Introduction

Our Sponsors

Our Speakers

December 2, 2019 - FarmVisit
a. Photos from the Farm Event

December 3, 2019 - Water for Agriculture
a. Presentations from the Event
b. Photos from the Dec 3rd Event

December 4, 2019 - Water Energy Nexus
a. Presentations from the Event
b. Photos from the Dec 4th Event

Our Exhibitors

Press Releases
It is my pleasure to welcome you to MEDRC’s Cutting-Edge Water Technology Showcase, 2019.

This year’s agenda is rich and varied, filled with exhibitors showcasing the latest advancements in water technology and innovation, combined with a lively and interactive few days of great water debates and networking opportunities.

I would like to thank all our sponsors, partners, contributors and participants for their generosity, interest and support, particularly our main event partners the Embassy of the Kingdom of the Netherlands in Oman and the Public Authority of Water (Diam).

I hope you will find the event informative and insightful and that it allows you an opportunity to expand your professional network and make valuable connections.

Finally, if you have any suggestions for next year’s event, please don’t hesitate to get in touch, your feedback is appreciated and would be most welcome.
The Public Authority for Electricity and Water (Diam) was established in 2007, by the promulgation of Royal decree 92/2007. It was followed by a Royal decree (58/2009) defining the responsibilities and jurisdiction of the PAEW. By Royal Decree 42/2018, “Public Authority for Electricity and Water” was replaced with name "Public Authority for Water".

Diam’s Vision is to be a world class utility contributing to the sustainable development of Oman.

Diam’s Mission is to ensure the provision of high quality, sustainable and reliable potable water services in the Sultanate of Oman.

In order to achieve the Vision and Mission - in line with Government Policy of expanding water access countrywide - Diam has prepared a strategy based on the following strategic themes:

- People & Communication
- Customer Centricity
- Financial Sustainability
- Asset Management and Operational Excellence

In order to achieve Diam’s Vision, Mission, Policies and Value, Diam continuously monitor, regularly report and measure the progress of actions taken using Integrated Management System (IMS) in order to ensure their overall effectiveness and efficiency.
The Embassy of the Kingdom of the Netherlands to the Sultanate of Oman is not just the diplomatic representation of the Dutch government. We also serve as an entry point for both Dutch and Omani companies, knowledge and research institutes for doing business. Such economic diplomacy has developed since 1665, when the first official relations between both countries were established. Ever since, a strong and long lasting bilateral relationship developed.

Currently, the Embassy is focused on connecting potential partners from the Sultanate and the Kingdom to jointly meet the challenge in the so-called 'water-energy-food nexus'. This inextricably linkage between three essential elements of life presents the world with a formidable challenge amid rising populations and climate change. With their vast expertise in water management and renewable energy, and being the world’s 2nd largest agrifood exporter, a variety of government agencies, companies, knowledge and research institutes from the Netherlands stand ready to partner up with counterparts in Oman, and to share their expertise, innovative and sustainable solutions. The Embassy stands ready to assist in generating and creating such opportunities for cooperation.
Oman Water Society (OWS) is a non-profitable non-governmental organization (NGO) found by professionals working in both the Government and Private Sectors who are involved in the water management, water supply and water projects. The aim of this Society is to create a platform for professionals with interest in water to exchanging ideas, researches, discuss challenges, enhancing their knowledge and expose themselves to the latest technology in the field.

The OMZEST Group, The OMZEST Group, now in its fifth decade of business excellence, has been making significant contributions to the economic development of Oman, helping creation of an empowered and successful nation. With business volumes exceeding a billion dollar, OMZEST provides employment to several thousands. We are a multi-location conglomerate with diverse interests across a wide range of products and services. With manufacturing and export operations that cater to the demand in nearly a hundred countries across the globe, our ambitions are on a global scale. With over 75 wholly owned and associate companies, OMZEST forms one of the Sultanate’s premier and diversified business Groups.
SPECIAL THANKS TO OUR SPONSORS, PARTNERS & EXHIBITORS
SHOWCASE PROGRAM

DAY 1
WATER FOR AGRICULTURE
DECEMBER 3, 2019

08.00 - 08.30 Registration

08.30 - 08.45 Welcome Remarks
H.E. Ciarán Ó Cuinn, Center Director, MEDRC
H.E. Laetitia Van Asch, Ambassador of the Kingdom of the Netherlands in Oman
H.E. Mohammed Al-Mahrouqi, Chairman, Diam

08.45 - 09.30 Official Inauguration of Exhibition

09.30 - 10.15 Water for Agriculture: Challenges & Needs in Oman - Moderated by Dr Moahmmed Al Rawahi, Director of Strategic Research Programme for water research, The Research Council (TRC)

10.15 - 11.15 ICT Solutions for Water Productivity in Oman - Moderated by Prof. Osman Abdalla, College of Science, Sultan Qaboos University

11.15 - 11.30 Coffee Break with VIP walk through of Exhibition

11.30 - 12.30 Non-Conventional Water Resources for Agriculture in Oman - Moderated by Dr. Salim Al-Mamary, Planning & Projects Manager, Majis

12.30 - 13.00 Salinity & Sea Intrusions Challenges: Solutions for Omani Farmers - Moderated by Mr. Thomas Kleefled, Senior Project Manager, QUALIES, Oman

13.30 - 14.30 Lunch for Invitees Only
With thanks to our sponsors Flowserve and A+A Group of Companies

14.30 - 16.30 B2B Discussions & Exhibition
Technology Showcase and Networking

16.30 Adjourn
SHOWCASE PROGRAM

DAY 2
WATER - ENERGY NEXUS
DECEMBER 4, 2019

08.00 - 08.30
Arrival and Registration

08.30 - 09.30
Exhibition & Networking
Technology Showcase & networking

09.30 - 09.35
Welcome Remarks
H.E. Ciarán Ó Cuinn, Center Director, MEDRC

09.35 - 10.20
Overview of Water-Energy Nexus Challenges in Oman - Moderated by Dr. Jauad El Kharraz - Head of Research - MEDRC

10.20 - 11.20
Seawater Intake Challenges in Oman: Solutions - Moderated by Dr. Mohammed Al-Abri, Sultan Qaboos University (SQU)

11.20 - 11.30
Coffee Break

11.30 - 12.30
Produced Water & Wastewater Treatment Challenges in Oman: Solutions - Moderated by Dr. Syham Bentouati, Managing Director, NAFAS International LLC

12.30 - 13.30
Desalination Industry Challenges (O&M, Training) in Oman: Solutions - Moderated by Eng Riadh Dridi, MEDRC

13.30 - 14.30
Lunch for Invitees Only
With thanks to our sponsors KWI

14.30 - 16.00
B2B Discussions & Exhibition
Technology Showcase and Networking

16.00
Adjourn
SOME OF OUR SPEAKERS

Abdullah Al-Abri
Executive Director
Ejaad

Abdulaziz Said Al Shidhani
General Manager Planning & Asset Management
Diam

Ahmed Al-Mazrouy
CEO
MAJIS

Zaher Al Suleimani
Chairman
Oman Water Society

Patrick Thienpont
CEO
Barka Desalination Company SAOC

Rauf Aliyev
Founder
A&A Group of Companies

Riadh Dridi
Head of Training
MEDRC

Saada Al-Shukaily
Head of Water Management
PDO

Sumitava Sengupta
Manager
Yokogawa

Jauad El Kharraz
Head of Research
MEDRC

Salim Al Mamary
Planning & Projects Manager
MAJIS

Abdullah Al-Ghafri
Associate Professor
University of Nizwa

Mohammed Al-Abri
SQU
Chair in Nanotechnology

Salim Sibani
ACWA Power Barka SAOG
CEO

Mohamed AL-Rawahi
Director of Strategic Research Programme
The Research Council

Andreas Vandré
Regional Manager, Educational Service
Flowserve

Peter Kerschberger
Application Manager
KWI-Intl

Musthaque Ahmed
Professor
Sultan Qaboos University
SOME OF OUR SPEAKERS

Arjen De Vos
Founder & Director
The Salt Doctors

Yong-Gyun Park
General Manager
GS Engineering & Construction Corp. (GS E&C)

Younis Al-Rawahi
Design Engineer
BAUER Nimr LLC

Tom Walker
Costa
Energy Optimization Specialist
SOHAR Port & Freezone

Remco Dost
Senior Project Manager
eLEAF

Mohamed Dawoud
Manager
Environment Agency Abu Dhabi

Thomas Andersson
Director
Qualies, Oman

Madan Iyengar
Chief Technical Officer
Noxall

Poolad Karimi
Senior Lecturer/Researcher
IHE Delft Institute for Water Education
Water for Agriculture: Challenges & Needs in Oman

- Dr. Hamed Suliman Al-Thuhli, Director of Irrigation and Agriculture Lands, Ministry of Agriculture and Fisheries Wealth
- Mr. Saed Al-Kharusi, Chairman, Omani Agriculture Association
- Dr. Salim Al-Mamary, Oman Water Society
- Eng. Saqr Al Amri, Section Head of irrigation, Water and Sewage. Royal Court Affairs
- Dr. Dennis Powers, Head of Projects, The Aflaj Research Unit, University of Nizwa

Moderator: Dr. Mohammed Al Rawahi, Director of Strategic Research Programme for water research, The Research Council (TRC)
Threats to the Sustainability of Oman’s Aflaj

Dr. Dennis Powers
Aflaj Research Unit
University of Nizwa
Threat 1: Groundwater Abstraction

25% of the aflaj have dried up

Of the 75% that remain, there has been reduction in the amount of cultivated land

ARU is conducting a research project to determine changes in land use in the aflaj between 1976 and present day (2016-2019).

In one example, Falaj Sabt, cultivated land fell by 40%

But this hides an important point. The fall in cultivated land was largely prior to 2000. Between 1976 and 2004 the fall was 35%. Hence from 2004 to 2016 it was only 5%.

While there was continued fall in land use, the threat was at least to some degree alleviated by the water laws of 1990 and 2000.
Threat 2: Lack of Economic Viability

• ARU conducted a survey of wakils of 91 falaj systems throughout Oman. Several questions asked about the challenges faced. Of the 91,
  • 72% identified high on-farm (non-water) costs as a significant challenge
  • And 76% identified low prices of agricultural output as a significant challenge

• Hence profits are getting squeezed from both sides
Threat 2: Lack of Economic Viability and Economies of Scale

- I would like to suggest that one of the main sources of this lack of economic viability is a single factor; namely the small farms that characterize the aflaj.

- Small farms prevent the aflaj from experiencing economies of scale; the principle that average cost falls as production increases.

- Hence the small farms of a falaj have higher costs, and lower profits

- To test this, ARU conducted a study of one falaj.
Threat 2: Lack of Economic Viability and Economies of Scale

- This study found the average level of profits was OMR302, representing 1.7% of average annual income.
- We then considered the relationship between average costs and production.
- There is a clear negative relationship. Small farms face high costs, and lower profits.
- To understand the extent of the economies of scale, we calculated what profits would be if all farms could realize economies of scale and operate at the lowest average costs.
- We found average profits would rise to OMR 559, representing 3.1% of average annual income.
Threat 2: Lack of Economic Viability and Prices

- Apart from costs, low prices also limits profits.
- Low prices are the result of a lack of market power. Each seller’s individual production is insufficient to provide the market power.
- As a result, farmers have only one option to sell, and that is to a single wholesaler, leading to low prices.
- In our study, Khalas dates were at a price of OMR 0.650/kg. The retail price was approximately OMR 2.000/kg.
- If even half of the distance between the wholesale and retail price was closed, average profits would rise to OMR 973, equating to 5.5% of family income.
Conclusions

- While the physical threats to the falaj persists, those threats have been mitigated, at least to some extent.
- The threats due a lack of economic viability remain though.
- I have argued the lack of economic viability is largely owing to the fact that falaj is characterized by small farms.
- The small farms prevent individuals from realizing economies of scale in production, and thus face higher average costs and lower profits.
- Moreover, the small farms have insufficient production to sell at a large scale to gain market power, and must therefore sell at low prices.
Recommendations

- It has been argued the economic viability of the aflaj are threatened due to the small farms that characterize the aflaj.
- The solution, in one sense, is simple; consolidate land holdings.
- In fact, since land/water is more valuable when consolidated, this is what one would expect.
- However, our survey revealed that while falaj farmers were willing to adopt new technologies and new crops, they were not willing to divest in land or water due to the heritage value.
Recommendations

- The other option to derive the benefits of consolidation of land holdings without divesting, is to create agricultural cooperatives for the aflaj.
- Cooperatives could reduce cost
- Perhaps even more importantly, a marketing cooperative could create bargaining power for falaj farmers, increasing prices and profits, and improving the economic viability.
- Further research is needed to more fully understand these issues; particularly the extent to which a marketing cooperative would increase prices.
THANK YOU!
ICT Solutions for Water Productivity in Oman

- Dr. Remco Dost, Senior Project Manager, eLEAF, The Netherlands
- Mr. Sumitava Sengupta, General Manager, Strategic Business Development, Yokogawa Middle East & Africa, Bahrain
- Dr. Poolad Karimi, Senior Researcher, IHE-Institute, The Netherlands
- Dr. Alessandro Bianciardi, Co-creator & Coordinator, Mangrove Still desalination, Hydrousa project, Italy

Moderator: Prof. Osman Abdalla, College of Science, Sultan Qaboos University
Earth Observation information services to support agricultural planning, monitoring and management

Remco Dost

Oman, 3 December, 2019
Agriculture is critical to the future

Farmers need to produce 70% more food by 2050:
- increase of land and water productivity
- expansion of arable and irrigated areas
Relation with sustainable Development Goals

**target 2.4:** Increasing agricultural productivity

**target 6.4:** Substantially increase water use efficiency

**target 15.3:** Combat desertification and achieve a land degradation neutral world

**target 17.18:** Increase the availability of high-quality, timely, and reliable data
Role of Earth Observation

- Continuous unbiased source of information
- Wide range of spatial and temporal scales
- Historical and actual global information
- Monitor the baseline, status and trends
- Input for tooling / applications
EO can contribute to M&E

- Accountability (ie. monitoring land degradation, productivity)
- Operational management (ie. quantifying trends to improve performance)
- Strategic management (ie. evaluating project impact)
- Capacity building (ie. provide tooling to boost capacity and self reliance)
ICT applications
Provincial water productivity Niger

Actual evapotranspiration
(mm/dry season)

Biomass production
(tons/ha/dry season)

Biomass water productivity
(kg/m³ in dry season)
Visualization yield/production performance
Irrigation advice by SMS in Sudan

Average yield increase 63%!
Water Auditing South-Africa/ Australia

• **Shows the water use from irrigation** and compares this to the water allocation

• **Gains:**
  – Monitor water use in large and/or remote area’s
  – Monitoring at a regular interval
  – Monitoring at field level
  – Monitoring is unbiased

• **Weekly updates**

• **Historic analysis possible**
THANK YOU

REMCO.DOST@ELEAF.COM

www.eLEAF.com
Established in 2000
eLEAF is a Netherlands based high-tech company with global experience offering quantitative information

Back to Panel Heading
Cutting Edge Water Technologies Showcase

Yokogawa in the water industry
Agenda

1. Corporate Profile of Yokogawa

2. Yokogawa Water Project References
1. Corporate Profile of Yokogawa
Yokogawa Group

#1 Independent Automation Company
for the energy & chemical industries

As of February 2017

KBC Advanced Technologies Limited
Yokogawa Europe
(Yokogawa Electric CIS (Russia))
Yokogawa Middle East & Africa (Bahrain)
Yokogawa China (China)
World Headquarters
Yokogawa Electric Corporation (Japan)
Yokogawa Electric Korea (Korea)
Yokogawa Electric Asia
(Yokogawa Engineering Asia (Singapore))

