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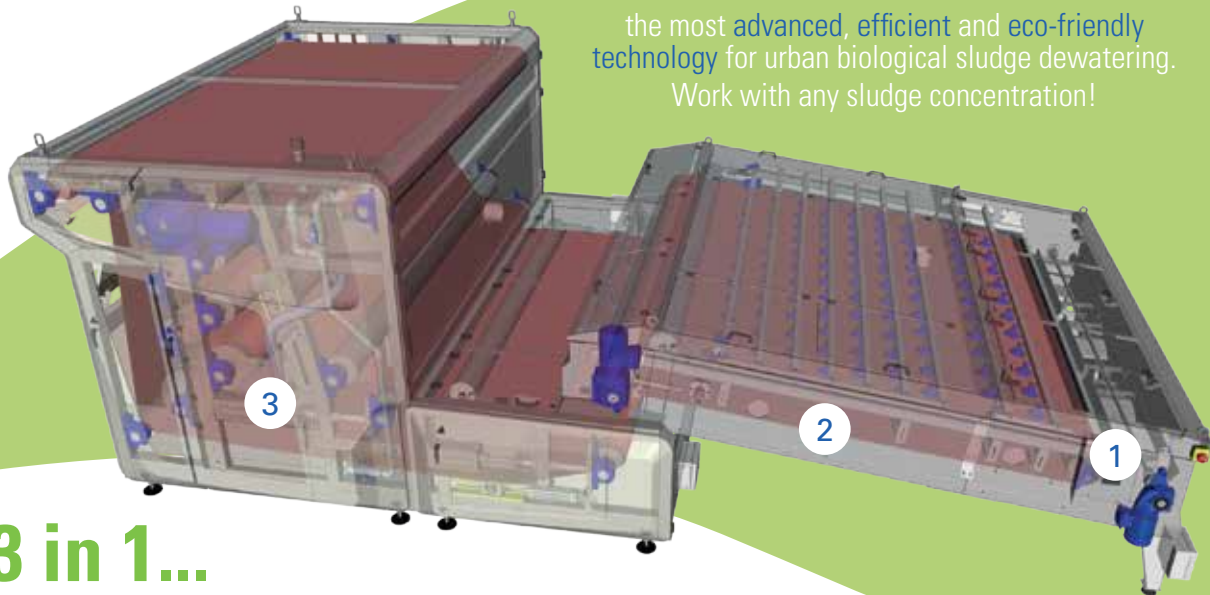


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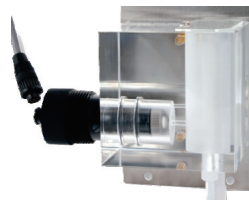


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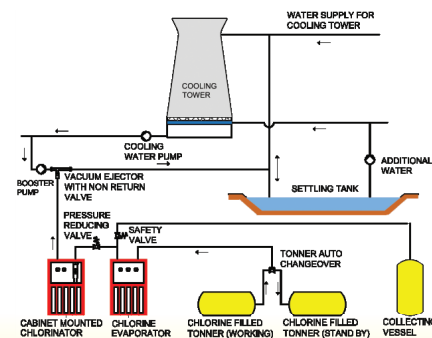
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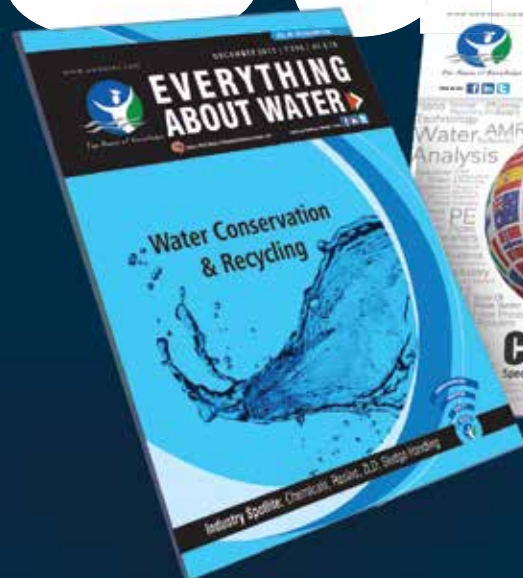
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INNOVATIONS AND WATER

Water has been identified as one of the major problems and biggest challenges for this Century. This has prompted huge investments in the water sector and a number of multinational companies have identified it as a focus area. With increasing demand in the drinking, industrial and wastewater sector, there is an acute need for new approaches and technologies. I recently had the opportunity to interact with some of the leaders of the water sector in Europe, North America and Asia and our discussions were focused on the same subject. Where are the innovations in the water sector going to come from?

