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Nimr Water Treatment Project, Oman

Introduction

The Nimr water treatment plant (NWTP) project is located in the south of the Sultanate of Oman. The temperatures in the region can be as high as 60°C in the summer months, making it a harsh environment to work in. This water treatment project was co-executed by Bauer Resources and Petroleum Development Oman (PDO). Following a 2-year design, construction & commissioning phase, the plant became commercially operational on 16th January 2011

Nimr On Site Nursery

The Nimr oilfield requires 240,000 m³/d of water to be managed to keep oil production going. Deep disposal wells were the main option so far, but the Nimr WTP can address the issues of loss of revenue from oil left in produced water, meeting stricter environmental regulations, high-energy costs during operation and the carbon footprint associated with disposal wells.

Project overview

The Nimr WTP was initially designed to treat 45,000 m³/d, which is less than a fifth of the daily volume of produced water generated by the oilfield. It started as a design-build-own-operate (DBOO) project under a 20-year operation and maintenance contract. This is a unique model, for which BAUER designed and built a wetland facility and is now operating it successfully close to 9 years. Shortly after the initial operation of the plant the water quantities were increased to 95,000 m³/d. In 2018 the construction of the 3rd expansion phase commenced and was completed to ensure water flow in May 2019 at a maximum capacity of 175,000 m³/d which is the todays capacity of the system. BAUER has taken the full liability for managing the water from the oil and gas producer for another 25 years from the operational date in 2019.

The composition of the produced water from the Nimr oilfield is brackish, with total dissolved solids (TDS) ranging between 7,000 mg/l and 8,000 mg/l. The recorded oil in water concentration is higher than 500 mg/l in average.

Aerial View NWTP

The plant layout includes a pipeline, which enters the NWTP system and leads to an oil and water separator. The water is then distributed into a wetland facility where it is channeled through four wetland terraces by gravity feed and by this does not require any pumping of water in the system. The overall area of the wetland has increased from is 2.5 million m² in phase one to approximately 5.1 million m² after the second extension to 175,000 m³/d.

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The system is using only local reed species. Despite the hot climate the area provides temperatures, which are suitable for the growth of *Phragmites australis* plants which is the main species used in the wetland cells. To diversify the wetland other species like Schoenoplectus, Typha and Juncus have been used and have improved the functionality for the system significantly. All the plants have been sourced locally in Oman and were then reproduced in a nursery on site. In total more than 2.5 Million individual plants have been planted in the commissioning phases of the project, which established a functional treatment system in less than three month from the first irrigation of the plants.
Finally, there are several evaporation ponds to reduce the water volumes used for future salt recovery in order to reuse the salt for drilling operations in the oilfields of Oman.

This makes the entire system a Zero Liquid Discharge System with the option to generate added value such as salt or reuse the water for any kind of additional projects.
From all ponds water can be accessed easily for any desired reuse.

A portion of the treated water is being reused for drilling purposes already. In 2014 Bauer Nimr has started using water for the irrigation of test plots for biosaline agriculture in order to evaluate a more sustainable reuse option for the treated effluent. Potential use can be to produce energy pellets, other biofuels, cotton or wood for construction purposes.
The reuse of water has developed significantly in the past couple of years. Therefore, a 25 ha farm land has been installed on site using different types of irrigation systems such as bubbler irrigation or flood irrigation as well as different types of soil amendments and fertilisers. Now, the water is used for irrigation of plants such as Cotton (Gossypium), Ricinus (*Ricinus communis)* or Jojoba (*Simmondsia chinensis)* to produce either downstream valuable products or biological oils for further processing. Further, some local tree species like Eucalyptus or Conocarpus are growing very well, giving hope that in a short period of time an upscale of the farming activities can take place in Nimr which will result in the reuse of the treated water from the wetlands completely.

Reducing the environmental footprint

The Nimr WTP project is reducing the environmental footprint in an unexpected scale. The project has won several international awards such as the “Global Water Award” in 2011, the ADIPEC “Best MENA Oil & Gas HSE Project” Award in 2012 and the “Excellence of Climate Action” Award as the Qatar Sustainability Summit in 2019.
This project is able to recover as much as > 750 bbl per day of crude oil from the produced water on average and oil recovery has peaked at some 1,000 bbl per day in the past. Since the start of the project, more than 2,000,000 barrels of crude oil have been recovered from the produced water stream and projections calculate up to 4,000,000 barrels can be recovered throughout the lifetime of the project.
The concept of the plant was to have zero energy used for the water treatment, thus reducing the energy footprint by installing a gravity flow system plant design, making the process even more energy efficient. That means the plant is constructed on a man-made slope and the water is able to flow through the wetlands naturally without any further pumping required.

Indicator	**Performance up to date 09/2019** (~ 9 years)
Water Treated	300,000,000 m³
Oil Recovery	2,100,000 bbl in total
Power Consumption Saved	~ 1,500,000 MWh
Treatment Performance	TPH < 0.5 ppm

The concept has replaced an energy intensive operation of underground disposal by high pressure pumps and led to an energy saving of so far approximately 1,500,000 MWh in the first approximately nine years of operation. According to our client sustainability report 2017, PDO this is saving 98 % of the energy compared to what has been used for the previous practice of deep well disposal in the oilfield.

To protect underground aquifers, the wetland area is lined with a mineral sealing layer rather than a HDPE liner, which is used typically. The climate and large surface area made using HDPE liners unfeasible. Local materials were sourced to establish the sealing layer. The sealing layer was designed in the laboratory and constantly tested on site for its quality. The whole process was approved by the client and the Ministry of Environment in Oman in the technical clarification phase of the project.
The use of a mineral sealing layer rather than a HDPE liner has reduced the energy footprint during installation phase by 80%.

