GREEN REMEDIATION BY FACILITATING INDUSTRIAL WATER USE AND HEAT SURPLUS IN THE PORT OF ROTTERDAM

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SUMMARY

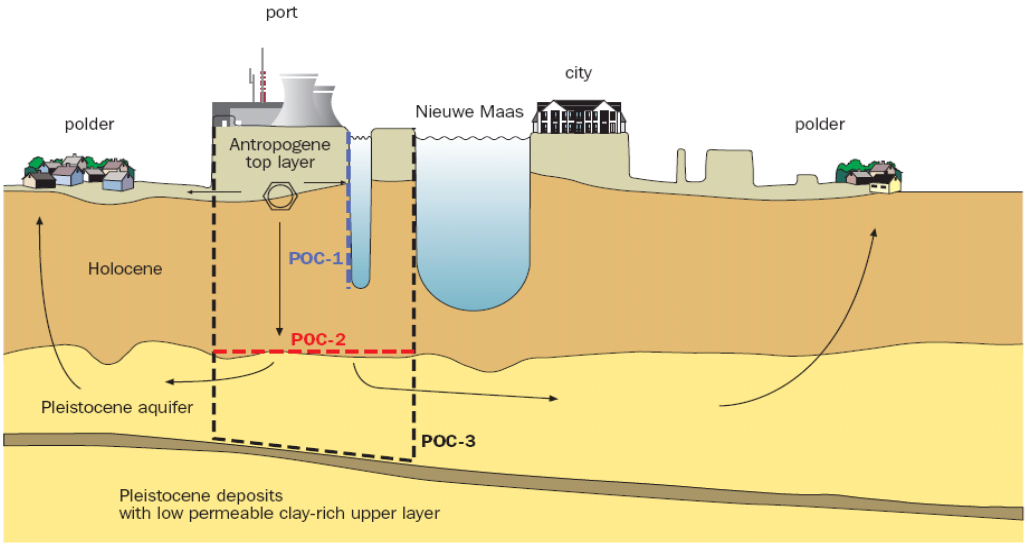
In the Port of Rotterdam the long-term presence of various industrial activities has resulted in soil and groundwater contamination. This contamination is substantial, complex and is usually not limited to one particular site but affects (ground)water systems at a regional scale. This being the case, site-specific approaches are neither effective nor cost efficient. In these cases it is better to develop an integral approach at megasite level, in which risk management scenarios are combined and measures are prioritized. The natural resilience of the soil and groundwater system will help significantly in reducing the risk of contaminated groundwater, if managed properly. In the EU WELCOME project an integrated management strategy (IMS) has been developed and later on successfully applied at the Port of Rotterdam. The implementation has revealed that a significant cost-reduction of up to 40% can be achieved in comparison to a site by site remediation approach, if measures are considered following a risk based approach on megasite scale.

Active remediation efforts will still be conducted within the framework of the Integrated Management Strategy in order to manage the risk of still present contaminations. Conventional remediation techniques need energy and produce CO2 which has raised doubts about the overall sustainability of these techniques. The introduction of green remediation approaches can significantly boost the sustainability of Area Management of Contamination. For megasites like the Port of Rotterdam the key to this ambition lies in the combination of several goals for energy and water. For the Port of Rotterdam it is possible to effectively combine industrial water use and the industrial heat surplus with the remediation of contaminated groundwater. By using the groundwater for cooling purposes and storing (part of) the heat surplus underground (Aquifer Thermal Energy Storage, or ATES), biological remediation can be stimulated under certain conditions. This will lead to both an improvement of the groundwater quality and a reduction of energy use and CO2 emissions.

INTRODUCTION

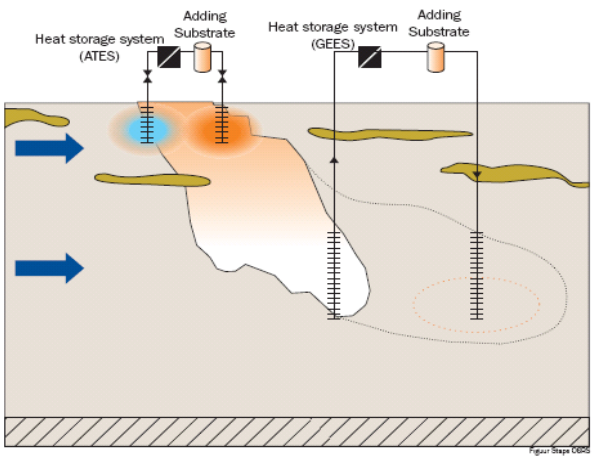
The groundwater in the Port of Rotterdam is significantly contaminated caused by heavy industrial activities in the past decades, for which the Port Authorities are searching a sustainable solution. Common practice nowadays is to approach historical contaminations that do not pose any ecological or human threats differently (monitoring and control), then newly formed contaminations (direct removal). The industry is not encouraged nor feels inclined to proactively deal with the contaminations. Especially the deeper groundwater contaminations in the first aquifer under the Port of Rotterdam are difficult and costly to remediate and are therefore hardly addressed. Contaminations have in many cases migrated past the site boundary, which makes things more complex. The contamination problem can therefore better be viewed on a more regional level and the entire port area should be considered a Megasite. The Port of Rotterdam is working on a risk based approach for area wide management of the contaminations. This strategy makes it possible to combine remediation efforts and make optimal use of the aquifers' natural potential to attenuate contaminations. The objective is to avoid unacceptable risks of the groundwater contaminations on one hand and ensure

the possibilities for the current and future use of the Port of Rotterdam on the other hand (see picture of the conceptual model below).