Despite widespread claims about the need for water conservation, treatment and recycling, it is an accepted fact that the water sector has not seen a breakthrough technology in the last decade. Discontinuous advancements in the industry like Membrane Technology, Nanotechnology or Plastic Material

Introduction all happened over a decade back. Significant research and efforts have been made to make incremental improvements like energy recovery or higher recovery. These are laudable and not at all to be discredited. But, generation-changing innovations need out-of-the-box thinking and a fresh approach.

Being a multi-discipline field, there is a need to think beyond rigid boundaries of engineering disciplines. It is also possible that new untested technologies do not get the kind of financial backing and management support that is needed at an initial stage.

Innovation is a truly difficult thing to explain. It comes out in the most unexpected situations and locations. One theory is that studying it too closely and applying scientific analysis to it, might itself defeat the purpose of innovation. From my end, all I would like is that we create the right environment for it to nurture

and flourish. That should benefit everyone.

One of such technology I would like to discuss in particular is of Desalination. Out of the 70 cities in the world with no direct access to additional fresh water source, 42 are in coastal areas.

About 97.2 percent of earth's water resources are in the sea. 39 percent of the world's population (2.4 billion people) lives within 100 kms of the sea. With increasing demand for good water and all other water sources depleting, the desalination sector has been growing rapidly in the last decade.

Seawater desalination is most effective when implemented in water sectors with strong water policies, well-defined water resource availabilities and demand, and strong technical expertise. Currently, desalination plants provide approximately 1 percent of the

world's drinking water supply and this number is increasing every year. Estimating the global market value for desalination is extremely difficult as it is composed of a few large projects. However, the global market is roughly USD 12 billion per year - about USD 6 billion per year in capital expenditures and about USD 6 billion per year in operating expenditures.

There is no denying the fact that water is an increasingly scarce resource, and likely to become more expensive. Other prudent solutions like water conservation and wastewater recycling need to be included in an overall water management plan. But the sea is a dependable source, which will never run dry. Involving all stakeholders in arriving at the right mix, will help in a more informed debate. Leading water professionals and technology-providers must take the lead. Using the massive resources of the sea might well provide the solution to the water problems of the world...

magazine contact

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MANAGEMENT
Managing Director & Group Editor: Sunil Ghorawat

BUSINESS HEAD
AVP: Nisha Aggarwal

ART
Sr. Graphic Designer: Nitin Ahlawat

CONTENT
Sr. Manager Content: Deepak Chaudhary

MARKETING & OPERATION
Manager: Rahul Mourya

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For editorial contributions / press releases, write to:
nisha@eawater.com

For advertising enquiries, write to:
enquiry@eawater.com

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OFFICE ADDRESS

New Delhi (Head Office)

A1/152, Neb Sarai, IGNOU Road
New Delhi 110 068, India
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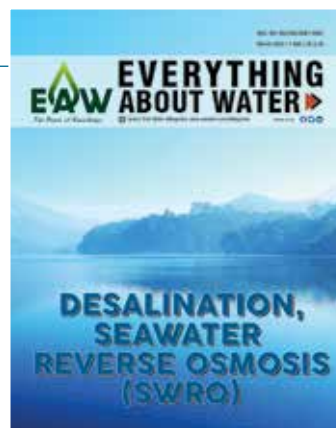
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Chennai

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Ahmedabad

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GLOBAL W

DROPLETS

SNIPPETS

1. LANXESS implements variable pricing surcharge for ion exchange resins and iron oxide adsorbers

Mumbai, 2022 - Specialty chemicals company LANXESS will globally implement a variable pricing surcharge for its Lewatit ion exchange resins and Bayoxide iron oxide adsorbers which will be applied with immediate effect. The existing fixed surcharge will be adjusted based on the most relevant input costs on a monthly basis. In April / May 2022 the adder will be at around EUR 0.9/l or the equivalent amount in national currency. Customers will be contacted individually.

