded that, e.g., the average electrical conductivity, as an indication of salt content, remained the same; turbidity values decreased; E-coli numbers, as an indicator for pathogens, decreased; and the bentazon concentration, as an indicator of herbicides, remained the same since degradation does not occur.



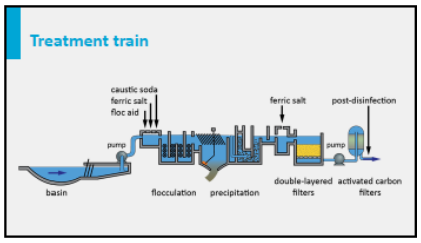
In order to be able to calculate, e.g., the decay of pathogenic micro-organisms it is necessary to determine if a reservoir can be considered to be completely mixed or in plug flow condition.



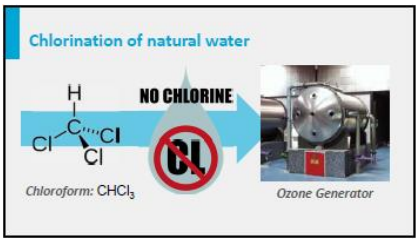
Completely mixed reservoirs are less efficient in the removal of pathogenic micro-organisms than plug flow reactors, as can be concluded from the equations.



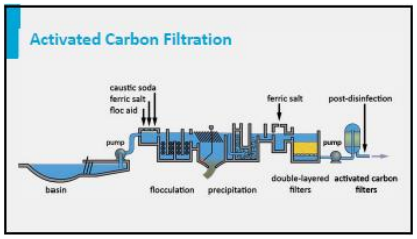
Several completely mixed reservoirs in series, however, will approach the efficiency of a plug flow.
To understand these equations, please do the exercises!



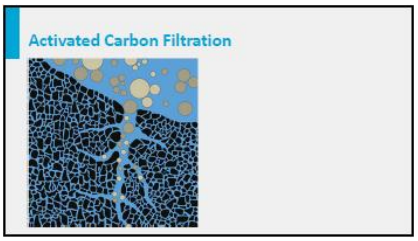
Surface water, after storage, needs extensive treatment. Conventionally, the main objectives were to remove turbidity, odor and taste, and to disinfect the water.
A conventional treatment train consisting of coagulation, where iron or aluminium salts are dosed, floc formation, floc removal, rapid sand filtration and chlorination, meets these objectives.



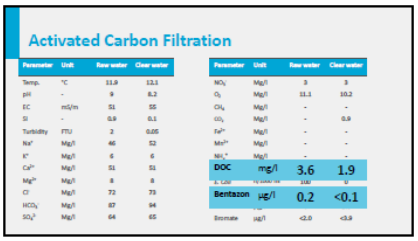
However, in 1973 the Dutchman Joop Rook discovered that chlorination of natural water results in the formation of carcinogenic disinfection by-products such as trihalomethanes of which chloroform is the best known.
Therefore, at the end of the last century, chlorine was abolished from the conventional water treatment plants and ozonation was used as alternative disinfection step.



In addition, at the end of last century, organic micro-pollutants, such as bentazon, were permanently present in the source water.
These organic micro-pollutants were also suspected to have impact on human health.
These micro-pollutants could not be removed by the conventional treatment steps and activated carbon filtration was added to the treatment train.



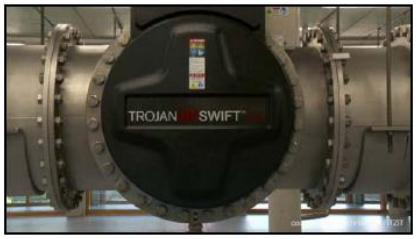
Activated carbon adsorbs the dissolved organic matter, including pesticides, and removes it from the water phase.



An example of such a treatment train is the former treatment system of Berenplaat of drinking water company Evides, the Netherlands.
As can be observed, the bentazon concentration is removed up to levels below the detection limit.
As can be seen, some of the natural organic matter, measured as dissolved organic carbon or DOC, is removed as well.

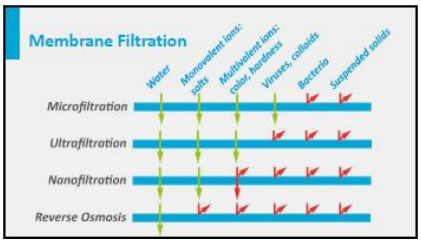
With the increasing contamination of the surface waters and the improved detection methods, more and more, organic micro-pollutants are found in the raw waters and even in drinking water.
Not all endocrine disrupting compounds are removed by activated carbon adsorption.
Therefore alternative treatment methods had to be found.
In addition, it was discovered that ozone disinfection, as an alternative for chlorination, also produced the carcinogenic compound bromate as a by-product.
Finally, several resistant pathogenic micro-organisms were identified that were difficult to eliminate with both chlorination and ozonation.

One of the developed methods is the advanced treatment process, AOP, consisting of the combination of ultraviolet light and hydrogen peroxide.



In this process so-called OH radicals are formed that oxidise the organic matter, present in the water.
In addition, the UV light sterilises the pathogenic micro-organisms, so that they cannot reproduce anymore.
The first full-scale plant based on UV/H2O2 was built by drinking water company PWN in Andijk, the Netherlands.

Another alternative is the application of membrane filtration. With microfiltration and ultrafiltration turbidity and pathogenic micro-organisms are removed, without the use of chlorine, ozone or UV, whereas with nanofiltration and reverse osmosis it is possible to remove the organic micro-pollutants.



Additional advantage of nanofiltration is that the water is partly desalinated and all bivalent ions are removed as well, softening the water.
With RO almost all salts are removed.
In the case of surface waters with a little too high level of salts, NF/RO can be applied as a partial treatment as is done in “Heemskerk” of PWN.

During this lecture I gave an overview over the developments in direct surface water treatment.
In the next lectures we will explain in more detail how to design the individual treatment steps, such as coagulation, sedimentation and rapid sand filtration, the basis of all surface water treatment systems.
Don’t miss it, see you next time!