Furthermore, many initiatives are taken to improve sustainable water and energy use in the Port of Rotterdam:

- The (petro)chemical industry uses a lot of energy. The costs for energy are expected to increase, which is a direct incentive to lower the energy consumption. This will also lead to a reduction in CO2 emissions. At the same time a substantial amount of industrial heat surplus is available in the Port of Rotterdam. Re-use of this energy surplus might therefore contribute to the energy ambitions.
- Sustainable water use in the industry (eg. cooling and process water), is stimulated in different ways and can on the long run lead to a cost reduction for the industry. Groundwater is generally considered a good source for water in the industry (chemically and biologically relatively pure). The use of (clean) groundwater for industrial processes is not in line with the national and regional water policies and is therefore discouraged. The presence of contaminations and the relatively high salt content of the groundwater in the Port of Rotterdam, limits the use and therefore the value of groundwater for industrial use. There are however several cost effective techniques to enhance the groundwater for industrial use and subsequently remove contaminations. Using groundwater for industrial use can therefore indirectly contribute to an improvement of the groundwater quality in the Port of Rotterdam.

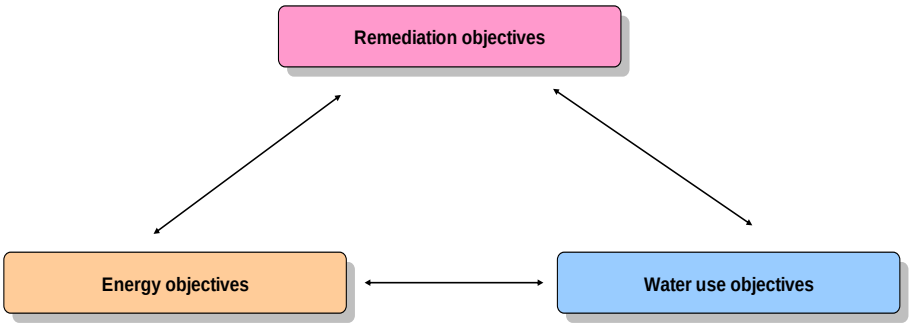


OBJECTIVES

Port of Rotterdam is searching for a sustainable use of the industrial heat surplus. One of the possibilities under consideration is the combination of groundwater remediation and aquifer heat storage (ATES, see picture below). There is a particular challenge to enhance the success of the Area Management of Contamination, by applying these smart combinations. This preliminary study has shown that combining groundwater remediation and ATES will serve multiple sustainability goals and implementation is feasible.

APPROACH

The 3 types of ambitions in the field of soil, water and energy can be cross linked for the Port of Rotterdam. This makes it possible to asses the feasibility of different combinations (see picture below).



To determine the feasibility to use industrial heat surplus for groundwater remediation the following questions have to be answered sequentially:

1. What are the objectives for the soil, water and energy and which ‘smart combinations’ are possible?
2. What conditions and constrains need to be considered?
3. How can these be translated to feasible concepts?

RESULTS

Three combination concepts have been considered in more detail and prove to be technically and legally feasible for implementation both on a local as well as a regional scale:

1. Groundwater remediation by discharging heat into the contaminated aquifer, without re-using the heat.
2. Groundwater remediation by combining aquifer heat and cold storage.
3. Groundwater remediation with traditional pump&treat in combination with re-use of the extracted water in the industry.

CONCLUSIONS

Smart combinations of groundwater remediation and aquifer energy storage are technically, financially and legally possible, though there are several constrains to be considered. The combination concepts fit well into the energy ambitions of the Port of Rotterdam and in the Area Management of Contaminations, as described above. The following conclusions can specifically be drawn:

- In the Port of Rotterdam the geology, geochemistry and hydrogeology prove to be suitable for aquifer energy storage, though the presence of methane gas in the first aquifer might form a limitation that needs to be considered. Furthermore there is sufficient heat surplus available to increase the groundwater temperature of all contaminated sites to a level where natural attenuation of groundwater contaminations is most optimal.
- The optimal temperature for enhancing the natural attenuation of contaminations is around 30º C. Only contaminations that break down naturally can be enhanced in this manor.
- The increasing of the temperature will also induce a mobilization of contaminations either absorbed on soil material or present in the soil as free phase. However, high temperatures are necessary for a significant effect.

- For all 3 combination concepts considered in this study an extensive infrastructure and in most cases on site water treatment facilities are necessary. Common aquifer energy storage facilities will circulate 10 m3 to more then 100 m3 per ~~day~~hour. This is of the same magnitude as the water consumption for industrial sites. The different water chains can thus be linked.
- The profit gained from a combination concept will strongly depend on the main objective. The system will in most cases be designed accordingly. If the main objective is to remediate the groundwater contamination, an increase of temperature can speed up the natural attenuation 4 times. If the energy objectives are leading, the system will generally be designed to only control the groundwater contamination and not necessarily remediate it. In both cases the combination of aquifer energy storage and groundwater remediation is financially beneficial, since separating the remediation effort will lead to extra costs for all sorts of subsurface infrastructure.
- Additional research is necessary to better understand the geochemical and biochemical processes in order to prevent well clogging on one hand and optimize the natural attenuation and mobilization processes on the other hand. There is also a need to look into the different financial aspects and the scale at which combinations concepts can be implemented.

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