This step became necessary since the already tense cost situation has worsened even further due to the war in the Ukraine. The markets worldwide are experiencing an unprecedented volatility and prices for energy, raw materials and transportation increased at unexpected and unpredictable magnitudes.

The LANXESS Liquid Purification Technologies business unit is one of the world's leading global solution providers for water treatment and liquid purification. Ion exchange resins and iron oxide adsorbers are used in numerous industries and applications to purify water and other liquid media effectively.

2. NX Filtration wins project for wastewater reuse at Cross Textiles

Enschede, the Netherlands, April 2022: Cross Textiles, a denim & lifestyle brand and producer with customers such as Jack & Jones, H&M, Inditex, Ralph Lauren and Mango, selected NX Filtration for the delivery of its direct nanofiltration (dNF) membranes for wastewater treatment and reuse at its production facilities in Çorlu, Turkey. The dNF technology enables the removal of colour and organics from the textile wastewater stream, making this water suitable for reuse in Cross Textiles' facilities.

This project follows a series of pilot tests

1. Danfoss builds the supermarket of the future at its headquarters in Nordborg

NUREMBERG/NORDBORG - Danfoss hosted a ground-breaking ceremony for the construction of one of the world's most energy-efficient supermarkets.

The Smart Store supermarket will be filled with the latest and most energy-efficient refrigeration and heating technology.

Instead of allowing the heat produced by cooling cabinets and freezers to go to waste, it will be captured and reused to provide heating for the supermarket and the local community through district energy. The cooling system in the new supermarket will also run on carbon dioxide - a natural refrigerant - which helps to reduce the overall climate impact.

Kristian Strand, President, Refrigeration & A/C Controls, Danfoss Climate Solutions

says: *"This ground - breaking - a much awaited event - is more important than ever. The origins of this project go back a long time, but the new energy - efficient Smart Store supermarket that we are starting to build today has only grown in relevance. The goal of the project is to show how easy and profitable it is to decarbonize our economy and ensure reliable and sustainable energy use. Heating and cooling are the largest energy consumers in supermarkets. The solutions we are building here today represent the core of Danfoss solutions and will showcase how we can approach zero energy use in food retail together."*

The state-of-the-art supermarket is situated right next to Danfoss' headquarters and will lead the way for how supermarket chains around the world can build climate-friendly and sustainable stores with the technologies that already exist today. The supermarket will be completed in the summer of 2023.

Additionally, this site will serve as an Application Development Center where Danfoss will work together with partners to co-develop new technologies and explore interfaces in the energy system surrounding energy storage.



ATER NEWS

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"The supermarket will be the focal point for a new part of our campus, where all buildings will be energy-efficient and meet special sustainability requirements. Our aim is to boost the green transition with concrete evidence of how far we can go with energy efficiency. We want to demonstrate to customers and partners how energy saving solutions work in real life. We want to show the greenest energy is the energy we don't use or reuse. That's why visits to supermarkets will be one of the major attractions when the IEA delegates arrive in Denmark in June for the 7th Annual Global Conference on Energy Efficiency,"
Jürgen Fischer, President, Danfoss Climate Solutions adds.

BALS, Brugsen for Als and Sundeved, Denmark's largest independent supermarket association, will rent the building from Danfoss and will install a COOP 365 discount supermarket. BALS, which works together with COOP, has a total of 13 stores in the area around Sønderborg in Denmark and since 2015 has consistently reduced the consumption of energy in its stores. So far, they have cut 44 percent of their total CO2 emissions. Therefore, it was a natural next step that BALS became a partner in the project.

Lars G. Andersen, managing Director of BALS, says: *"We already have a lot of experience, but the energy price spikes have put further pressure on the need for change. Our 13 supermarkets have been modernized and we have nearly no cost for heating in the stores because the heat comes from our freon-free refrigeration systems, solar cells, and heat pumps. It is an advantage with the current energy prices, and it reduces our CO2 emissions. We are proud to be part of one of the most energy-efficient supermarkets in the world and test the solutions that can help buildings become climate neutral."*

Showroom for customers

Danfoss is establishing a showroom in a part of the supermarket building, where all installations are visible to visitors and customers. Danfoss' solutions for heating and cooling such as CO2 as a refrigerant, heat recovery and the interaction between installations will thus be experienced while they are in operation.