Yokogawa Corporation of America (USA)
Yokogawa América do Sul (Brazil)
Yokogawa Electric Korea
Yokogawa Electric CIS (Russia)

$3.45B in sales / $252M net income
114 affiliates in 59 countries
19,000 employees
4,000 project engineers 2,000 service engineers 1,200 solution consultants & software engineers 44,000 projects worldwide

Co-innovating tomorrow

© Yokogawa Electric Corporation

3rd December 2019
7 Affiliates and 23 Sales/Service Offices, 8 Engineering centers covering Middle East and Africa (66 countries) with 1,500 Employees of more than 30 Nationalities

Total FAT Facility (Middle East & Africa): - 14,000 m²
Product Portfolio – Total Control Solution

Level 3
Management & Operation Support

- Water Loss Management
- Energy Performance Optimization
- Operation Support
- Alarm Analysis
- Historian
- Asset Management
- Cyber Security

Level 2
Control & Monitoring

- DCS
- SCADA/PLC
- Safety System
- Data Acquisition
- Power Monitoring

Level 1
Sensors & Field

- Flow
- Press.
- Level
- Temp
- Analyzer
- Field Wireless
- Field Camera
2. Yokogawa Water Project References
Yokogawa covers all applications on the water supply chain with recent required solutions.
One of the TOP share companies for WTP

1000 cubic meters per day = 1 mega-liters per day
Recent Global Water Projects

**France**: Geolide, WWT (OTV)
**Spain**: San Pedro I & II, RO (Acciona)
**Canada**: Calgary, WWT (Acciona)
**USA**: Oviedo, WT
**Nicaragua**: Juigalpa, WWTP (LG-HITACH)
**Brazil**: Baixo I, IL (L-EPC)
**Peru**: Provisur, RO/MMTP (Tedagua)
**Chili**: Escondida, RO (Doosan)
**UAE**: Jubail, WWT
**Montenegro**: Podgorica, WD
**Jordan**: WAJ, WD
**Palestine**: PWA, WWT
**KSA**: Medina, WP (Sinopec)
**Bahrain**: EWA, RO
**Thailand**: MWA, WD
**Venezuela**: PWA, WD
**Korea**: K-Water, WT
**Vietnam**: Thai Binh, WWT
**Philippines**: Cebu, WD
**Indonesia**: Petanu, WT
**Australia**: Bondi, WWT

**Kuwait**: Shuwaikh, MSF
**Qatar**: Dukhan, WP
**UAE**: QEWC, RO
**S’pore**: Changi WWT
**Singapore**: PUB, AMS
**Tembusu, IND
**NZ**: Christchurch, WD
**Cambodia**: PPWSA, WD
**Philippines**: Cebu, WD
**Indonesia**: Petanu, WT
**Australia**: Bondi, WWT
Global Representative Desalination PJT Reference Map

**Spain:**
- Cabo de Gasa, RO/DCS (Acciona)
- Arucas, RO/DCS (Acciona)
- Bilbao Ceuta, RO/DCS (Acciona)
- Planta de Sureste, RO/DCS (Acciona)
- Bahia de Palma, RO/DCS (Degremont)
- Catagena, RO/DCS (Abengoa/Acciona)
- Desaladora de Catagena, RO/DCS (Abengoa)
- Almeria, RO/DCS
- Adeje Arona, RO/DCS
- Sindosa, RO/DCS
- Ceura, RO/DCS

**Morocco:**
- Agadir, RO/DCS (ABENGOA)

**Cape Verde:**
- Santiago, RO/DCS (ACIONA)

**Libya:**
- Gecoal Zuara, MED/DCS (Sidem)
- Gecoal Zawia, MED/DCS (Sidem)
- Gecoal Sussa, MED/DCS (Sidem)
- Gecoal Derna, MED/DCS (Sidem)

**Saudi Arabia:**
- Shoab SWRO Phase 1 (Doosan)
- Qunfuda 1 & 2, MED/DCS (Sasakura)
- Al Wajh, MED/DCS (Sasakura)
- Um Liuj, MED/DCS (Sasakura)
- Rabigh, MSF/DCS (Sasakura)
- Al Lith, MED/DCS (Sasakura)
- Farasan, MED/DCS (Sasakura)
- Al Jubail, MED/DCS (Sasakura)
- BAPCO, MSF/DCS (Jhonson)
- Ma’aden, MSF/DCS (Hanwha)
- Makka Taif, MSF/DCS (MHI)
- Jubail 1-6, MED/DCS (Olayan Descon)
- Al-khafji 1-2, MSF/DCS (MES)
- Marafique 4, RO/DCS (PCMC)
- Yanbu 3, MSF/Analyzer (Doosan)
- Rabigh 2, MSF/Analyzer (Doosan)
- Jeddah 3, RO/Analyzer (Doosan)

**Chile:**
- Escondida, RO/Analyzer (Doosan)

**Peru:**
- Provisur, RO/DCS & STARDOM (Tedagua)

**Algeria:**
- Rhourde EL, MED/DCS (UTE)
- Kahrama, MED/DCS (IHI)
- Beni Saf, RO/DCS (Tedagua)
- Skikda, RO/DCS (Abeinsa)

**Iraq:**
- Basrah, RO/SCADA (Hitachi/OTV)

**Kuwait:**
- Az Zour South, RO/DCS (Sidem)
- Az Zour 1-8, MSF/DCS (MHI)
- Shuwaikh, MED/DCS
- Kuwait Oil, MED/DCS (Sumitomo)
- Doha West SWRO Phase 1, RO (DOOSAN)

**Bahrain:**
- Ras Abu, RO/DCS (Sasakura)
- Ad Dur, RO/DCS (Weigher Westgrath)

**UAE:**
- Jebel Ali Station K, RO/DCS (ACCCIONA)

**Qatar:**
- Ras Abu A2, RO (Hitz/ToyoThai/MHI)
- Ras Abu A3, RO/DCS (Acciona)
- Um Al Houl, RO/DCS (Acciona)
- Doha West SWRO Phase 1, RO (DOOSAN)

**Oman:**
- Sharqiyah IWP RO/DCS (DOOSAN)
- Al-Ghbra 1-2, RO/DCS (Hitz)
- Al-Ghbra 3-4, RO/DCS (Hitz)
- Ad Dur, RO/DCS (Degremont)

**Singapore:**
- Tuas, RO/SCADA (Hydochem)
- Pulau Seraya, RO/SCADA (CH2MHILL)
- TMUC, RO/DCS (Marubeni)

**Australia:**
- South Seawater 2, RO/Analyzer (Valoriza)

**As of Mar. 2019**
Yokogawa direction to “Smart City Infrastructure”

Current portfolio

Billing System by Kalki Tech

DDMO Energy Saving for WWTP

Advanced solutions for optimization

Smart city Infrastructure

Digital Twin (OMEGA Simulator)

IIOT (AMS)

Mission-critical system that is not allowed to stop

• Monitoring control system (DCS)
• Production management system (PMS, MES, LIMS)

Flexible system that allows trial and error

• Wireless sensor · Information from temporary sensor
• Integrated DB (Big Data)
• Analysis and support system

OT

Secure Network

High Reliability Sensor (Permanent use)

Low cost, diverse sensor group (Temporary)

IT

Operational Technology

Industrial IoT

Effluent COD

Effluent NH₄

Blower power consumption

25.1%

Cut

Original unit

4,627 kw/d

3,470 kw/d

24.7%

Cut

0.130 kw/m³

0.098 kw/m³

Statutory limits

50 mg/l

47 mg/l

1.09 mg/l

1.33 mg/l

Statutory limits

5 mg/l

Before

After
MANGROVE TECHNOLOGY PLATFORM

Cutting-Edge Water Technologies Showcase Water for Agriculture 2-4/12/19 - Muscat
WHAT THE MTP DOES

A cost effective, nature inspired system able to kick start regenerative reforestation and agroforestry projects in arid lands aiming at carbon neutrality

We produce freshwater and salt from sea-brackish water/brine

We kick start reforestation while regenerating the soil

We gather data to optimize the production parameters
THE NATURE-INSPIRED TECHNOLOGY

- Desalination units
- Organic incubators
- IoT devices
DESALINATION UNIT

The *cascade-wick solar still* consists on a polymeric thermoformed component of 1 m².

The current design is able to produce 3.9 – 4.1 l/m²/d using regular seawater as input.

- **Passive**
- **Modular**
- **Conceived to be build with easily available materials**
HYDROUSA

- Aims to provide innovative solutions for Mediterranean islands in terms of water/wastewater treatment and management, which will close the water loops and will also boost their agricultural and energy profile.

- Water loops will include water from non-conventional sources including wastewater, rainwater, seawater, groundwater and vapour water, all resulting in recovered and marketable products.

- Technologies demonstrated in three Mediterranean islands (Lesvos, Mykonos and Tinos) and transferability assessed in 25 early adopter cases.

- The project is led and coordinated by National Technical University of Athens, (NTUA). 27 partners including Universities, SMEs, research centres, municipalities

EU funded H2020
THANK YOU!

Alessandro Bianciardi
a.bianciardi@wemimic.it
Non-conventional Water Resources for Agriculture in Oman

- Dr. Saada Al-Shukaili, Head of Water Management, Middle East Produced Water Advisory Board member, Petroleum Development Oman (PDO)
- Prof. Mushtaque Ahmed, College of Agricultural and Marine Sciences, Sultan Qaboos University (Non-conventional Water Resources for Agriculture in Oman: What Needs to be Done)
- Mr. Tomas Walker Costa, Energy Specialist, Sohar Port
- Dr. Thomas Andersson, Senior Advisor, Organisation for Quality and Innovation Strategies, Oman (Presentation: Ecosystem Restoration Using Water-Saving Technologies - A Comprehensive Approach)
- Dr. Slim Zekri, College of Agricultural and Marine Sciences, Sultan Qaboos University

Moderator: Dr. Salim Al-Mamary, Planning and Projects Manager, Majis
PDO Produced Water Re-use in Agriculture

By
Saada Al-Shukaili
Area ~ 10 Km²
Nimr Water Treatment Plant

- Total treated PW~150 Km3/d
- Treatment performance: <0.5 ppm OiW
- Spread greening: 10.5km2
- Increased Biodiversity and Habitat: 120 bird, 2 fish species recorded

Source: from Bauer Nimr LLC
Bio-Saline Agriculture using Water from Nimr Reedbeds

Key Objective:
• Study re-use of wetland treated produce water for irrigation of salt tolerant plant species
• Study flood and overhead irrigation (bubbler, sprinkler and drip irrigation)

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Common name</th>
<th>End product</th>
<th>Growth form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia nilotica</td>
<td>Acacia (Qarot)</td>
<td>Wood / honey wax</td>
<td>Perennial tree</td>
</tr>
<tr>
<td>Acacia ampliceps</td>
<td>Acacia</td>
<td>Wood / honey wax</td>
<td>Perennial tree</td>
</tr>
<tr>
<td>Casuarina equisetifolia</td>
<td>Casuarina</td>
<td>Wood / windbreak</td>
<td>Perennial tree</td>
</tr>
<tr>
<td>Conocarpus lancifolius</td>
<td>Kuwaiti tree</td>
<td>Wood / windbreak</td>
<td>Perennial tree</td>
</tr>
<tr>
<td>Eucalyptus camaldulensis</td>
<td>Red river gum</td>
<td>Wood / windbreak</td>
<td>Perennial tree</td>
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<tr>
<td>Prosopis cineraria</td>
<td>Ghaf</td>
<td>Wood</td>
<td>Perennial tree</td>
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<tr>
<td>Simmondsia chinensis</td>
<td>Jojoba</td>
<td>Wood – Oil</td>
<td>Perennial tree</td>
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<td>Distichlis spicata</td>
<td>Distichlis grass</td>
<td>Forage - landscaping</td>
<td>Grass</td>
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<tr>
<td>Passalum vaginatum</td>
<td>Salt grass</td>
<td>Forage – landscaping</td>
<td>Grass</td>
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<td>Cotton spp.</td>
<td>Cotton</td>
<td>Textile</td>
<td>Annual</td>
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<td>Brassica napus</td>
<td>Canola</td>
<td>Oil – Biofuel</td>
<td>Annual</td>
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<tr>
<td>Cyamopsis tetragonoloba</td>
<td>Guar</td>
<td>Guar gum</td>
<td>Annual</td>
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<tr>
<td>Ricinus communis</td>
<td>Castor</td>
<td>Oil – Biofuel</td>
<td>Annual</td>
</tr>
<tr>
<td>Salicornia bigelovii</td>
<td>Dwarf Saltwort</td>
<td>Oil – Biofuel</td>
<td>Annual</td>
</tr>
</tbody>
</table>

1Tree added to the project on G5

Perennial, Annual Plant Species and Grasses Trialed
• 13 original species
• One added mid-way
Bio-Saline Agriculture using Water from Nimr Reedbeds

- **Eucalyptus Camaldulensis** (Red River Gum)
- **Acacia Nilotica** (Qarat)
- **Conocarpus Lancifolius** (Kuwaiti Tree)
- **Gossypium Arboreum** (Cotton)
A new environmental friendly Sewage Treatment Plant (STP) is constructed for the Yibal Camp.

It provides habitation and biodiversity values, and enhance Green profile of the Company.

No chemicals required for the treatment process. This contribute a positive impact to the environment.

STP uses various species of plants which will have a good impact to the environment by increasing the plants within the camp area.

No chemicals required for the treatment process. This contribute a positive impact to the environment.

Few equipments were needed which supports to reduce the maintenance cost and lesser spare parts needed (saving of approx 10% Opex).
Non-conventional Water Resources for Agriculture in Oman: What Needs to be Done

Mushtaque Ahmed, Ph.D.
Professor, Sultan Qaboos University
Email: ahmeddm@squ.edu.om
Non-conventional Water for Agriculture

- Treated wastewater
- Greywater
- Oil-production water
- Artificial rain
- Virtual water!
- Desalination
<table>
<thead>
<tr>
<th>Year</th>
<th>Water demand (Mm3)</th>
<th>Water supply (Mm3)</th>
<th>Deficit (Mm3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agricultural demand</td>
<td>Municipal demand</td>
<td>Total demand</td>
</tr>
<tr>
<td>1990</td>
<td>1152</td>
<td>73</td>
<td>1225</td>
</tr>
<tr>
<td>1995</td>
<td>1152</td>
<td>156</td>
<td>1308</td>
</tr>
<tr>
<td>2000</td>
<td>1150</td>
<td>185</td>
<td>1435</td>
</tr>
<tr>
<td>2011</td>
<td>1546</td>
<td>235</td>
<td>1781</td>
</tr>
</tbody>
</table>
Treated Wastewater in Oman

- More than 400 WWT plants in Oman
- Produced by: government; private sector; individual owners
- Haya is the biggest producer (65,000 m³/day in 2010 which will rise to 201,000 m³/day in 2025)
- Total production 37 Mm³ (2005); Expected to be 100 Mm³ in (2025)
- Potential reuse: Urban applications; Irrigation; Wetland; Industrial; Aquifer recharge; Potable water (?)
Case Study on Treated Wastewater Reuse

- Daily treated wastewater available: 40,000 m³/day
- Selected crops: Wheat, Cowpea, Maize
- Irrigation to be done conjunctively (mixed with fresh groundwater)
- Irrigation all year round
- Total cropped area: 3800 ha
- Total water (14 Mm³ TWW, GW 10.3 Mm³)
- Cost Benefit Analysis: Not done yet
- Costs: Transport costs, cost of treated wastewater, cost of pumping, cost of seeds, fertilizers, pesticides
- Benefits: extra production
Greywater Reuse

- Defn: wastewater from domestic appliances and fittings with the exception of that from WCs and bidets (in Oman 80% (?) of domestic water is greywater)
- Reduces demand for freshwater
- Reduces amount of wastewater entering sewer or septic systems
- Reduction in the threat of groundwater pollution
- Household units can easily save 1 m3/day
- 20,000 households will save 20,000 m3/day (one less large desalination plant)
Greywater Treatment System

A: Sand Trap
B: WW Storage
C: TW Storage
D: Sand + Carbon Filter
E: Chlorine dosing pump
F: Submersible pump
G: Submersible pump

* Detention
* Aeration
* Filtration
* Chlorination
Greywater Economics

- 388,000 water connections in Oman
- 20,000 greywater units producing 1 m³/daily each, total 20,000 m³/day
- Cost @ 600 OR each.
- 12 Million OR (50% Govt Subsidy, 6 Million OR)
- GHG Emission saved 4 kg/m³ of desalinated water
- 80,000 kg/daily, 29,000 tons/yr
- Cost savings by not building desalination plant (capital cost) 6 Million OR???, No O & M cost
What Needs to be Done?