Compared to deep disposal wells, this wetland approach has lower energy requirements and less carbon footprint. The table below shows the energy and carbon footprint associated with the two methods.

Operational energy requirements for wetland plant and deep disposal wells

Disposal options	Power required	Total power used in project	CO_2
Deep Well Disposal	Up to 5.5 kWh/m³	5,200,000 MWh	4,400,000 t
Wetland	< 0.1 kWh/m3	75,000 MWh	50,000 t

Water Inlet Terrace 1

Project success and outlook

Starting from 45,000 m³/d the project has grown to 175,000 m³/d capacity for PDO and Bauer which demonstrates the technical and commercial success for both sides.

The use of a mineral sealing layer rather than a HDPE liner has reduced the energy footprint during installation by 80%. The oil content in the produced water is reduced from 500 mg/l when entering the NWTP to less than 0.5 mg/l when leaving the wetland system. (Treatment Efficiency >99.9%).

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A portion of the treated water is being reused for drilling purposes already at a rate of up to 10,000 m³/d. Very successful trails have been setup to produce high quality water via a reverse osmosis system, providing WHO drinking water quality. Furthermore, agricultural trails have shown promising progress to allow full scale farming activities in the near future.

Inlet, Oil-Water Separator and Buffer

The system has become an ecosystem which attracts several species of fauna and flora and it was proven that the plant structure in the system has changed throughout the operational period to a natural plant association. Up to date more than 120 native and migratory birds have been counted on site. The wetlands have even become home to two species of fish despite its remote location.

Internationally known scientists and birdwatchers are visiting the plant minimum once a year to provide records to Bauer and the Ministry of Environment and to ensure that the birds are not negatively affected by any of the treatment areas.

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Metering

Wetland Terrace 1

Bird visiting the wetland

On Site Nursery

NWTP Aerial View

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2011 Global Water Awards: The awards were presented by guest speaker Kofi Annan. BAUER Resources GmbH's reed bed treatment plant in Oman won the "Industrial Water Project of the Year" category, beating off competition from three other nominations.

Further Awards including several HSE awards have been granted to the project and the project team.

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Technical Design 45,000 m³/d

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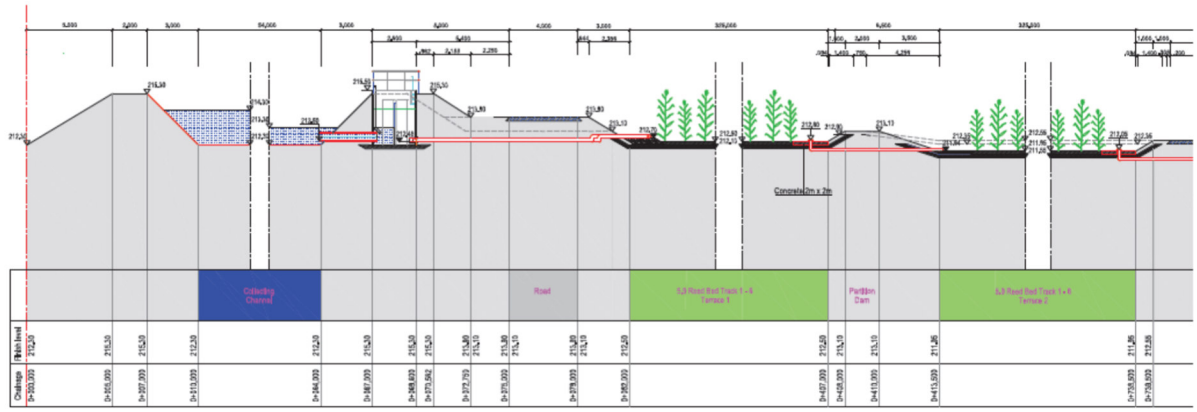
Gravity flow wetland…



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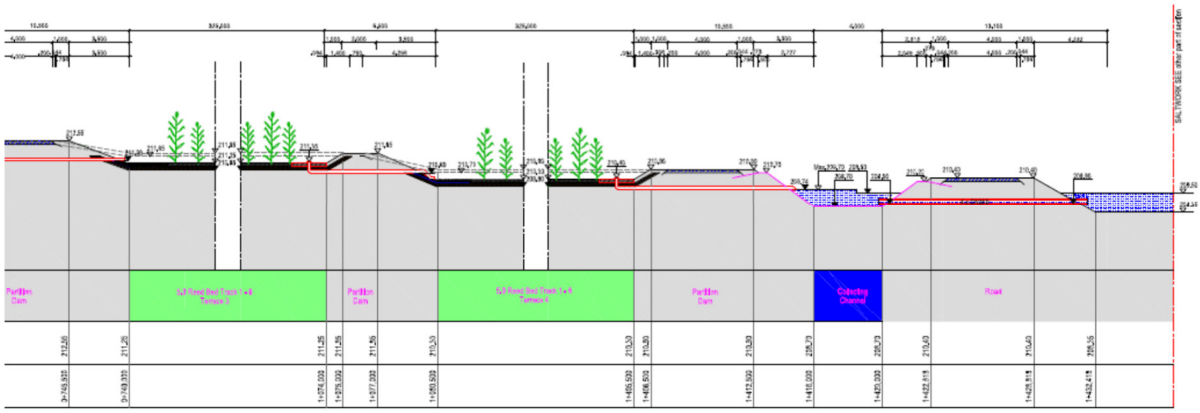

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