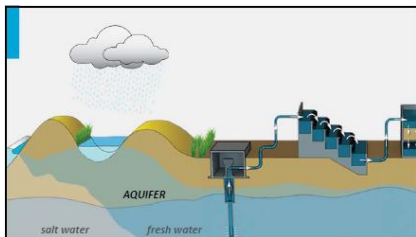
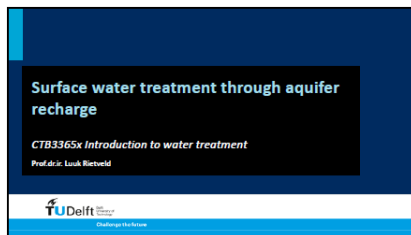


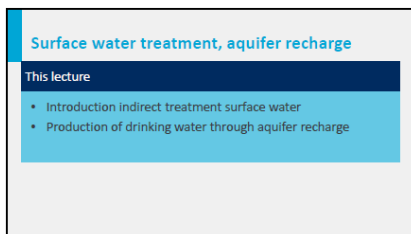
D5g – Artificial infiltration



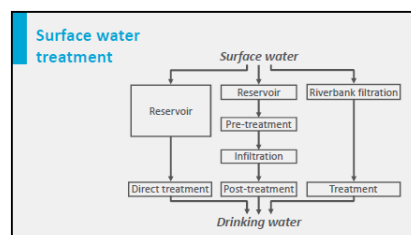
Luuk Rietveld



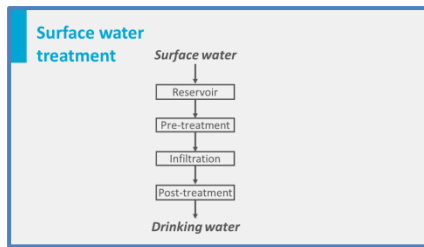
Did you know that making use of nature, by infiltrating pre-treated surface water in the underground, is common practice in the Netherlands as alternative for the direct treatment of surface water?



This lecture gives an introduction to this indirect treatment of surface water for the production of drinking water, through aquifer recharge.



As explained in the lecture about direct surface water treatment, 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.



Artificial aquifer recharge has the advantage that, in delta areas,

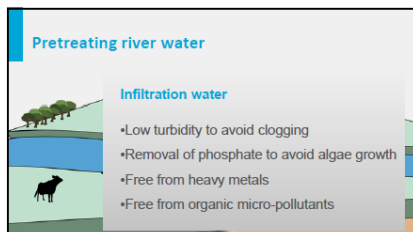
Artificial aquifer recharge in delta areas

Sufficient surface water available
Groundwater that is free of pathogenic micro organisms
Constant water quality
Insensitive to calamities
Extra possibilities for recreation and wild-life

sufficient surface water is available. In addition, it has the advantages of groundwater that it is free of pathogenic micro-organisms, because of natural decay; has a constant water quality, including temperature, due to mixing; and that it is relatively insensitive to calamities, because of its storage capacity. The additional advantage of artificial aquifer recharge is that it is performed in large, protected areas in the neighborhood of urbanization, giving extra possibilities for recreation and wild-life.



An example of the infrastructure needed for artificial aquifer recharge is the one for the city of The Hague and surrounding areas. Raw water is taken in from a branch of the river Meuse, about 50 km way from the city, pre-treated at Brakel and Bergambacht and then transported with two transport mains to three different infiltration areas in the dunes near The Hague: Monster, Scheveningen and Katwijk. After post-treatment on these locations, the water is directly distributed.



The infiltration water must have a low turbidity to avoid clogging of transport mains and infiltration ponds, phosphate has to be removed to avoid algae growth in the infiltration ponds and the water should be free from heavy metals and organic micro-pollutants to avoid accumulation of these contaminants in the natural environment.



In practice this pre-treatment consists of a conventional treatment system with coagulation/flocculation, sedimentation and rapid sand filtration. In the example of treatment plant Cornelis Biemond of water company Waternet,

Water Quality

Parameter	Unit	Raw water	Clear water
Temp.	°C	11.5	11.9
pH	-	7.9	9
BDV	mg/l	51	51
Si	-	8.2	8.9
Turbidity	FTU	10	2
K ⁺	Mg/l	6	6
Ca ²⁺	Mg/l	63	51
Mg ²⁺	Mg/l	8	8
Cl ⁻	Mg/l	61	72
HCO ₃ ⁻	Mg/l	154	87
SO ₄ ²⁻	Mg/l	52	64
NO ₃ ⁻	Mg/l	4	9
O ₂	Mg/l	9.2	11.1
CH ₄	Mg/l	-	-
CO ₂	Mg/l	3.5	-
Fe ²⁺	Mg/l	-	-
Mn ²⁺	Mg/l	-	-
NH ₄ ⁺	Mg/l	-	-
DOC	Mg/l	4.1	3.6
E. Coli	n/1000 ml	6800	100
Bentazon	µg/l	0.2	0.2
Bromate	µg/l	<2.0	<2.0