• Regulations especially for greywater
• Incentives
• Make it available
• Education & Extension
Artificial Rain: Is it a Non-conventional Resource?

• Summer season on the eastern and western Hajar mountain range and Dhofar mountain range by fixed earth stations operating by spreading ions to facilitate the incorporation of raindrops

• The project composed of 12 ground stations, were distributed on the mountain range of East and West of Hajar mountain range, 628 rainfall network monitoring stations and 2 wind analysis station

• The results indicates an estimated average rate of 18% enhanced rain during the period of operation
Oil Production Water: Resource or Headache?

• Low cost treatment, use of constructed wetlands
• Nimr reedbed system (100,000 m$^3$/day treatment using constructed wetlands)
• Reuse: salt production, biosaline agriculture, greening the desert, agroforestry, aquaculture, biofuel, carbon credit, energy savings!!
• Use of ceramic membranes is a promising technology
• Regulations need to be formulated based on science and international experiences
Virtual Water!

- 2017 study shows 11.6 MCM net water exported through low quality dates
- Economically makes no sense!
- Alfalfa export also results in virtual water export
- What do we do with the saved water?
- Social issues?
## Virtual water content

<table>
<thead>
<tr>
<th>Crop</th>
<th>Import Quantity [t]</th>
<th>Import unit/value [OMR/t]</th>
<th>Export Quantity [t]</th>
<th>Export unit/value [OMR/t]</th>
<th>% of produced exported</th>
<th>VW\textsubscript{exp} [m$^3$]</th>
<th>VW\textsubscript{imp} [m$^3$]</th>
<th>NVW [m$^3$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dates</td>
<td>10,612</td>
<td>425</td>
<td>14,825</td>
<td>295</td>
<td>1.36</td>
<td>41 Million</td>
<td>29 Million</td>
<td>11.6 Million</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>9,807</td>
<td>131</td>
<td>56,050</td>
<td>63</td>
<td>19.67</td>
<td>19 Million</td>
<td>3.3 Million</td>
<td>15.7 Million</td>
</tr>
</tbody>
</table>
Desalination for Agriculture

- Simple to operate
- Cost of energy is a challenge
  - Could be reduced due to regulated seasonal requirements
  - Advancement in technology could reduce energy requirements
  - Cost is coming down significantly
  - Potential for use of renewable energy

Energy consumption and desalination costs in Spain [FAO, 2003]
Major Findings on the Extent of Use of Desalination in Oman

- More than 1,000 small desalination plants in Omani farms
- Oman plants are small, 10-50 m3/day capacity; salinity limit 10,000 mg/L; low value crops are irrigated (3-6,000 OR/unit)
- Energy source is normal power grid; brine disposal is the main constraint
- Amounts and quality of produced water of international standards
- Reject water is about 50-60% of intake
- Means of disposal of brine: dumping on soil surface, into soil pits, or abandoned wells
- Water used for irrigating field crops; i.e., most have no greenhouses
- Some farmers mentioned that they stop running the units to allow time for water to infiltrate into subsurface
- All farmers do not have permit from any governmental agency
What Needs to be Done in Small-scale Desalination Use in Omani Agriculture

• Allow only for Controlled Environment Agriculture
• Allow only for high value crops
• Must have brine management facilities
• Promote use of renewable energy
• Only allow units that have high production rate (e.g. 80%)
• Specify target Water Use Efficiencies based on global experiences
Take Home Messages on Non-conventional Water Use for Agriculture

• Water supply for agriculture can be increased thru non-conventional resources
• These resources can be made economically and environmentally sustainable under certain conditions even for small units
• Focus should not only be on using non-conventional resources/technology but also reduce the demand thru water conservation practices in agriculture
• Great prospect of using renewable energy in controlled environment agriculture
• Government has a large role to play in bringing about change
Sohar Port and Freezone

Strawberry challenge – A Catalyst for the future
Global success story

- Over US$26 billion invested to-date
- Investments from China, India, Brazil, GCC and Europe
- One of world’s fastest growing Port and Freezone developments
SOHAR Port and Freezone

- 50:50 JV between Oman Government and Port of Rotterdam
- First ships docked in 2004
- Adjacent Freezone added in 2010
Port and Freezone management model

- Port and Freezone authorities act as landlords
- Landlord provides infrastructure at high international standards
- Private businesses operate as tenants on long land-Leases
Regional first

- Dedicated agro terminal is regional first, with knowhow from Rotterdam
- 500 tonnes/day flourmill under construction; new sugar refinery; storage for vegetable oils, grains and other staples
- Downstream food manufacturing, processing, packaging and logistics
Regional dependency

- GGC imports 80% of its food requirements
- Sohar is the main import hub for food products for Oman.
- Lack of suitable land and water scarcity limit agricultural production
  - 62,000 Ha of cropped land in Oman
  - 256,000 recorded farmers
  - Harsh climate limits production output
Trade deficit in Fuit and Vegetables

Regional Fruit and Vegetable Market – Trade Surplus/Deficit:

<table>
<thead>
<tr>
<th>Country</th>
<th>Deficit in USDm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morocco</td>
<td>-937.0</td>
</tr>
<tr>
<td>Israel</td>
<td>782.0</td>
</tr>
<tr>
<td>Syria</td>
<td>774.0</td>
</tr>
<tr>
<td>Egypt</td>
<td>251.0</td>
</tr>
<tr>
<td>Jordan</td>
<td>222.0</td>
</tr>
<tr>
<td>Tunisia</td>
<td>147.0</td>
</tr>
<tr>
<td>Palestine</td>
<td>53.0</td>
</tr>
<tr>
<td>Sudan</td>
<td>(74.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>(89.0)</td>
</tr>
<tr>
<td>Yemen</td>
<td>(91.0)</td>
</tr>
<tr>
<td>Bahrain</td>
<td>(95.0)</td>
</tr>
<tr>
<td>Qatar</td>
<td>(162.0)</td>
</tr>
<tr>
<td>Libya</td>
<td>(174.0)</td>
</tr>
<tr>
<td>Oman</td>
<td>(210.0)</td>
</tr>
<tr>
<td>Kuwait</td>
<td>(266.0)</td>
</tr>
<tr>
<td>Iraq</td>
<td>(332.0)</td>
</tr>
<tr>
<td>Algeria</td>
<td>(456.0)</td>
</tr>
<tr>
<td>S. Arabia</td>
<td>(925.0)</td>
</tr>
<tr>
<td>UAE</td>
<td>(1,197.0)</td>
</tr>
<tr>
<td>Region total</td>
<td>(2,877.0)</td>
</tr>
<tr>
<td>GCC total</td>
<td>(1,033.0)</td>
</tr>
</tbody>
</table>
Al Batinah region

- Al Batinah Region has historically been the food basket for Oman
  - Strong tradition in farming
  - Fruits and vegetables produced for Oman and GCC
- Dominated by traditional agriculture
  - Fully dependent on irrigation
    - At risk due to sea water contamination of ground water
  - Labor intensive
  - Low production yield
- High potential for modernization
  - Knowledge remains a missing link
High-tech greenhouses

- What are greenhouses
  - A greenhouse is a building that controls temperature, humidity and light in an effort to increase crop output.

- Why greenhouses
  - Green houses are a means to create a large volume of crops.
  - More efficient use of water and other resources
  - Farmers grow crops more efficiently, using less man power, obtaining better returns
Best practices significantly reduce the consumption of water and space, while optimizing yield production.

- Two critical resources in Oman.
Sohar Port and Freezone

Strawberry challenge – A Catalyst for the future
Introducing the Strawberry Challenge

- International competition between universities

- Five teams will compete during one whole year to design, build and operate a fully sustainable greenhouse

- Each team will receive:
  - One container
  - Solar power
  - Strawberry plants
  - UV lights
  - Limited capex
Introducing the Strawberry Challenge

- **Objective of the competition**
  - Knowledge development
  - Increase awareness of sustainability
  - Promote high-tech farming
  - Set the foundation for future projects
  - Promote Sohar Region as an agricultural hub in the region
  - Pave the way for SME’s to develop a new sector

- **Objective for the students**
  - Grow the largest number and tastiest strawberries
  - Develop knowledge of complex systems
Introducing the Strawberry Challenge

- Duration: Year 2020
  - Three months to Design / Apply
  - Three months to Build
  - Six months to Grow

- Potential for active sponsoring and partnerships:
  - Financial support through:
    - Sponsor the event
    - Support a team (Ex: Your company/Uni team)
    - Create an award
  - Value in kind support through:
    - Solar panels; materials, plants, services and support
Sohar Port and Freezone

Strawberry challenge – A Catalyst for the future

In partnership with

Embassy of the Kingdom of Netherlands

Sohar University
Ecosystem Restoration Using Water-Saving Technologies - A Comprehensive Approach
Dhofar fog forest

Landsat TM Image Bands742 of Dhofar Mountains
The relationship between the monsoon, Mountain vegetation's, the fogwater interception, landforms and the recharge of the Salalah plain aquifer in a profile from the mountain to the sea.
Project steps

- **Assessment** of land, soil, (native) species, saplings, seeds availability, logistics, add-ons, fencing
- Prepare **project plan, organisation, optimisation, division of labour, knowledge transfer**
- **Arrangement of logistics-equipment, land preparation**, hiring, procurement
- Monitoring, custodial management, data collection and processing, smart sensors – IoT
- **Community engagement**, traditional, schools, web – social media, App
- Seeds collection, **nursery** capacity, germination
- Incorporation in **carbon credit project**
- **Scaling** plantations, monitoring, custodial management
Social Media

Website
### Performances across tree species, 5-8 months after plantation

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Arabic Name</th>
<th>English / Common name</th>
<th>Planted by April 30th 2019</th>
<th>Survived % Latest, Nov 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bosvellia Sacra</td>
<td>Luban</td>
<td>Frankincense Tree</td>
<td>145</td>
<td>98</td>
</tr>
<tr>
<td>Ziziphus Spina Christi</td>
<td>Sidr</td>
<td>Sidr Apple Tree</td>
<td>23</td>
<td>63.2</td>
</tr>
<tr>
<td>Tamarindus Indica</td>
<td>Subar / Tamar Hindi</td>
<td>Tamarind Tree</td>
<td>103</td>
<td>98.1</td>
</tr>
<tr>
<td>Acacia Nilotica</td>
<td>Al Qart / Qerat</td>
<td>Acacia</td>
<td>236</td>
<td>92.8</td>
</tr>
<tr>
<td>Acacia Gerardii</td>
<td>Tulh / Talahh</td>
<td>Acacia</td>
<td>69</td>
<td>97.1</td>
</tr>
<tr>
<td>Acacia Senegal</td>
<td>Qataba / Thur</td>
<td>Acacia</td>
<td>164</td>
<td>97.6</td>
</tr>
<tr>
<td>Commiphora Habessimica</td>
<td></td>
<td></td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>761</td>
<td><strong>Survived (%)</strong></td>
<td></td>
<td>92.8</td>
</tr>
</tbody>
</table>
The Future of Water and Humanity

- Combatting Global Warming, Desertification and Dust Storms
- Plantation with Water-Saving Technologies and Carbon Credit Projects
- Value of Ecosystems: Oceans, Wetlands and Eco-tourism
- Decentralised Technologies in Water Management
- Industry, Produced Water and Treatment Solutions
- Sustainable Infrastructure and Logistics
- Innovation, Entrepreneurship and Leadership
- NBS, IoT and Quality of Life in the Urban Environment
- Chemicals and Health Hazards
- Youth Workshops on Valuing Water
- Leveraging Cultural Assets

Climate Change, Water Cycles and Ecosystems

History, Diplomacy and the Future

Quality of Life, Health and Leadership
Salinity & Sea Intrusions Challenges: Solutions for Omani Farmers

  (Presentation: Monitoring of Salinity Changes in Batinah Coastal Aquifers)
- Dr. Ahmed Al Boussaidi, Associate Professor, Sultan Qaboos University (Presentation: Plant Growth Promoting Rhizobacteria and Enriched Compost to enhance Growth of Crops under Saline Condition)
- Dr. Arjen de Vos, Founder & Director, The Salt Doctors, The Netherlands
- Dr. Mohamed Dawoud, Manager, Water Resources Department, Environment Agency – Abu Dhabi, UAE
- Dr. Abdulrahim Al-Ismaili, Associate Professor, Sultan Qaboos University

Moderator: Dr. Chris Moody, Science and Technology Advisor, Ministry of Foreign Affairs
Monitoring of Salinity Changes in Batinah Coastal Aquifers (1982-2016)
Outlines

• Introduction
• Salinity surveys and studies
• Water Quality
• Seawater intrusion in Al Batinah Coast
  — Study Area
  — Results
• Seawater intrusion in Salalah plain
  — Study Area
  — Results
• Measures to Reduce The Deterioration of Groundwater Quality
• Recommendations
Introduction

- Groundwater is the primary source of fresh water in coastal areas, especially in dry and semi-arid areas.
- Groundwater represents (78%) of water supply in Oman (digging wells, building Aflaj, installing pumps).
- The growing population and rapid development led to increased demand for fresh water and therefore over pumping causing seawater intrusion.
- Within the framework of efforts of (MRMWR) to protect water resources and development, the salinity of groundwater measurements are monitored periodically.
Salinity Surveys and Studies

• **1982 - 1985:** General Authority for Water Resources conducted a study through the collection and analysis of salinity data from wells located in the coast of Batinah.
  - The results were published in three reports during the years 1983, 1984, 1985.
  - The reports identified six water quality levels based on the viability of this water for drinking and agriculture purposes.

• **Since 1989:** Ministry of Water Resources started conducting field surveys of groundwater samples every two years covering the period (1989-1997).

• **1992-1993:** The Ministry of Water Resources (MWR) undertook three extensive surveys, covering the entire Salalah coast over the period 1992 to 1993.

• **since 1995 :** Salinity data were used to monitor and detect the groundwater quality and deterioration.

• **2000 - present:** Salinity reports are issued every five years: 2005, 2010 and 2016 and compared with all results since 1983.