"Our new Smart Store shows what is possible with today's technology, such as our Alsense software. The integration of hardware and software tools into this store underscores the growing importance digitalization has for the green transition. BALS is the perfect partner because their employees, neighbors and customers will contribute to this important experience," **says Tuuli Sarvilinna, Senior Vice President Electronic Controllers and Services, Danfoss.**

The service part of the building will be handled by Ohmia Retail, a Norwegian partner responsible for the operation and monitoring of all installations. The supermarket will be connected to Nordals Fjernvarmeværk and will be able to supply surplus heat to the local district heating network.

Facts:

An OK gas station and a car wash will be located on the premises.

DROPLETS

SNIPPETS

during the first half of 2021. These pilots demonstrated the ability of dNF to remove color, turbidity and organics, including specific components for the textile industry (such as dyes, detergents and fixing agents) from Cross Textiles' wastewater stream.

This enables the reuse of wastewater and therewith reduces Cross Textiles' water footprint. Based on these results, Cross Textiles decided to implement a full-scale water reuse system with a capacity of 1,200 cubic meters per day, enabling them to reduce their water intake with over 50%. The system will be based on NX Filtration's dNF40 membranes that offer the most selective characteristics in the market. The system is expected to be commissioned in the second quarter of 2022.

ÖkoteK, NX Filtration's distributor in Turkey, supported Cross Textiles during the pilot tests and system design. ENTA, specialist in water treatment systems, has won a tender to provide the overall system based on NX Filtration's dNF membranes.

Mehmet Yüceyurt, General Manager at ENTA: "We are proud to have been selected by Cross Textiles and to be able to use the innovative dNF technology in our water treatment system. This technology allows us to achieve high performance results in a relatively simple and very robust system set-up."

Sebnem Aybige Barlas, Vice President at ÖkoteK: "This project is an excellent example of the potential of dNF technology to reduce industrial companies' water footprint, in combination with offering strong sustainability benefits. dNF-based systems avoid the use of pre-treatment chemicals and require substantially less energy than conventional systems."

Rick te Lintelo, Sales Director at NX Filtration: "We are proud to support Cross Textiles in their journey to reduce their water footprint. This is yet another example of the enormous potential of our dNF technology to avoid

GLOBAL WATER NEWS

DROPLETS SNIPPETS

wastewater discharge and enable reuse in the textile industry.”

3. Changes on the LANXESS Board of Management



Mumbai, March 28, 2022 - Stephanie Coßmann, Labor Director and member of the Board of Management of LANXESS AG, will leave the Cologne-based specialty chemicals company at her own request on March 31, 2022, to pursue her professional career outside LANXESS.

Coßmann (48), who holds a doctorate in law, has worked at LANXESS since 2004. After various tasks in the legal department, she headed the Human Resources department from 2017. Since January 1, 2020, she has been a member of the Board of Management and Labor Director of LANXESS AG. She has been responsible for the Human Resources and Legal and Compliance corporate functions as well as for the Leather business unit.

LANXESS CEO Matthias Zachert: “My colleagues on the Board and I would like to thank Stephanie Coßmann for the trustful cooperation. She has contributed to making LANXESS a modern and attractive employer, especially through her work in HR and as Labor Director.”

LANXESS Chairman of the Supervisory Board Matthias Wolfgruber: “We very much regret the departure of Ms. Coßmann and thank her for her valuable work. We wish her much success and all the best - both for her professional and personal future.”

Stephanie Coßmann's successor is to be

The entire supermarket area and surroundings will be around 14,000 m². The COOP 365 store will be almost 1,500 m².