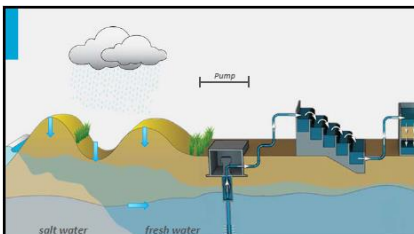
you can see that indeed the turbidity is removed. Unfortunately, the organic micro-pollutant bentazon is still present and not removed in the conventional treatment plant.



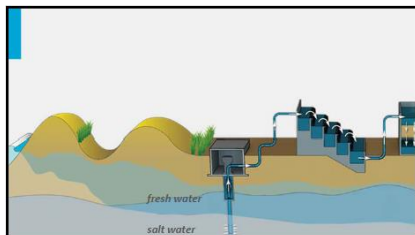
An example of an infiltration area are the dunes in Scheveningen, near The Hague. The infiltration ponds are clearly visible and give a positive value to this natural system. Sometimes the infiltration ponds need maintenance and then they are drained and the bottom is scraped to remove the sludge layer and stimulate infiltration. The area is also used for recreation, interlinking water supply with leisure.



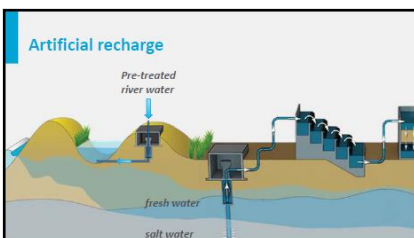
At the back the beach of Scheveningen is clearly visible. The post-treatment plant is situated at the edge of the infiltration area, producing the final drinking water for further distribution.



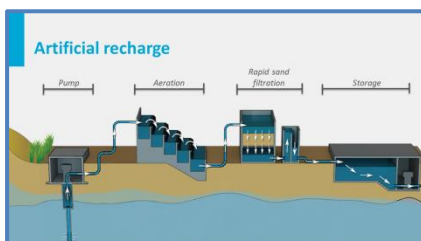
In the past the dune area was also used for drinking water production. Then the aquifers were only recharged by rain water.



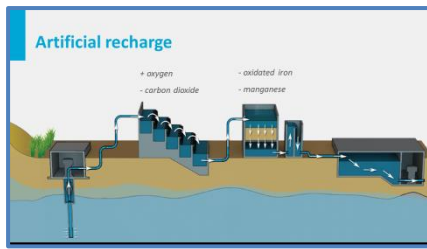
However, after the second world-war, the abstraction exceeded the recharge, leading to up-coning of brackish groundwater.



Therefore, artificial recharge became necessary. The infiltrated river water has a residence time of approximately 2 to 3 months, is then abstracted with a closed drainage system and pumped to the post-treatment. Since the infiltrated river water has become groundwater during its residence in the underground,



post-treatment basically consists of aeration and rapid sand filtration.



During aeration oxygen is added and carbon dioxide is stripped. The oxidized iron and manganese is then removed by the rapid sand filter.

Activated Carbon Filtration

Parameter	Unit	River water	Clear water
Temp.	°C	11.9	12.1
pH	-	9	8.2
BOD	mg/l	51	55
SI	-	0.9	0.1
Turbidity	FTU	2	0.05
Na ⁺	mg/l	46	51
K ⁺	mg/l	6	6
Ca ²⁺	mg/l	51	51
Mg ²⁺	mg/l	8	8
Cl ⁻	mg/l	72	75
HCO ₃ ⁻	mg/l	67	64
SO ₄ ²⁻	mg/l	64	65
NO ₃ ⁻	mg/l	9	9
O ₂	mg/l	11.1	10.2
CO ₂	mg/l	-	-
Fe ²⁺	mg/l	-	-
Mn ²⁺	mg/l	-	-
NH ₄ ⁺	mg/l	-	-
DOC	mg/l	3.6	1.9
Σ Col	n/1000 ml	180	0
Benzenes	μg/l	<0.5	<0.1
Benzon	μg/l	0.2	<0.1
Bromide	ppb	<2.5	<0.9

Because most of the infiltrated river water, still contains organic micro-pollutants, activated carbon is frequently applied, either in powdered form or as a granular activated carbon filter.

Surface water treatment through aquifer recharge

CTB3365x Introduction to water treatment

Prof dr.ir. Luuk Ritveld

TU Delft

Challenging the future

This was the last lecture about drinking water treatment. Good luck with your examination about this part, and enjoy the next part about wastewater treatment!