Studies contribute greatly to highlight the riskiness of saltwater intrusion, as well as focusing on areas that have experienced improvement or deterioration in groundwater quality.
Water Quality Levels for Electrical Conductivity (Salinity):

- Fresh Water: $< 2000 \mu s/cm$
- Low salinity: $2000 - 6000 \mu s/cm$
- Moderate salinity: $6000 - 10000 \mu s/cm$
- High salinity: $10000 - 16000 \mu s/cm$
- Very high salinity: $> 16000 \mu s/cm$
# Seawater Intrusion in Al Batinah

<table>
<thead>
<tr>
<th>Al Batinah located on the northern part of Al Hajar As Sharqi mountain.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area 14,621 km²</td>
</tr>
<tr>
<td>50% of the total agriculture production is coming from Al Batinah.</td>
</tr>
<tr>
<td>The groundwater of Al Batinah represents more than 90% of the available water resources used for agricultural purposes.</td>
</tr>
</tbody>
</table>
### Study Area

**Length = 270 km**  
**Width = 5 - 10 km**  
**Area = 3000 km² (21%)**  
**29 catchments**

---

#### South Al Batinah Area

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Area (km²)</th>
<th>Wells No</th>
<th>Samples No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taww</td>
<td>114.6</td>
<td>64</td>
<td>43</td>
</tr>
<tr>
<td>Maawil</td>
<td>169.2</td>
<td>69</td>
<td>67</td>
</tr>
<tr>
<td>Bani Kharous</td>
<td>93.7</td>
<td>64</td>
<td>55</td>
</tr>
<tr>
<td>Faraa</td>
<td>82</td>
<td>68</td>
<td>58</td>
</tr>
</tbody>
</table>
Results – Al Batinah Coast

- 43% of wells EC is less than 6000 s/cm
  - 15% (141) of wells EC is less than 2000 s/cm

- 57% of wells EC is more than 6000 s/cm
  - 15% (144) of wells EC is more than 16000 s/cm

The number of wells where EC exceeded more than 10,000 s/cm is constantly increasing (40%) in 2016, compared to 20% in 2010 and only 7% in 2005.
Results – Al Batinah Coast

Salinity Increased by 65 % in (510) Wells.

Groundwater salinity improved by 17 % in (455) wells.
Results – Al Batinah Coast

Highest EC value ($\mu$s/cm) in Wadi Ahen in Wilayat of Saham in the North Batinah Region and the water level of the well was less than five meters.

Lowest EC value ($\mu$s/cm) in Wadi Al-Mayham-Al-Mabharh-Al-Hager in Wilayat Al-Suwaiq in the North Al Batinah Region and the water level was well (32.5 m).
The quality of groundwater improved significantly during 2016 in wadi Al Hayl, Al Khoadh, Russil and Aiden.

- Water quality has deteriorated in Wadi Manouma, where freshwater has decreased by 22% and saline water has increased by more than 16,000 μs/cm by 6%.

- Fresh water has reduced by half and salt water has increased by double over the last six years in Wadi Al-Mabaila.

Salinity of water in the coast of Al Batinah 2016 - the area of Seeb
Salinity Changes in Ground Water - Seeb

Wadi Al Khoadh

Wadi Russail

Wadi Manouma

Wadi Maabila

EC (US/cm)

> 2,000

- 2,000

- 6,000

- 10,000

<16,000
Results – Al Batinah Coast

- Water quality has deteriorated significantly over the last six years:
  - Wadi Al-Taw, Wadi Bani Kharous and Wadi Al-Faraa. High salinity water gained more than 10,000 μs/cm by 8%, 14% and 5%.
- There is a slight improvement in Wadi Al-Ma'awel catchment, where there is an increase in the area of fresh water (blue) during the year 2016 by 9%.

In general, the coastal areas between the Barka-Musanaa are still among the areas most affected by saline water intrusion.
Salinity Changes in Ground Water – South Batinah

Wadi Maawil

Wadi Al Faraa

Wadi Bani Karous

Wadi Taw

EC (US/cm)

> 2,000

- 2,000 6,000

- 6,000 10,000

- 10,000 16,000

<16,000
North Al Batinah Area

• The quality of ground water in the area between Musanaa-Al-Suwaiq and Wadi Bani Ghafir has deteriorated.

• The area of high salinity water increased by more than 10,000 μs/cm in the area of Al-Khaburah in the Mashin, Hawasina, and Shafan.

• The coastal parts between Wilayat Sohar and Shinas have deteriorated in the quality of groundwater, such as the Wadi al-Jizi, Wadi Suq, Wadi Faydh, Wadi al-Qawr and Wadi Huraym.
Results – Al Batinah Coast

North Al Batinah Area

• The quality of groundwater has improved in coastal areas, which included the catchments of the Wadi al-Sarmi, the Wadi Sakhin and Wadi Ahin.

• The quality of the water has improved in Wadi Hilti-Salahi and in some the catchments such Bani Omar al-Gharbi, al-Badi'a and Rajama, and Wadi Hatta.
Salinity Changes in Ground Water – North Batinah

**EC (US/cm)**
- > 2,000
- 2,000 - 6,000
- 6,000 - 10,000
- 10,000 - 16,000
- < 16,000
Measures to Reduce the Deterioration of Groundwater Quality

- **Construction of recharge dams**: 15 dams in Al Batinah area

- **Water Resources Development**:
  - Study of the effect of weed plantations on groundwater
  - Putting foundations for determining water quotas for different sectors

- **Water Consumption Guidelines**:
  - Prohibiting digging new farm wells
  - Prohibiting digging new individual wells for other uses
  - Monitoring pumping quantity from wells

- **Monitoring Water Situation**:
  - Updating Water Resources Network
  - Continue Surveying and Monitoring Salinity
Recommendations

- Implementation of the principles of integrated water resource management in all watersheds and involve water users in the preparation and implementation of these principles and concepts.
- Continue to implement the procedures of changing the existing irrigation systems to modern irrigation systems to reduce the loss of irrigation water and the waste of water resources.
- Reuse of treated water, especially for agricultural purposes.
- Change the cropping pattern to prevent wasting water.
- Continue to monitor changes in groundwater salinity to assess the impact of these measures on the improvement of the water situation.
Thank you for listening..

Acknowledgements:

Ministry of Regional Municipalities and Water Resources

OMAN WATER SOCIETY

MEDRC
Plant Growth Promoting Rhizobacteria and Enriched Compost to Enhance Growth of Crops under Saline Condition

Ahmed Al-Busaidi and Mushtaque Ahmed

Department of Soils, Water and Agricultural Engineering, College of Agricultural & Marine Sciences, Sultan Qaboos University, Muscat, Oman

ahmed99@squ.edu.om
*Arid Country with annual rainfall of 100 mm
* Annual Evaporation 7,714 MCM
* Groundwater is the main source of water

Soil Suitability of the Sultanate

- S1 - most suitable
- S2 - marginally suitable
- NS - non-suitable

- 92.93% (29,204,610 ha)
- 2.52% (792,000 ha)
- 4.55% (1,430,000 ha)

Total area = 31,426,466 ha

Annual Mean Temperature

- -40°C to 30°C
- -40°F to 80°F
Challenge 1: Water Shortage

Plant Stresses: Drought
Seawater Intrusion (over pumping)

Salt Affected Area of Oman = 44.18%
Challenge 2: Soil Salinity
Municipal Wastes Management

3R Approach

“3R” Approach from Solid Waste Management Applied to Wastewater Treatment and Reuse

Reduce

Reuse

Recycle
Option 1: Treated Wastewater
Treated Wastewater Application
## Treated Wastewater outside Muscat

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Production (m³/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>38,861</td>
</tr>
<tr>
<td>2020</td>
<td>69,129</td>
</tr>
<tr>
<td>2025</td>
<td>353,998</td>
</tr>
<tr>
<td>2030</td>
<td>537,773</td>
</tr>
<tr>
<td>2035</td>
<td>572,137</td>
</tr>
<tr>
<td>2040</td>
<td>664,706</td>
</tr>
</tbody>
</table>

### DID YOU KNOW?
You would have to flush your toilet around six million times to generate the same volume of wastewater that the city's two treatment plants receive every day.
Option 2: Municipal Wastes Management
Solid Waste Converted to Compost
Option 3: Soil Microbes
Soil-Water-Plant (Bio-Compost)
Soil-Water-Plant (Stimpo and regoplant)
Objectives

• Evaluate all three options (TWW, Recycled Compost, Soil Microbes) in improving plant growth

Methodology

• Bacteria were isolated from saline soils.
• The best bacteria that gave better growth in saline media were selected.

• The best two bacteria were reproduced and used for field trials.

• They were compared with two bio-stimulants (Stimpo and regoplan) and grown in three different composts.
Greenhouse
Fresh & Saline (TWW) Waters

Radish and Okra plants

Animal Manure (M)
Composted Plant Res. (G)
Animal + Plant (K)
Soil Salinity (dS/m)

Fresh water

Treated saline water

Are they Toxic Salts or Useful Elements (Nutrients)?

EC (mS/cm)
Sodium Adsorption Ratio (SAR) = Na/(Ca+Mg)

Toxic Salt (Na) in each Compost

<table>
<thead>
<tr>
<th></th>
<th>Fresh</th>
<th>Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
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<tr>
<td>M</td>
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<tr>
<td>G</td>
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</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zn</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>-----</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td>Fresh</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>BS</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Reg</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>CN</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>BS</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>Reg</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>CN</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>0.72</td>
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<tr>
<td></td>
<td>B2</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>BS</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>Reg</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>CN</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>1.86</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>BS</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>Reg</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>CN</td>
<td>0.89</td>
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<tr>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>BS</td>
<td>0.29</td>
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<tr>
<td></td>
<td>Reg</td>
<td>0.70</td>
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<tr>
<td></td>
<td>CN</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>BS</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Reg</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>CN</td>
<td>0.47</td>
</tr>
</tbody>
</table>

**Treated**
Higher values with (K) Supplying more Nitrogen
Radish Chlorophyll Content

G compost

K compost with soil Bacteria
Compost with Water Quality

Fresh water

Treated saline water
Highest Production
Even under saline condition
Supporting bacteria growth
Highest Production

Natural Bacteria was the best
Elements Concentrations (Radish)

<table>
<thead>
<tr>
<th>Elements</th>
<th>Zn</th>
<th>Cu</th>
<th>Cr</th>
<th>Cd</th>
<th>Pb</th>
<th>Ni</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-400</td>
<td>5.0-20</td>
<td>0.03-14</td>
<td>0.1-2.4</td>
<td>0.2-20</td>
<td>0.02-5</td>
<td>-</td>
</tr>
</tbody>
</table>

![Graph showing concentrations of elements in radish]
## Elements Concentrations (Okra)

<table>
<thead>
<tr>
<th>Element</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>1-400</td>
</tr>
<tr>
<td>Cu</td>
<td>5.0-20</td>
</tr>
<tr>
<td>Cr</td>
<td>0.03-14</td>
</tr>
<tr>
<td>Cd</td>
<td>0.1-2.4</td>
</tr>
<tr>
<td>Pb</td>
<td>0.2-20</td>
</tr>
<tr>
<td>Ni</td>
<td>0.02-5</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
</tr>
</tbody>
</table>

![Graph showing concentrations of various elements in Okra](chart.png)
Conclusion

- Application of different composts and bacteria had a role in supporting plant growth and its productivity.
- For the composts application, it was found that mix compost (plant & animal, K) was the best compost in creating good environment for plant growth by providing more water and nutrients in root zones compared to M and G composts.
- In addition, it was enhancing bacteria growth by providing almost all needed parameters for better bacteria growth.
- However, the study should be repeated so clear conclusion can be achieved.
Second Experiment (In Progress)

Thank You

back to Panel 4
Do you always need fresh water and non-saline soils for crop production?

Are there varieties of conventional crops that can be used for cultivation under saline conditions?
Open-air lab for selection trials and crop salt tolerance

800 varieties of 50 different crops tested

More tolerant and robust varieties of potato, carrot, beetroot, chard, cauliflower, cabbage, lettuce,...
Saline agriculture takes a system approach

Combination of water/soil/crop management and various socio-economic factors

- climatic conditions (temperature, rainfall,...)
- soil (salinity, structure, pH, fertility, tillage,...)
- water (salinity, storage, irrigation, drainage...)

**crop** (salt tolerant, yield, market, cultivation,...)

- input materials (seeds, irrigation equipment,..)

- farmers (preference, level of knowledge,...)
- training/capacity building (pilot, long term demo,...)
- entrepreneurship (market, business model,...)
- policy (rules, regulations, government participation,...)
- PPP (public private partnerships,...)

- * crop selection
- * cultivation strategy
- * inputs
- * knowledge & skills
- * market

The Salt Doctors
Put it into practise

So, can we put it into practise?

Does it work “in the field”?

Examples from Pakistan, Kenya, Bangladesh
Implementation **Pakistan** 2016-2017

**Introduction of salt tolerant potato**

In Pakistan, 6 million hectares of salt affected farm land

Activities: validation and demonstration salt tolerant potato, introduction at field scale, training, capacity building and marketing

Result: 28% yield increase under moderate saline conditions, compared to the local variety
Implementation Kenya 2018

Introduction of salt tolerant carrot

Results: 94% yield increase compared to local variety, model for 98% groundwater use reduction

Activities: tailor-made cultivation strategy salt tolerant carrot, training, capacity building and marketing, smart water management (water harvesting), develop approach for agro-forestry
Implementation coastal **Bangladesh** 2017-2020

**Set up test facility, testing local crops for salt tolerance**

**Training-of-trainers, 200 lead farmers, 5000 group farmers**

**Providing knowledge, skills and seeds to the farmers**

---

**Results**
- after 2 years, based on independent project evaluation
- 260 random surveys from 1920 group farmers and 80 lead farmers

- **Food security increased from 15% to 65%**
  - Based on Household Food Insecurity Access Scale (0 full food security)

- **Use of salt affected fallow land increased from 0% to 76%**

- **average household income increased by 34%**
  - Percentage with more than 100 euro increase:
    - 55% for lead farmer, 4% for group farmer

- **Employment increased by 10% for lead farmer, 41% for group farmer**

- **Vegetable consumption (150 g/day, 10 months/year) increased from 26% to 74%**

- **Household improved dietary diversity increased from 75% to 100%**

- **Women with improved skills for sustainable food production increased from 9% to 79%**

- **Access to land for women increased from 4% to 87%**

---

*Supported by [The Salt Doctors](http://www.thesaltdoctors.com)*
Salt tolerant and robust varieties of different crops have been identified

These crops have been successfully cultivated in different countries, under different conditions

Saline agriculture is a combination of smart water, soil and crop management

Tailor-made solutions needed for local conditions

An adaptation strategy is needed, in combination with practical training (develop knowledge and skills), to get results in the field

Demonstration of results + positive impact value chain, to make saline agriculture “low risk” for adoption

For further info: Arjen de Vos
arjen@thesaltdoctors.com
Seawater Intrusion into Costal Aquifers: Challenges and Mitigation Measures

Dr. Mohamed A. Dawoud
Water Resources Advisor
Environment Agency – Abu Dhabi

MEDRC
Seawater Intrusion into Coastal Aquifers

Contents

• What is it?
• Why it happens?
• Why is it a Problem? Impacts?
• How Can it Be Controlled?
• What Can be Expected in the Future?
What is Seawater Intrusion?

Ghyben-Herzbargweg Relationship
What is Seawater Intrusion?

- The sea water has a higher density than freshwater. This higher density has the effect that the pressure beneath a column of saltwater is larger than that beneath a column of the same height of freshwater.
- There is a relationship based on the density difference between saltwater and freshwater that can be used to estimate the depth to saltwater based on the thickness of fresh water zone above sea level.
Impacts of Seawater Intrusion?

- Environmental Impacts
- Economical Impacts
- Social Impacts
Impacts of Seawater Intrusion?
How Can it Be Evaluated?

- Evaluate the size and extent of the problems.
- By the installation of monitoring wells, which are used to determine the boundaries of the salt/fresh water interface and the rate at which salinity levels are increasing. This data and other information on the hydrologic and geologic properties of the aquifer are introduced to numerical models.
How Can it Be Controlled?

Methods for controlling salt water Intrusion in coastal aquifer systems:

• Reduce pumping
• Relocate wells
• Directly recharge aquifer
• Freshwater recharge into wells paralleling the coast, creating a hydrodynamic barrier
• Create an trough parallel to the coast by excavating encroaching salt water from wells
• Extracting seawater before it reaches wells
• Extraction/injection combination
• Construction of impermeable subsurface barriers
Relocate wells?