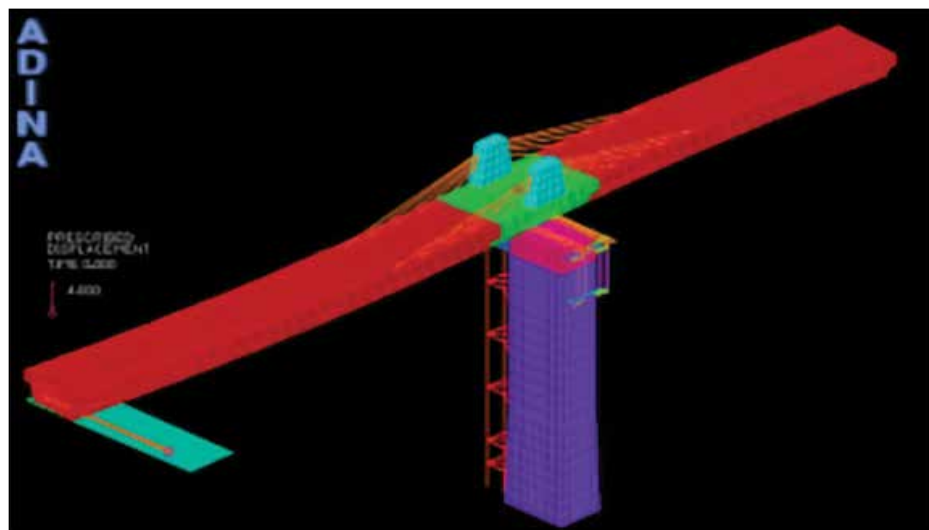
Danfoss owns all installations in the store, allowing continuous monitoring and optimization of systems. In this setting, Danfoss continuously tests applications, new products and uses the building as a showroom and training facility for visitors and customers.

2. Bentley Systems Announces Acquisition of ADINA to Extend Nonlinear Simulation throughout Infrastructure Engineering

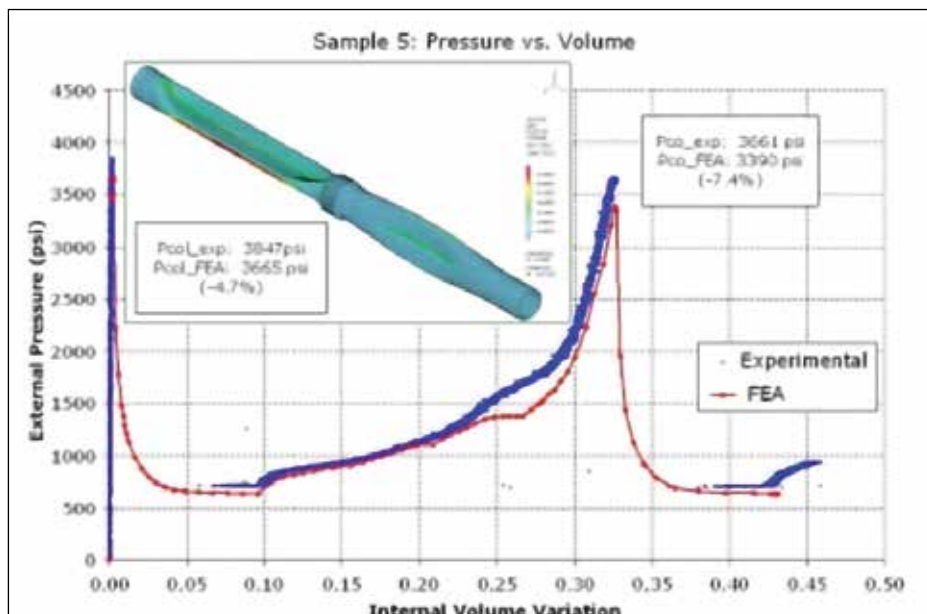
EXTON, Pa. - April, 2022 - Bentley Systems, Incorporated, the *infrastructure engineering* software company, today announced it has acquired Watertown, Massachusetts-based ADINA R & D Inc., a leading developer of finite element analysis software applications used in a comprehensively diverse range of engineering fields (adina.com). ADINA was founded in 1986 by Dr. Klaus-Jürgen Bathe, professor of mechanical engineering at the Massachusetts Institute of Technology and a world-renowned leader in the field of finite element analysis and its applications.