Scavenger Well

**PROJECT PROFILE**
- Scavenger Well in Baton Rouge, LA
- Separates fresh drinkable water from salt water
- No treatment plant needed
- First of its kind in the U.S.

**PROJECT DETAILS**
- Designed by Layne hydrogeologists
- Constructed by Layne drillers
- Product of a three year collaboration
- Project Partners: Owen & White and Baton Rouge Water Company
Relocate wells?
Integrated Aquaculture System
Aquifer Recharge with TSE?

### Region Daily Production (m³) Daily Reuse (m³) Daily Discharge to Environment (m³)

<table>
<thead>
<tr>
<th>Region</th>
<th>Daily Production (m³)</th>
<th>Daily Reuse (m³)</th>
<th>Daily Discharge to Environment (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abu Dhabi</td>
<td>689,461</td>
<td>262,212</td>
<td>427,249</td>
</tr>
<tr>
<td>Eastern Region</td>
<td>185,166</td>
<td>176,957</td>
<td>8,208</td>
</tr>
<tr>
<td>Western Region</td>
<td>35,672</td>
<td>28,701</td>
<td>6,971</td>
</tr>
<tr>
<td>Total</td>
<td>299,910</td>
<td>467,870</td>
<td>441,428</td>
</tr>
</tbody>
</table>
Direct Use of TSE

Dubai road Project:
- Length is 45 Km
- Daily capacity of 140,000 cubic meters
- Cost estimate 220 Million Dirham

Al Ain road Project:
- Length is 70 Km
- Daily capacity of 270,000 cubic meters
- Cost estimate 720 Million Dirham
Aquifer Recharge with TSE?
Orange County Case Study

• Manages and replenishes the Orange County Groundwater Basin—OC’s largest source of drinking water
• Ensures water reliability and quality
• Prevents seawater intrusion & subsidence
• The Basin provides ~75% of water needs of 2.4 million people in north and central OC
Aquifer Recharge with TSE?
Orange County Case Study

CROSS SECTION OF ORANGE COUNTY GROUNDWATER BASIN

EXPLANATION
- Sands, Gravels
- Water-bearing Sands, Gravels
- Silts, Clays
- Colored Water
- Saline Water
- Consolidated, Non-water-bearing Formations
- Water Table

NEWPORT-INGLEWOOD FAULT ZONE

SOUTHWEST A

HUNTINGTON BEACH

OCWD AQUIFER RECHARGE AREA

ELEVATION (FEET MEAN SEALEVEL)

NORTHEAST A'

EXPLANATION
Aquifer Recharge with TSE?
Orange County Case Study

- 24 recharge facilities
- Total area: 1,500 acres
- Storage Capacity: 26,000 af
Aquifer Recharge with TSE?
Orange County Case Study

• The Groundwater Replenishment System (GWRS) has been operating since January 2008.
• The state-of-the-art treatment plant has been in the planning phase since 1994 and construction began as late as 2003. The first phase of the plant cost $480m.
• The GWRS underwent a $142.7m expansion, which broke ground in January 2012. The project was completed in 2013.
• In 2015, the project capacity was 100 MGD (378,000 cubic meters)
Aquifer Recharge with TSE?
Orange County Case Study

Without OCWD
10-Yr Avg (2003-2013)
Future Estimate

- Sustainable Yield w/o OCWD
- Local Water
- Santa Ana River Base Flow
- Natural Recharge (Rain, subsurface inflow)
- Storm Flow
- Recycled Water
- Imported Water

Sustainable Yield w/o OCWD 0
55,600
75,000

22%
High imported water costs makes local resources development attractive.

- **Cost per Acre Foot**
  - **Replenishment Assessment**
  - **MWD Treated Water**
  - **Untreated MWD** $700
  - **GWRS** $500
  - **Santa Ana River/Storm Flow** $20
  - **Natural Recharge** $0

- **Desalination?** $1900
High imported water costs make local resources development attractive.

Dr. Mohamed A. Dawoud
Water Resources Advisor,
Environmental Quality Sector
Environment Agency – Abu Dhabi
Tel. +97126934680
Email: mdawoud@ead.ae
Dec 2\textsuperscript{nd} 2019
Farm Visit
Dec 3rd 2019
Water for Agriculture
Several questions asked about the challenges faced. Of the 911:

- 72% identified high on-farm (non-water) costs as a significant challenge
- 76% identified low prices of agricultural output as a significant challenge
Overview of Water-Energy Nexus Challenges in Oman

- Eng. Abdulaziz Al Shidhani, GM, Planning & Assets Management, Public Authority for Water (DIAM)
- Eng. Ahmed Al-Mazrouy, CEO, Majis
- Mr. Brian Wood, Senior Advisor at Oman Power & Water Procurement (OPWP)
- Eng. Nihad Al Bimani, Asset Information Manager, Haya Water
- Dr. Abdullah Al Abri, Director of EJAAD

_Moderator: Dr. Jauad El Kharraz, Head of Research, MEDRC_
Seawater Intake Challenges in Oman: Solutions

- Dr. Peter Kerschberger, Application Manager, KWI International Environmental Treatment GmbH, Austria
  (Presentation: DAF as powerful protection against algal attacks)
- Mr. Patrick Thienpont, CEO, Barka Desalination Company, Barka 4
- Mr. Marouan El Khattabi, Middle East Director, GS Inima Environment, UAE

Moderator: Dr. Mohammed Al-Abri, Director, Nanotechnology Research Center & Associate Prof., College of Engineering, SQU
Dissolved Air Flotation (DAF) as powerful protection against algal attacks

Dr. Peter Kerschberger
2019
SWRO Desalination Pre-Treatment

- SCOPE: Treat raw water to control membrane fouling | Remove suspended solids (particles, silt, algal matter, organics, etc.) oil and grease

Source: Villacorte et al. 2015
**Dissolved Air Flotation (DAF) for Seawater Desalination Pre-Treatment**

- DAF is appropriate method to significantly remove low-density particulate matter
- DAF provides more process flexibility than any filtration- or sedimentation technology

**Function and Performance**

A. Chemical treatment to prepare particles for flotation
B. White water generation (Micro-Air-Bubbles)
C. White water injection, flotation and clear water & sludge removal

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effluent water turbidity</td>
<td>below 1 NTU</td>
</tr>
<tr>
<td>Algae removal efficiency</td>
<td>above 95%</td>
</tr>
<tr>
<td>Sludge concentration</td>
<td>2-5%</td>
</tr>
</tbody>
</table>
• Physical Size of AOM can vary by a factor of 1,000 → Appropriate treatment
  • Picoplankton 0.2 – 2 microns | Brown tide organism 2 – 3 microns
  • Red tide-former 200 – 2000 microns
  • Many algal cells in the range of 20 – 60 microns

Source: Villacorte 2014
Membrane Fouling | Operational Impacts

- AOM is a trigger for membrane fouling
  - Biofouling (substrates) and particulate fouling
  - Transparent Exopolymer Particles (TEP, sticky)

- Fouling layer will lead to a systematic decrease of membrane performance
  - Reduction of permeate flux rate (conversion rate) | Increase of feed pressure to maintain water production
  - Non back washable fouling: Fouling layer only partially removable due to its sticky nature → Progressively lower permeability

- Operational issues and highly frequent replacement of membranes → High specific costs
**DAF as Pre-Treatment | Benefits**

- **Pre-Treatment Layout:** Robust combination of DAF and filtration including chemical conditioning
  - Results in terms of water quality are comparable to filtration only
    - Additional benefit to handle highly degraded seawater
    - Higher chances to actively respond to different water qualities (Filtration limits: Backwashing – Frequency and chemicals)
    - If sludge treatment done carefully, nothing to plug

- **Harmful algal blooms**
  - Maintain plant production
  - Smooth algae removal process with low shear input
    - Preventing cell lysis and release of algal toxins and AOM that supports fouling

- **Natural protection against hydrocarbons**
  - Oil tanker spillage
THANK YOU FOR YOUR ATTENTION
References

- Villacorte, L.O. et al. 2015. Seawater reverse osmosis desalination and (harmful) algal blooms. Desalination, Volume 360, 16 March 2015, Pages 61-80
Produced Water and wastewater treatment challenges in Oman: Solutions

- Mr. Rauf Aliyev, A+A, Founder & Owner, Azerbaijan (Presentation: New Era in Industrial & Waste Waters Treatment)
- Eng. Mundhir Al-Battashi, Water Management Engineer, Petroleum Development Oman (PDO)
- Eng. Marwa Al Mahdouri, Process engineer, Haya Water
- Dr. Alexandros Stefanakis, Constructed Wetlands Expert & Tender Manager, Bauer company (Presentation: Constructed Wetlands for wastewater treatment in Oman: promoting sustainability in the water-energy-food nexus)
- Dr. Madan Iyengar, Nanotechnologist, Noxall LLP (Bahwan Group) (Presentation: Relevance of Nanotechnology in dis-infection and de-contamination of wastewater / effluent & air pollution)

Moderator: Dr. Syham Bentouati, Managing Director, NAFAS International LLC
GREEN WORLD

REAGENT “RAPID”
JOINT-STOCK CORPORATION “GREEN WORLD” INTRODUCES ITS OWN DEVELOPMENT –

innovative low-molecular amphoteric universal complex action reagent with chelate effect “RAPID”

CHANGE YOUR REAGENTS INTO “RAPID”

The 1st universal complex action reagent “RAPID” has the expressed properties of 6 reagents:

1. FLOCCULANT
2. COAGULANT
3. BACTERICIDE
4. DEMULSIFIER
5. ANTISCALANT
6. CORROSION INHIBITORS

THERE IS NO ANALOGUE IN THE WORLD AT THE PRESENT

Reagent “RAPID” is extremely effective in oil-producing and oil-refining industries.

With the help of reagent “RAPID” in oil production the emulsion easily separates into: OIL, PURE WATER, SOLIDS.
The destruction of consistent aqueous emulsions, in particular – emulsions of oil, petroleum products and other hydrocarbons.

The usage in petroleum production and oil treatment processes on fields (emulsification, demulsification, dehydrating, oil desalting).

The usage as the corrosion inhibitor for protection of equipment and pipe-lines in oil and gas production industries.

The usage as the bactericide.

Resumption/restoration of oil recovery.

The usage in washing of oil tankages terminals (railway tanks, other tanks).

The processing of oil slurry ponds and storages, that leads to the repeated usage of valuable hydrocarbon and extremely reduction of environmental pollution.

ECOLOGICAL COMPATIBILITY

The quality of waste water after its purification with the help of reagent "RAPID" corresponds the safety standard and requirements of environmental services. Industrial effluent does not pollute the environment, and you are protected from impressive payments for contravention of environmental standards.

The usage of reagent "RAPID" reduces power consumption in 1,5-2 times on the account that viscosity of pumpable liquids reduces, consequently, energy efficiency of an enterprise increases.
Increasing of longevity of injection wells, and, consequently, the reduction in expenditure for development the new ones.

The reduction of pumping equipment and pipe-lines consumption on account of better solid filtration, precipitating with the help of reagent “RAPID”.

The increasing of marketable oil output for 1-2% on account of deep purification of wastewater, because of effective separation input water-oil emulsion for oil and pure water (with the about 0% of residues in it).

The increasing of effectiveness and depth of purification for formation water.

The increasing of enterprise capacity with the lower expenses.

The reduction of used reagents leads to optimisation of technological processes.

The reduction of your nonmanufacturing expenses (warehouse, logistic, labour and other expenses).

The reduction of time for the preparation, as “RAPID” supplies in liquid form and does not require any preparation: reagent is ready for using.
**REAGENT “RAPID” CONDUCTS 6 TASKS ON ITS OWN:**

<table>
<thead>
<tr>
<th>INNOVATIVE REAGENTS OF “RAPID” SERIES</th>
<th>Reagents on basis of POLYACRYLAMIDE</th>
<th>CORROSION INHIBITORS on basis of various composition</th>
<th>BACTERICIDE on basis of various composition</th>
<th>On basis of various composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Flocculant</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Coagulant</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Corrosion inhibitors</td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>4. Bactericide</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>5. Antiscalant</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Demulsifier for water-oil emulsion</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The average reagent dosage, g/m³</td>
<td>5-50</td>
<td>5-300</td>
<td>20-100</td>
<td>up to 500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>up to 300</td>
</tr>
</tbody>
</table>

**THE REAGENT OF NEW GENERATION “RAPID” IS SUPER EFFECTIVE FOR WATER-OIL EMULSION, 0,5-40 % – 99,5-60 %”**.
The expected economic effect from reagent “RAPID” can be hundreds of thousands dollars per year for the average company.

THE AMOUNT OF REAGENTS FOR 1 M³ WATER PURIFYING USING THE CURRENT TECHNOLOGY

On average 610 g/m³ reagents will be needed for water purifying of the same water volume

THE AMOUNT OF REAGENTS FOR 1 M³ WATER PURIFYING USING THE REAGENT OF NEW GENERATION “RAPID”

Reagent “RAPID” replaces 6 reagents on its own: Flocculant, Coagulant, Corrosion inhibitor, Bactericide, Antiscalant, Demulsifier.

with the strong impurity of water the maximum reagent dosage of 50 g/m³ is required.

with the average impurity of water the reagent dosage of 30 g/m³ or less is required.

Antiscalant 150 g/m³
Bactericide 250 g/m³
Corrosion inhibitors 60 g/m³
Flocculant + Coagulant 150 g/m³
EVALUATE THE HIGH EFFICIENCY OF REAGENT “RAPID” FOR FAST WATER TREATMENT:

- **It reduces the reagent purchase expenses in 2-3 times**, because you need only one reagent – “RAPID” instead of 6 ones. Consequently, the cost of production is declining.

- **The speed of admixtures deposition** in water solution increases in 5-7 times with the significantly low consumptions of reagent.

- **It increases the work period of key wells** and reservoir recovery.

TO SUM UP, UNIVERSAL REAGENT “RAPID” CONDUCTS 6 TASKS AT A TIME:

- **The reduction of expenses** for buying of varied expensive as you need only one — "RAPID".

- **The increase of production volume** on account of time reduction for the purifying process.

- **The lack of fines** for environmental pollution on account of more qualitative wastewater purification.

- **The reduction cost of purification** for 1m³ of water.

- **The increase of energy efficiency** for enterprise.

- **The increase of petroleum product output** with the purification before 2% from volume.

Moreover, using the reagent “RAPID”, it is not needed to change the operational water purification system on the enterprise.

The pilot tests show that the efficiency of waste water purification with the reagent “RAPID” is 5-10 times as high as the efficiency of the current specific reagents.
JOINT-STOCK CORPORATION “GREEN WORLD” INTRODUCES ITS OWN DEVELOPMENT –

innovative highly dispersed sol of aluminosilicate materials with various modifiers of organic and inorganic nature.

REPLACE YOU REAGENTS WITH THE SORBENT “RAPID”

The universal complex reaction reagent “RAPID” can be applied simultaneously to the three purification methods:

1. REAGENT
2. SORBENT
3. PHYSICOCHEMICAL

AT THE MOMENT THERE IS NO ANY ANALOGUE IN THE WORLD

One of the key peculiarities of the reagent – HIGHLY DISPERSED STATE.

THE ADSORBENT PARTICLE SIZE IS 20 — 50 FOR SPECIFIC SURFACE THAT'S ABOUT 400 — 500 M²/G OF REAGENT.
THE SPHERES OF USAGE

✔ Water purification and water treatment of iron and steel companies, refineries, fuel and energy enterprises
✔ In the processes of drinking water treatment and water purification of domestic sewage
✔ While using sorbent RAPID, the saline solution background is not increasing
✔ It can be used in run-around systems
✔ It does not lose its properties even in high mineralization water
✔ It shows its high efficiency comparing to known coagulants.

ECOLOGICAL COMPATIBILITY

✔ Sorbents “RAPID” undertake the extracting the ions of heavy and non-ferrous metals, hardness salts, petrochemicals, hydrogen sulphide and some other organic contaminants.

✔ Some methods of applying the reagent “RAPID” in the processes of selective extraction and concentration of vanadium, molybdenum and indium are elaborated.
<table>
<thead>
<tr>
<th>Adsorbent</th>
<th>Extracted Component</th>
<th>Sphere of Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAPID T</td>
<td>Fe(II), Fe(III), Al, Ni, Cu, Zn, Mn</td>
<td>Water treatment of drinking water, effluent treatment in metallurgy</td>
</tr>
<tr>
<td>RAPID C</td>
<td>Cu, Zn, Ni, Mn</td>
<td>Wastewater treatment of electrodepositions</td>
</tr>
<tr>
<td>RAPID S</td>
<td>S, H2S, CH3COOH, organic acids</td>
<td>Hydrogen sulphide extraction from oilfield waters</td>
</tr>
<tr>
<td>RAPID W</td>
<td>Ca, Mg, Sr, Ba</td>
<td>Water softening in water treatment processes, radionuclide extraction</td>
</tr>
<tr>
<td>RAPID K</td>
<td>V, Mo, In</td>
<td>Concentration of components from complex systems.</td>
</tr>
</tbody>
</table>
The own laboratory complex with analytic equipment for product synthesis provides the continuous work on search and invention of effective solutions for specific targets on wastewater purification and water treatment, expense reduction and increase of final profit.

Scaling and own production. The price of final product does not include rent of equipment and transport expenses.

JOINT-STOCK CORPORATION “GREEN WORLD” PROVIDES:

The modern and unique solutions of production, preparation, transportation and oil and gas processing fields, and also, industrial water supply (wastewater purification and water preparation in different branches of industry).

The complex service and control system for water resources of your enterprise: from audit and planning to operating and support. We are perfectly aware of what we are doing that is why we solve your problems of contaminated runoff effectively and profitably for you.

Automatization of metering and controlling processes of water cycle reagents. It prevents the metering mistakes and makes the water treatment mush as possible low-consumption and effective.

THOSE, WHO WORK ON INNOVATIVE DEVELOPMENT:

1 Doctor of Chemistry, 2 Candidates of Technical Science, 1 Candidate of Chemistry.
Our experts will conduct a presentation, laboratory and pilot tests where you will be able to make sure of universal reagent "RAPID" effectiveness.

Contact us to test reagents on your enterprise:

Tel: + 994 12 4961866
Tel/Fax: + 994 14960026 (ext.:126)

Web: www.aagroup.az
E-mail: abbas.bagirov@aagroup.az
Adress: Akhmadbay Agaogli str,24B; Baku, Azerbaijan/ AZ1008

Phone number +7 (343) 622-20-22, e-mail: info@green-world.biz
For more on reagent “RAPID” see: www.green-world.biz

START TO WORK EFFECTIVELY – USE “RAPID”.
Constructed Wetlands for wastewater treatment in Oman: promoting sustainability in the water-energy-food nexus

Dr. Alexandros Stefanakis

Constructed Wetlands Specialist & Tender Manager, BAUER Nimr LLC, Oman & Bauer Resources GmbH, Germany
Lecturer, Department of Engineering, German University of Technology in Oman
Regional Coordinator for Africa & Middle East, “Wetland Systems for Water Pollution Control”, International Water Association
alexandros.stefanakis@bauer.de; a.stefanakis@gutech.edu.om; stefanakis.alexandros@gmail.com
Natural Wastewater Treatment Systems

► An alternative approach than conventional/mechanical technologies
  + cost effective / reduced capital costs
  + green and sustainable
  + minimizing wastewater transportation

**Constructed Wetlands**
designed to mimic the functions of natural wetlands
BUT under controlled conditions

Naturally occurring pollutant removal processes
✓ water
✓ substrate media (e.g., gravel)
✓ plants
✓ microorganisms
✓ environment (sun, soil, air)

- natural responses (e.g., gravitational flow and sedimentation)
- natural components (e.g., plants, gravel, biological organisms)

**Services of wetland technology**
✓ Wastewater treatment
✓ Sludge dewatering and stabilization
✓ Flood control / runoff treatment
✓ Habitat creation
Nimr Oilfield, Oman

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shade temperature</td>
<td>5°C</td>
<td>60°C</td>
</tr>
<tr>
<td>Max. daily variation</td>
<td></td>
<td>25°C</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>30%</td>
<td>98%</td>
</tr>
<tr>
<td>Rain fall</td>
<td>0 mm</td>
<td>25 mm for 1 hour</td>
</tr>
</tbody>
</table>

Area before the project
Nimr Oilfield, Oman

- Total produced water volume: 270,000 m³/day

- Shallow aquifers disposal was phased out in 2005 due to environmental issues → only option for Petroleum Development Oman = deep water disposal (DWD)

- Traditional disposal = deep-well disposal - DWD (>1.5km depth)
  → energy and OPEX intensive
  → aquifer contamination risk
  → bottleneck on production

- Influent TDS = 7-8000 ppm

- Oil in Water = average of 350 ppm

- **Goal:** To replace deep DWD with a reliable, environmentally-sound alternative
~65% of produced water generated at the Nimr Oilfield (270,000 m³/day) is treated in this facility (half of the daily water consumption in Oman’s capital)

~18% of produced water generated by PDO
Nimr Water Treatment Plant: simplified process chart

Treatment of 175,000 m³/d produced water

Produced Water from PDO

Turn-Over Point
- Metering skid
- Flow control valves
- Equalization basin
- Hydrocyclones
- Floating skimmers

Crude oil
> 85% oil recovery
> 400 bbl/day oil

Constructed Wetlands
- Treatment
- Evapotranspiration

Evaporation Ponds
- Zero-outflow
- Salt residue

Reuse

> 85% oil recovery
> 400 bbl/day oil
Nimr Water Treatment Plant

- Hydro-cyclone oil Separators
- Fiscal transfer metering
- By-pass pipeline to ensure continuous production
- Buffer Pond
- Gravity flow
- Wetlands
Nimr Water Treatment Plant: Phase 3
Nimr Water Treatment Plant

1200 football fields
Case study 5: Produced water treatment

From this...
(Wetland inflow)

...to this!
(Wetland outflow)
Nimr Water Treatment Plant: treatment performance

<table>
<thead>
<tr>
<th>Performance</th>
<th>Oil recovery</th>
<th>TPH &lt; 0.5 ppm (99% removal)</th>
</tr>
</thead>
</table>

- Oil recovery: ~400 bbl/day
- TPH: < 0.5 ppm (99% removal)
Nimr Water Treatment Plant: environmental performance

Since NWTP is in operation, 4 deep well pumps have been shut down

- Wetland plant uses only 1/50 of the energy consumed including all related infrastructure facilities → Energy savings compared to wetland system > 99%

- NWTP contributes to approximately 4.3% (↑6%) of Oman’s overall Intended Nationally Determined Contributions to reduce the national emissions by 2%

<table>
<thead>
<tr>
<th></th>
<th>Energy Consumption [kWh/m³]</th>
<th>CO₂ emissions over 20 years operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Wells</td>
<td>Up to 4.0</td>
<td>3,200,000 MWh, 1,700,000 t CO₂</td>
</tr>
<tr>
<td>Mechanical Wastewater Treatment Plant</td>
<td>0.8 - 1.0</td>
<td>700,000 MWh, 390,000 t CO₂</td>
</tr>
<tr>
<td>Wetland</td>
<td>&lt; 0.1</td>
<td>4,000 MWh, 2,150 t CO₂</td>
</tr>
</tbody>
</table>
Nimr Water Treatment Plant: food-water-energy nexus
Making NWTP a global example of industrial ecology and circular economy

- **Treated effluent**
  - Aquaculture
  - Biosaline agriculture
  - Desalination
  - Solar farm

- **Closing materials cycle**
  - Compost
  - Biogas
  - Reeds biomass
  - Date palms
  - Fodder

- **Operations**
  - Constructed Wetlands
  - R&D

- **Offset of emissions**
  - CO2
  - Biofuel
  - Wood

- **Market value**
  - Water conservation

- **DWD**
  - Biofuel
  - Wood
Nimr Water Treatment Plant: Biosaline Agriculture Project

Grasses

Annual species

Perennial species
Nimr Water Treatment Plant: Biosaline Agriculture Project

- Castor oil plants
- White cotton lint
- Grasses
- Trees
Nimr Water Treatment Plant: nursery

Wetland plants stock for seed collection

Germination

Pricking

Growth and establishment
A man-made valuable habitat for migratory and resident birds and other wildlife

> 130 different bird species in and around the wetland cells and ponds have been identified

→ a new, attractive island refuge in the desert for birds migrating between Asia and Africa
Nimr Water Treatment Plant: conclusions

- Constructed Wetlands technology: proven sustainable concept for effective de-contamination of produced water
- Nimr Water Treatment Plant, Oman: global reference of carbon footprint mitigation and increased resilience for produced water management operations
- Food - Water - Energy nexus in the oil & gas industry: many opportunities, further research needed to enhance the sustainability aspects of the operations
- A variety of options available for further exploitation of the treated produced water → reuse in agriculture on focus
- Circular economy approach: all waste streams (water, biomass) viewed as a valuable resource, we can
  → close the materials cycle
  → save energy
  → save fresh water resources
  → reduce carbon footprint
Thank you!

Contact details:
Dr Alexandros Stefanakis, Constructed Wetlands Specialist
Tel: +968 96441544
alexandros.stefanakis@bauer.de; stefanakis.alexandros@gmail.com
EVOLUTIONARY TECHNOLOGY

**THEME:** RELEVANCE OF NANOTEchnology in dis-infection and de-contamination of wastewater / effluent & air pollution.

Dr. Madan Iyengar
(Nanotechnologist)
Chief Technical Officer

NOXXALL LLP
Bengaluru – Karnataka –
Republic of INDIA
UNIQUENESS
CREATING A
REVOLUTION
THE POWER OF
NANOTECHNOLOGY
noxxall.com
In true terms Nanotechnology is futuristic - combines the knowledge of physics, chemistry and engineering – having diverse applications like -

• ARTIFICIAL INTELLIGENCE
• SPACE SCIENCES
• ENVIRONMENTAL SCIENCES (Rhino)
• HEALTH SCIENCES
• SOIL SCIENCES
Recent Developments

- Nano Satellites
- Drug Delivery (cancer)
- Microbots
- Electronics
- Food
- Batteries (mobiles)
- Fuel Cells (cars / bikes)
- Solar Cells
- Carbon Nano Tubes
TRULY MADE - IN - INDIA

- We take pride to mention that presently we have NO GLOBAL COMPETITION for our technology….hence this makes our process and products UNIQUE….

- Truly a GREEN TECHNOLOGY with application of GREEN CHEMICALS.

- A technology based on the conceptual lines of PANCHA BHoota……having applications for and in…..

WATER – AIR – EARTH - SPACE – FIRE
THE CHEMISTRY MAKES ALL THE DIFFERENCE

SYNERGY REACTION

EXOTHERMIC
HIGH ENERGY DISCHARGE DUE TO CHEMICALS REACTION

ELECTROTHERMIC
HIGH CONDUCTIVITY DUE TO METALS REACTION

PHOTOTHERMIC
REFLECTION – REFRACTION OF HEAT AND ENERGY

DUE TO THIS COMBINATION OF REACTIONS BIO ACIVITY IS DESTROYED BEYOND REPRODUCTION

- Nanotechnology enables to combine all these reaction in a single design – which is ANOT.
Worlds 1st

- Reaction time 2 sec to 6 minutes
- Reduces over 30+ parameters
- Single / pre treatment (*conditions)
- Mobile etp cum stp
- Installation: plug and play
- Need based operation
- Lowest power consumption
- Small foot print
- Roof top installation
## CETP – PARAMETERS

(WITHOUT UV – RO)

<table>
<thead>
<tr>
<th>PARAMETERs</th>
<th>UNIT</th>
<th>RAW EFFLUENT</th>
<th>NOXXiT TREATED</th>
<th>CHANGE IN %</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPREANCE</td>
<td>TURBID</td>
<td>ALMOST CLEAR</td>
<td></td>
<td>95%</td>
</tr>
<tr>
<td>COD</td>
<td></td>
<td>5889</td>
<td>1190</td>
<td>79%</td>
</tr>
<tr>
<td>BOD</td>
<td></td>
<td>1602</td>
<td>298</td>
<td>81%</td>
</tr>
<tr>
<td>CONDUCTIVITY</td>
<td></td>
<td>20274</td>
<td>10025</td>
<td>50%</td>
</tr>
<tr>
<td>TURBIDITY</td>
<td></td>
<td>130</td>
<td>6</td>
<td>95%</td>
</tr>
<tr>
<td>TSS</td>
<td></td>
<td>528</td>
<td>16</td>
<td>96%</td>
</tr>
<tr>
<td>TDS</td>
<td></td>
<td>10251</td>
<td>5293</td>
<td>48%</td>
</tr>
<tr>
<td>TOC</td>
<td></td>
<td>897</td>
<td>269</td>
<td>70%</td>
</tr>
</tbody>
</table>
• IT IS OBSERVED BY CASE STUDIES THAT ANOT PROCESS (NOXXiT) REDUCES TDS RANGING FROM MINIMUM 10% TO OVER 50% IN PRE-TREATMENT.

• % IN REDUCTION VARIES FROM INDUSTRY TO INDUSTRY.

• REDUCTION IN “MAN MADE TDS” ONLY.

• IMPROVES EFFIENCHENY OF ULTRA / REVERSE OSMOSIS SYSTEMS.

• REDUCES REJECTION AND IMPROVES PERMEATE.

• INCREASES THE PERFORMANCE LIFE OF FILTRATION SYSTEMS / MEMBRANES.
NOXXALL® A Unique formulated invention

- TEXTILES
- AUTOMOBILE
- LAUNDRY
- PHARMACEUTICALS
- HEAVY INDUSTRIES
- HOSPITALS
- CONSTRUCTION
- CHEMICAL DYEING INDUSTRIES
- OIL EXTRACTION UNITS
- PETROCHEMICALS
- DAIRIES
- COOLING TOWERS
- RESEARCH LABORATORIES
- FOOD AND BEVERAGES
- MUNICIPAL CORPORATIONS
- SEWAGE AND EFFLUENT TREATMENT PLANTS

*conditions apply.
We introduce **STATE OF THE ART - Sugofil®** modular treatment plants that are compatible to *ANOT (Advanced Nano Oxidation Technology) process.*
Sugofil® 100 kl plant @ ONGC
Slaughter House Effluent
Fish Meal - Effluent
MINING EFFLUENT
CHEMICAL EFFLUENT
PAINT EFFLUENT
LAUNDRY EFFLUENT
Boiler - Cooling tower

[Image of water samples labeled as No1 Raw Cooling Tower Water, No1 Noxxit Treated, No2 Raw Boiler Blow, No2 Noxxit]
CONSTRUCTION CAMP SITE
CHIPS PROCESS EFFLUENT
• Sugofil® Modular treatment plant capacities range from as low as 5 kld d to over 500 kld and technology can convert present MLD plants.

• Sugofil® Modular treatment plants could be erected and installed within hours to operation levels.

• Sugofil® Entire plant re-locatable with short notice.

• These plants occupy very less space and could be located above ground or on ROOF TOPS.
Union minister for petroleum checks quality of NOXXALL® treated water
Sugofil®
@STRIDES - MOZAMBIQUE
Sugofil®
READY STOCK AT WAREHOUSE
Sugofil® WATER BUNK

WATER BUNKS - A CONCEPT - TO TREAT SEWAGE NEAR STREAMS AND PROVIDE TREATED WATER FOR REUSES LIKE CONSTRUCTION, VEHICLE WASHING, CONTRACT SUPPLY TO WATER DEPENDENT INDUSTRIES, FILL LAKES AND PONDS ON CSR.
OLD - SAYING

❑ REDUCE
❑ RECYCLE
❑ REUSE

RAIN WATER HARVESTING

(seasonal yet scanty)
NEW MANTRA

FUTURE

SEWAGE HARVESTING

24 X 7 – 365 DAYS
CONTAMINATION IN BEACHES AND RIVERS
HOW EFFLUENTS POLLUTE

- No swimming
- No fishing
- No drinking
- Polluted water

Do not enter

[Images of polluted water bodies and effluents discharging into water]
OZO NANO SCIENCES
BENGALURU - KARNATAKA
REPUBLIC OF INDIA

THANK YOU !!!
noxxall.com

MAKE IN INDIA
Desalination industry challenges (O&M, Training) in Oman: Solutions

- Mr. Andreas Vandre, Regional Manager Educational Service Europe, Middle East, Africa, Flowserve Dortmund GmbH & Co KG
- Mr. Yong-Gyun Park, General Manager, GS Engineering & Construction Corp, Korea
- Eng. Younis Al Rawahi, RO Engineer, STOMO

Moderator: Eng. Riadh Dridi, Head of Training, MEDRC
Agenda

- Introduction Flowserve
- Flowserve Experience in Desalination
- Service and Aftermarket
- Optimization support (Process and Products)
- Projects
Introduction Flowserve

Portfolio of Products and Services

A Broad Set of Product Capabilities
  Pumps - Valves - ERD - Seals

Critical Industry Application Solutions

Aftermarket Support Services

- Global Quick Response Center (QRC) Footprint
- Manufacturing Support
- Engineering Support
- Spare Parts Support
Flowserve Experience in Desalination

Every day, in desalination plants all over the world, Flowserve pumps, energy-recovery products and valves help to bring fresh water to millions of people, industrial and agriculture use.

Two (2) out of every three (3) Mega SWRO projects have FLOWSERVE equipment
Flowserve in Desalination

Flowserve SOLUTION

✅ >35 years experience in desalination.
✅ Largest Desalination installation base.
✅ Desalination Center of Excellence.
✅ Design support for most competitive equipment selection.
✅ Power consumption analysis and optimization.
✅ Global Project Management - single point of contact.
✅ Local support ensured through a global network of service centers.
✅ Service and Maintenance Contracts for highest availability and continuous efficiency optimization.
✅ Operation and service training.
Services

- **TRAINING**
  - Pump Fundamentals
  - Seal Fundamentals
  - Energy Recovery Devices
  - Vibrations, Noises

- **ROUTINES**
  - Maintenance procedures
  - Bench Marking
  - Check Lists
  - Scheduled Activities

- **ANALYSIS**
  - Trend Analysis
  - Engineering Studies
  - Root Cause Analysis (RCA)
  - Upgrades and recommendations
Thank you
Best Partner & First Company

For Water & Energy Production

SWRO-PRO Hybrid Desalination

December 4, 2019
1. GS E&C – Introduction
2. Pressure Retarded Osmosis (PRO)
3. PRO for Seawater Desalination
4. Benefits
5. Market & Application
Diverse and well-balanced business portfolio to provide a full array of services and ensure sustainable growth in today’s volatile economic environment.
1. GS E&C - Introduction

Water Business Projects

19 DESALINATION PROJECTS
(Total 960,000 m³/d)
2. Pressure Retarded Osmosis (PRO)

Seawater Desalination Challenges

Desalination Energy Consumption

3~4 kWh/m³

Environmental Impacts of Brine

- Negative Impacts on the marine eco-system
- Cost for brine treatment and discharge
- Brine discharge regulations and salinity limits

<table>
<thead>
<tr>
<th>Location</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA (EPA)</td>
<td>Increment ≤ 4 ppt</td>
</tr>
<tr>
<td>Australia (Sydney)</td>
<td>Increment ≤ 1 ppt</td>
</tr>
<tr>
<td>UAE (Abu Dhabi)</td>
<td>Increment ≤ 5 %</td>
</tr>
<tr>
<td>Oman</td>
<td>Increment ≤ 2 ppt</td>
</tr>
</tbody>
</table>

GS E&C provides an innovative LOW-ENERGY & ECO-FRIENDLY solution for Seawater Desalination
2. Pressure Retarded Osmosis (PRO)

Desalination Brine is Waste? **Resource!**

- **Seawater** → **RO Membrane** → **Brine** (60%, High Salinity: 60,000 ~ 70,000 mg/L) → **PRO** → **Drinking Water**

**Desalination Plant**

**Osmotic Energy Recovery**
2. Pressure Retarded Osmosis (PRO)

**PRO Principles**

- **STP Effluent**
- **Low Pressure Pump (Feed Solution)**
- **Discharged Water**
- **High Pressure Pump (Draw Solution)**
- **Pelton Turbine**
- **Diluted Brine**
- **SWRO Brine**
2. Pressure Retarded Osmosis (PRO)

PRO Technology History

1954

PRO Power Generation Concept Introduction (R.E. Pattle, Nature)

2009~2013

PRO Power Generation Pilot Research (Statkraft, Norway)

2011~2014

2013~2018

Desalination Brine

Seawater

SWRO-PRO Hybrid System Development (GS E&C, Korea)
3. PRO for Seawater Desalination

**SWRO-PRO Desalination System**

**• SWRO-PRO Process Concept**

Pressure Retarded Osmosis (PRO) = Energy Converter (from chemical potential energy to mechanical energy)

1. SWRO: Seawater Reverse Osmosis
2. PRO: Pressure Retarded Osmosis
3. ERD: Energy Recovery Device
3. PRO for Seawater Desalination

**SWRO-PRO Desalination System**

**1. WATER**

**2. ENERGY**

**3. ENVIRONMENT**

SWRO-PRO Desalination Plant

WTP Effluent or NEWater Brine
3. PRO for Seawater Desalination

SWRO-PRO Hybrid Processes

**PRO w/ Pelton Turbine**
- HP
- SWRO
- PX
- Brine
- PRO
- Permeate
- Pretreated Seawater
- Low Concentration Brine
- Pelton Turbine

**Characteristics**
- **ELECTRICITY GENERATION** using Pelton Turbine
- **LOWER** energy recovery **EFFICIENCY**

**PRO w/ Pressure Exchanger**
- HP
- SWRO
- PX
- Brine
- PRO
- Permeate
- Pretreated Seawater
- Low Concentration Brine
- Pressure Exchanger

**Characteristics**
- **ENERGY RECOVERY** using Pressure Exchanger
- **HIGHER** energy recovery **EFFICIENCY**
3. PRO for Seawater Desalination

**SWRO-PRO Core Technologies**

- **System Optimization**
  - Optimal design and operation

- **PRO Pretreatment**
  - Optimal pretreatment system
  - PRO membrane fouling control

- **PRO Membrane**
  - PRO membrane & module
  - Spiral-wound & hollow fiber types

- **Energy Recovery Device**
  - Pressure exchanger
3. PRO for Seawater Desalination

PRO Technology Development

• SWRO-PRO Demonstration (World’s First & Largest)

1. Demonstration Plant Capacity: 240 m³/d
4. Benefits

**Economic, Environmental, & Social Benefits**

1. **S**aving energy for seawater desalination
2. **M**itigating environmental impact of brine
3. **I**ncreasing public acceptance of a desalination facility
4. **R**educing the cost of brine discharge & power supply
5. **R**educing CO₂ emission
4. Benefits

Economic, Environmental & Social Benefits

- Total Capex Increase (20~30%)
  - PRO Facilities
  - Intake/Outfall Power Facilities
  - Pretreatment Facilities
  - SWRO & Post Treatment Facilities

Energy Saving (25%)
4. Benefits

Economic, Environmental & Social Benefits

**Economic Analysis**

- **OPEX**
  - **10% Decrease**
  - **25% Power**
  
- **Conventional (SWRO)**
  - **Labor, Chemical, etc.**
  - **Power**

- **GS (SWRO-PRO)**
  - **Labor, Chemical, etc.**
  - **Power**

- **28% Increase** (Mil. USD)
  - SWRO: 110
  - SWRO-PRO: 141

**Brine Impact**

- **Brine Salinity**
  - **40% Reduction**
  
- **Conventional (SWRO)**
  - 70,000 mg/L

- **GS (SWRO-PRO)**
  - 42,000 mg/L

**Pay-back Period Analysis**

- **Effect of Power Tariff**
- **Decrease by Power Tariff Increase**

- **Pay-back Period (Year)**
  - **Power Tariff (USD/kWh)**
  - From 0 to 0.35
Various PRO business models can be developed to satisfy the local and regional needs related to water and energy.
Thank You
Dec 4th 2019
Water Energy Nexus
Al Joudah Food Tech Laboratory started its operation as Commercial Testing Laboratory in January 2019. It is the most modern Food, Beverages and Water testing Laboratory in Oman capable of testing all products from farm to fork. This Laboratory project started as an initiative to support Food Safety and Food Security programs of the government and to build full Food Testing capability as per international Food Testing requirements in Oman. The venue of the Laboratory is inside Rusayl Industrial Estate with well-designed Laboratory Layout, State of the Art Testing Equipment and highly qualified and experienced Analysis Technologists and Laboratory Experts.

The salient features of this new Laboratory are as below

- Accredited Laboratory as per Latest Accreditation Standard ISO 17025:2017 with
- Accreditation for Pesticides Analysis of Fruits and Vegetables, Full Halal Testing
- (Alcohol & Porcine), Food Toxins Testing, to name a few.
- Registered with the Directorate General for Specifications and Meterology (DGSM) at the Ministry of Commerce and Industry in the Sultanate of Oman.
- Laboratory uses Latest Laboratory Information Management System (LIMS) which guarantees Data Integrity, Full sample Traceability and seamless process flow till the delivery of Analysis Report to customers.
- Building Sample collection capability from any part of the country as per customer requirement.
- Pursuing Accreditation from Gulf Accreditation Centre (GAC) for comprehensive testing of Olive Oil, Fish, Honey and Water analysis.
Established in 2000, eLEAF is a Netherlands based high-tech company that provides Earth Observation based applications and data to optimise agricultural production and water management. eLEAF product offering is targeted at the entire agri-business value chain ranging from farmers to food processors as well as non-profit organizations, public institutions and governments.

To sustain the growing population in the era of climate change more food needs to be produced with less water resources in a sustainable way. This calls for a drastic improvement of the current performance of food production systems, where the use of pesticides and herbicides need to be critically evaluated. eLEAF’s data can optimise food production and crop water use efficiency, identify food security threats and safeguard fair allocation of available water resources. This is where eLEAF makes a difference.

The core of eLEAF’s technology is called Pixel Intelligence Mapping (PiMapping®). It generates detailed time series of among others biomass production, crop water consumption, crop water stress and water productivity. PiMapping® technology is used for field scale assessments up to continental monitoring. This data is quantified, accurate and based on state of the art satellite technology.

eLEAF’s agricultural products include a crop monitoring platform FieldLook, which provides farmers with weekly updates on their crop’s health and water use and visualizes underperforming areas for immediate action. We offer irrigation advice and yield estimates for wheat, barley, potato, grapes (www.fruitlook.co.za), sugarcane and other crops.

The water management products are aimed at water authorities. eLEAF’s algorithms quantify plant water use, be it for irrigated or rainfed crops, grassland or natural parks. This data can be provided for single fields up to entire countries or basins. Per day, per week or per year. eLEAF’s water management tools provide water managers with improved insight into water need, allowing them to optimise the complex task of effective integrated water resources management.

eLEAF is based in Wageningen, the Netherlands and employs 25 professionals.
Practical Approach and Services

The Salt Doctors is a social enterprise that combines the expertise of different professionals to develop tailor-made solutions. Farmers grow food and they have to be enabled to adapt to the increasing salinity levels worldwide. Based on many years of knowledge and know-how, The Salt Doctors have developed a practical approach that focuses on getting results in the field. Salinity and crop production assessments, providing crop cultivation strategies (including crop/soil/water), training (in the field), assistance during the crop season, and making sure that all the right input materials (like seeds) are available, are part of the services, as well as capacity building of extension officers and (research) institutions, assistance with practical research and breeding, and developing adaptation strategies.

Proven track record

In Pakistan our method delivered up to 42% higher potato yield compared to local conventional methods (2016-2017). In 2018 we were able to double the carrot yield under saline conditions in Kenya. In Bangladesh, we are currently training over 5000 farmers on saline agriculture. Results show that the majority of the trained farmers are now using the salt affected soil and are able to cultivate nutritious crops with good market value like potato, carrot, cauliflower, cabbage and beet, and their income increased by 34% after 2 years into the project. This cultivation takes place during the season when the farmers did not plant any crop due to the salinity issues and many of the trained farmers are now close to year-round crop production and year-round employment. This is especially important since many farmers migrate from the rural areas during a large part of the year and migration due to salinity will only increase if no adaptation measures are taken.

So saline agriculture can make use of the saline resources of the world, both soil and water, and is a proven strategy to adapt to salinity. When farmers know how to cultivate crops under saline conditions and all input materials are available, like the seeds of salt tolerant crops, then the crop yield under saline conditions can increase to a great extent and the farmer’s livelihood can be improved. By developing a practical approach, and by making sure it reaches the farmers, it is not only possible to live with salinity but to thrive in salt affected areas.

www.thesaltdoctors.com | arjen@thesaltdoctors.com | +31 6 2474 9714

The 'Solar Still'

The company “Kascade” is an innovative Dutch company which developed a patented “Solar Still” which makes it possible to produce drinking water from any water source only using solar energy. It is one of the most efficient and cost effective desalination systems and it has many advantages compared to other systems like reversed osmosis or flash evaporating. The most important advantages of the system are:

- Simplicity
- Durability
- No use of fossil energy
- Friendly for the environment
- Low cost price

OTHER APPLICATIONS

The “Solar Still” can easily be modified into a solar dryer. The solar dryer can be used to dry fish, fruit, etc.,

CUSTOM MADE SOLUTIONS

Kascade is a specialized in custom made solutions. We can provide large water desalination systems for agriculture/horticultural purposes but also smaller systems for individual households.

http://kascade.nl | info@kascade.nl | +31 (0)6 38 37 94 74
IHE Delft strives to strengthen the programmes of universities and research institutes as well as the knowledge and capacity base of ministries and other water sector organizations in Africa, South-America and Asia/Pacific.

We do this by training water professionals on-the-job, creating water education networks, joint research, policy advice, distance & e-learning, participation in innovative projects and facilitating knowledge sharing. Water supply, sanitation and water resources are affected not only by climate change, rising demands for water and increasing pollution of sources but also by weak human and institutional capacity. Developing countries and countries in transition are often ill-equipped to tackle problems and to play their role in international negotiations and sustainable development, which sustains a situation of dependency. Building strong local and regional education and research environments to educate future water leaders and creating adequate institutions enabling the sound management of water resources are at IHE Delft’s core.

Website: https://www.un-ihe.org/ - tel: +31 (0)152151715

The Organisation for Quality and Innovation Strategies (Qualies) started in Salalah, south of Oman, in 2001, based on the vision that Oman and the Middle East needed a creative and innovative free-standing organisation capable of addressing the spectrum of issues related to research, human resource management, technology and enterprise development which are required to generate new opportunities in support of a prosperous and sustainable society. For many years, Qualies focused primarily on support of research and education efforts within local communities. As of 2012, however, a reorganization started, through which Qualies teamed up with international partners to establish a platform for supporting innovation and developing a series of significant project agendas capable of fulfilling the objectives of the organization.

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16-18 MARCH 2020
OCEC MUSCAT

SUSTAINABLE FACILITIES FOR A HEALTHIER ENVIRONMENT

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DAY 2: FACILITIES & FACILITY MANAGEMENT
DAY 3: PEST CONTROL & PESTICIDES

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MEFMA
OMAN WATER SOCIETY
Sustainable Development Goals

12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 IQY
17 PARTNERSHIPS FOR THE GOALS
3 GOOD HEALTH AND WELL-BEING
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
11 SUSTAINABLE CITIES AND COMMUNITIES
KWI INTERNATIONAL ENVIRONMENTAL TREATMENT GMBH

KWI is one of the leading providers of global water treatment solutions with high expert knowledge on Dissolved Air Flotation. KWI specializes in equipment for the processing and treatment of industrial and municipal wastewater, and the treatment of fresh and salt water to produce drinking water. The company manufactures sophisticated, high-end flotation plants. KWI’s water treatment plants are robust, highly efficient and able to handle a huge throughput of water.

As one of the pioneers of Dissolved Air Flotation technology, KWI is renowned globally for excellence in delivering robust and cost-effective solutions based on proven process designs incorporating exclusive, patented equipment and technology.

Our 4,700 installations in 77 countries are evidence of the 70 years of KWI’s experience. KWI is the longest established manufacturer of water and wastewater flotation plants in the market today.

Customer benefit from the global structure with its diverse capabilities, combined with the local, efficient service that we provide. KWI has offices as well as agents and distributors throughout Europe, the Far East and the Americas.
FLOWSERVE

Our history began over 200 years ago, and today Flowserve employs more than 17,500 associates in 300-plus locations around the world, including over 180 quick response centers that provide aftermarket parts and services to customers. And Flowserve offers more than 100 distinct pump models and a wide range of valve and seal products.

Through our unmatched combination of products, engineering and aftermarket services, we help our customers achieve tangible business results: lower operating costs, optimized performance, prolonged equipment life, mitigated risks and higher productivity.

Around the world, Flowserve is striving to create extraordinary flow control solutions to make the world better for everyone. Draw on our industry expertise to help address your most pressing challenges:

- Reduce expenses
- Minimize risk
- Maximize performance

Why Flowserve?

Expertise & Experience
Has more than two centuries of history—and this deep experience enables us to be a go-to resource for solving the toughest challenges across all industries.

Comprehensive Portfolio
Offers the industry’s most complete fluid motion control portfolio, enabling you to spend less time shopping and evaluating. Better yet, this enables us to create the best standard and custom solutions for you.

Superior Quality & Reliability
Products are designed for the utmost safety and reliability—all to help you reduce unplanned downtime while keeping workers and the public safe.

Maximize Operations
We’re much more than pumps, valves and seals. We help you maximize your systems’ overall operational efficiency through data insights, innovative upgrades and local QRC expertise.

Local Support Worldwide
We’re everywhere you do business. Flowserve’s 180+ Quick Response Centers help to minimize downtime and resources with fast, dependable response.

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“Green World SC” was founded in January 2017 and is part of the “A + A Group of Companies”. The office of the company is located at Russian Federation, Yekaterinburg, Avtomagistralnaya str 6/1.

The main products and services of “Green World’s” activities are the development, manufacturing and implementation of new types reagents and sorbents for water treatment, water and waste waters treatment in the oil, petrochemical and utilities and metallurgical industries.

Products:
“Green World” company offers a line of innovative universal reagents for complex action of the “RAPID” series. These reagents are designed for deep and effective treatment of drinking, waste, process and bottom/production water contaminated with both organic and inorganic types of pollution. The use of this reagent helps to increase the productivity of treatment facilities, the reliability and stability of their operation at low temperatures and peak loads, reduce the cost of dewatering and disposal of the resulting sludge and deep water treatment to the required standards.

Services:
“Green World” SC offers
- Modern and truly unique solutions in the field of industrial water supply
- Comprehensive service and water management system for your enterprise: from audit and design to operation and maintenance
- Automation of the processes of dosing and control of reagents of water cycles, while the wastewater treatment process will be as economical and efficient as possible

The effectiveness of the Rapid complex reagent was proved by laboratory and production tests at various Governmental and Industrial enterprises. (Gazpromneft, Kazmunaigas, SUMZ, and others)
Do you depend on quality data to make essential decisions for your business and brands? Arabian Research Bureau ensures you’re directly connected to your customers to get real insights.

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www.arabianresearch.com
Yokogawa is a market leader in Water & Waste Water industry offering Instrumentation, Control & Automation (ICA) solutions. We offer Process Instrumentation / Automation Solutions in the Middle East & Africa region with engineering and commissioning of the projects. Yokogawa product range comprises of Sensors (Transmitters – Flow, Level, Temperature, Pressure; Process Analyzers, Test & Measuring instruments); SCADA, PLC, DCS catering entire Water value chain (Sea Water Desalination, Storage, Transmission/Distribution - Pipelines, Sewage Treatment / Pipelines, Reuse Water pipelines, Irrigation Network). In addition, Yokogawa offers Advanced Productivity and Asset Management Solutions, a Hi-fidelity Model based Operator Training Simulator (OTS) specially designed for Water Plant Operators & Cyber Security solutions.

Our non-stop creative energy is focused on getting the right solutions to our customers. Our technology expertise and unyielding focus on the customer have made us a trusted partner worldwide and a strong contributor to industry since 1915.

We have over 900+ system installations in Water & Waste Water industry globally and have large installation references in Saudi Arabia, UAE, Kuwait and Qatar in the Middle East. Further, we help customers maintain the asset & plant at optimum performance by providing committed after-sales support through training and 24 x 7 service support.

Yokogawa released its CENTUM distributed control system (DCS) in 1975, a world first. CENTUM VP is the ninth generation in the CENTUM series. Known for their rugged performance, CENTUM systems set high standards for engineering and technology excellence while ensuring backwards compatibility with previous system versions and support of the latest technology applications. Knowledge-driven engineering lies at the heart of CENTUM, a Yokogawa flagship product that has been proudly serving the process industry, over the past 40+ years.
GS E&C

Construction Leaders

As a construction leader in the 4th Industrial Revolution, GS E&C soars ever higher towards the global top tier, creating sustainable value through its passion and innovation. GS E&C (GS Engineering & Construction) has made growth as Korea’s best level construction company in all project areas, such as plant, power generation, environment, civil engineering, architecture and housing, etc. The company was founded in 1969. Since then, as a result of concerted company-wide efforts, GS E&C was incorporated into the DJSI Asia Pacific for the tenth consecutive year and ranked 22nd among the top 250 global construction companies selected by Engineering News-Record (ENR) of the United States.

Our main objective is sustainable growth, and on this basis, we are continually working to achieve profitability in our current key businesses, while strategically fostering our next growth businesses to become a Global Top Tier construction company. For this purpose, GS E&C is making full preparation for securing Global core capabilities along with strategic nurturing of the new growth project, not to mention excellent performance at the existing major business.

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email: lsh3@gsenc.com
www.gsenc.com/en/
NADA RABI

Nada Rabeei is one of the leading companies in designing and manufacturing Water Treatment, Waste Water Treatment and Water Desalination Systems in the Middle East. The capacity of (ND) Custom designed products range from 1,500 gallons to million gallons per day and above. Typical industries served are industrial, civil, farms, homes, chemical, petrochemical, oil field, pharmaceutical, semiconductor, auto parts, power, food and beverages and municipal authorities. ND is specialized in the supply of equipments and products covering Reverse Osmosis, Ion Exchange, Ultra-Filtration, Pressure Vessels for Multimedia Filters, Clarifier, Scrapers, Mechanical, Screens, De-gritting Devices, De-Watering Devices (Rotary Drums, Filter Presses and Belt Presses), Dissolved Air Floatation System, Oil Coalesces and PLC Controllers for R/O Systems.

Nada Rabeei Co. Ltd. (ND) unique policy of designing, manufacturing, erecting and maintaining its own systems, in combination with the advantage of locally available labour and high quality materials makes us a leader in the water treatment industry. As a result, the end products are high performance / high quality and easy to maintain systems.

We can provide Reverse Osmosis (R/O) desalination plants for drinking and industrial water (using Seawater, Brackish and High Brackish water as feed) with complete facilities such as PLC and MCC control system. The recovery percentage for such plants for Brackish and High Brackish water is (65-70)% and for sea water is (40-45)% using the latest made in U.S.A. membrane technology. Our highly experienced team of engineers and technicians are well trained to install, operate and maintain our water plants.

NOXXALL

Greetings from NOXXALL LLP, Bengaluru, Karnataka, Republic of India... We would like introduce an emerging and unique “MADE IN INDIA” technology for application in treatment of waste water like sewage and or industrial effluents from diverse industries – the need of the hour at these times. ADVANCED NANO OXIDATION TECHNOLOGY – vetted, assessed, validated and certified by the prestigious INDIAN INSTITUTE OF SCIENCES – Bengaluru and Bangalore University. A technology based on the PANCHABHOOTA CONCEPT for application in most environmental issues like water, air and soil remediation.

- We were invited by UNITED NATIONS to Malacca in Malaysia to present our technology to the global community of around over 25 countries. We were invited by INDIAN INSTITUTE OF TOXICOLOGY RESEARCH to present our technology on the occasion of their 50th year celebrations.
- We treat rogue effluent from industries like petroleum, slaughter houses, textiles, ordnance factory and domestic sewage providing relief for reuses or safe discharge.
- We feel that if industrial effluents are recycled and reused we could SAVE GROUND WATER (A gift by GOD) for humanity.
- We are proud to mention that our technology process has NO GLOBAL COMPETITION else ware in the world.
- New emerging technologies have to be given a fair chance to prove merits for application. WATER BUNKS in industrial areas are the future along with decentralized - containerized MOBILE TREATMENT PLANTS.
- Made in INDIA technologies are awakening global communities to look for solutions in environmental issues, hence we feel our ANOT has a global potential to provide solutions.

Amol Kumta
Business Development Manager
Mob: +968 92157923
Web:www.bahwanengineering.com
Continental Shelf of Solar Technology (CSST), Oman established in 2015, is one of the most innovative Solar engineering company in sultanate of Oman located at Al khoudh, Muscat. At present, CSST is the only company in Oman which is having three showrooms exclusively for solar products and projects in Al Khoudh, Al Mabaela and Salalah. Also, we have a well-equipped consultancy office with experienced engineers at Al khoudh CSST has committed to give high quality solar products and Projects to the society of Oman by keeping vision of Green environment. This is an Omani company in which we design, prototype, manufacture, market and distribute all type of solar products. We have already registered in DCRP to do the grid connected system for houses/ commercial/industries up to 132 KW.

Our products
- Solar street lighting
- LED /flood lighting
- Backup power systems
- Solar Power Plant
- Photovoltaic Modules
- Solar Traffic Lighting Systems
- On grid and off grid PV Systems
- Water Pumping Systems
- Solar PV Industrial Systems
- Solar fencing Systems
- Solar Water Heating Systems and Swimming pool heating systems
- Solar Home Systems
- Solar Roofing

Majid Al Alawi - General Manager  email: majid.csst@gmail.com  Tel: +968 9202 2249
Mazoon Printing Press is one of the largest presses based in Sultanate of Oman. Incorporated in the year 1968, we are the most progressive and professionally managed printing company with expertise in high volume book, flyer & commercial printing business in the Middle East region.

Our state-of-the-art printing factory in Muscat features latest printing and binding machinery to ensure high standards in print production. Built upon a strong founding vision, Mazoon Printing Press has grown into a global printing company, catering to a wide range of clients in local and international markets.

We are specialists in printing of high quality books, flyers, magazines, packaging, brochures, annual reports and directories for local sales in Oman and exports to Middle East, Africa and UK. With over 50 years of great success we are excited to move forward, meeting the challenges of new technological solutions, building on the creativity of our professional team and delivering finished products that add a vision of colours to your world.

Mazoon Printing, Publishing & Advertising LLC
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Mob: 0096899344652
Email: customer.service@mazoonprinting.com/
ajay.bahadur@mazoonprinting.com
MEDRC showcases cutting-edge water treatment technologies

The event sets out to gather key decision makers responsible for deploying innovative water treatment technologies in Oman together with leading global suppliers of the latest high-tech solutions.

Technology at our disposal will only move the strong global demand forward and put our consumers and customers in the driver’s seat. In addition, our partners who are also leaders in this field are expected to set a good example for other countries in our region.

In the six weeks leading up to World Water Day on March 22, MEDRC’s Managing Director, Mr. Saleh Al Attiyah, said that Oman was taking steps to ensure that water supplies are maintained and that the country’s water sector was transformed into a sustainable one.

The water sector in Oman has been severely affected by two different high-impact events. The first occurred in 2019 when the Ministry of Water and Irrigation announced a significant increase in water prices. The second event was the outbreak of the COVID-19 pandemic in 2020, which led to a decrease in water demand and a decrease in the availability of water for distribution.

Mr. Al Attiyah said that the country was in the process of transforming its water sector into a sustainable one, with the aim of reducing the country’s dependence on imported water. The government has already taken steps to increase the country’s water production capacity and is currently working on developing new water sources, such as desalination and rainwater harvesting.

The government has also introduced a number of policies to encourage the use of water-saving technologies and practices, such as the installation of water-efficient appliances and the development of water-efficient agriculture. MEDRC is playing a key role in this transformation, offering cutting-edge water treatment technologies that can help to meet the country’s water demand and ensure the sustainability of the water sector.

The government has also introduced a number of policies to encourage the use of water-saving technologies and practices, such as the installation of water-efficient appliances and the development of water-efficient agriculture. MEDRC is playing a key role in this transformation, offering cutting-edge water treatment technologies that can help to meet the country’s water demand and ensure the sustainability of the water sector.
Online Publications

<table>
<thead>
<tr>
<th>Publication</th>
<th>Headline</th>
<th>Date</th>
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<tr>
<td>Al Shabiba</td>
<td>مركز مدريك يعرض أحدث تقنيات معالجة المياه في السلطنة - جريدة الشبيبة</td>
<td>December 4, 2018</td>
<td><a href="https://www.shabiba.com/article/236340">https://www.shabiba.com/article/236340</a></td>
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<tr>
<td>Oman TV</td>
<td>Interview with Dr. Jauad El Kharraz on ‘From Oman’ TV show (Min 43:28 to 59:16)</td>
<td>December 5, 2019</td>
<td><a href="https://www.youtube.com/watch?v=eOmLtie03yE&amp;feature=youtu.be">https://www.youtube.com/watch?v=eOmLtie03yE&amp;feature=youtu.be</a></td>
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Table: Online News of MEDRC’s Cutting Edge Technology Showcase

Sample of Social Media Activity
Sample of Social Media Activity

**Tweet**

MEDRC Water Research
@MEDRCorg

Day two of #MEDRC's Cutting Edge Water Technology Showcase event sponsored by @NLinOman kicks off this morning with a panel discussion on #nexus challenges in Oman featuring expertise from @diam_on @MajisOman @haya_water @OmanPwp #water #energy #Oman

**Tweet**

MEDRC Water Research
@MEDRCorg

Key stakeholders in Oman's water sector engaged in this morning's discussion with contributions from Eng. Nihad Al Bimani, Asset Manager at @haya_water and Patrick Thiernpont, CEO, Barka Desalination Company @SUEZ

**Tweet**

MEDRC Water Research
@MEDRCorg

The exhibition hall during this morning's busy Cutting-Edge Water Technology Showcase @diam_on @NLinOman

---

Arjen de Vos - 2nd Founder & Director at The Salt Doctors

Great to be part of the ‘Cutting-Edge Water Technology Showcase’ in Oman last week, organized by MEDRC Water Research and the Dutch embassy. Up to 80% of the required food is imported in Oman. At the same time there are many opportunities to use the vast amounts of saline water in the country for agriculture. The Salt Doctors are ready to help with that.

Dutch expertise can help Oman tackle water-stress challenges
omandistricom

---

Reactions

Like Comment Share

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