Civil, structural, and mechanical engineers choose ADINA software for its authoritative veracity, including in analysis of buildings, bridges, stadiums, pressure vessels, dams, and tunnels. By virtue of the ADINA System's integral robustness across disciplines, materials, and simulation domains (structures, mechanical, fluids, thermal, electromagnetic, and multi-physics), engineers use it to perform comprehensive safety and performance studies where reliability and resilience are of critical importance.

With infrastructure digital twins, users can simulate the complete behavior of structures to create confidence in designs that are much safer and more cost-effective than those merely analyzed to meet prescribed code standards. Of particular importance for infrastructure resilience, ADINA will also be applied within digital twins of existing infrastructure assets, now made practical by the Bentley iTwin platform, to simulate



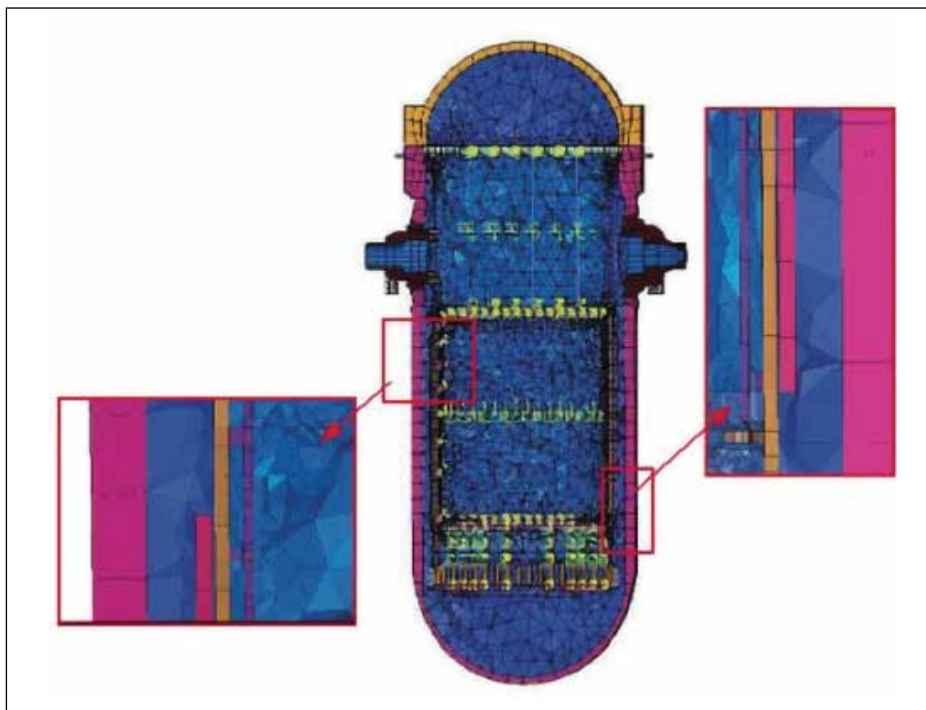
The frictional sliding of a pre stressed concrete bridge girder can be studied with ADINA technology.



Collapse analysis of pressurized pipe can be performed with ADINA software.

their responses and vulnerabilities to stresses so extreme that nonlinear effects must be considered - caused (for instance) by seismic, wind, flood, pressure, thermal, collision, or blast forces.

The ADINA System's nonlinear simulation capabilities will in turn become directly



Simulation of a pipe break in a nuclear reactor using ADINA technology.

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appointed as soon as possible. LANXESS remains committed to increasing the proportion of women in management positions.

4. SPML Infra Received INR 1157.08 Crore Order of Isarda Water Supply Project in Rajasthan under Jal Jeevan Mission

Kolkata, 25 March 2022: India's leading water infrastructure development company, SPML Infra Limited has received a new bulk water supply project order (Isarda Water Supply Project to provide safe drinking water in Dausa and Sawai Madhopur districts) from Public Health Engineering Department, Tonk, Rajasthan under the flagship scheme of Jal Jeevan Mission.

The ambitious Isarda Water Supply Project of Govt. of Rajasthan envisages providing safe drinking water facility to almost 25 Lac rural and urban populations that will benefit 1079 villages and 5 towns in Dausa and 177 villages and 1 town in Sawai Madhopur districts in Rajasthan. The order valued at INR 1157.08 Crore (USD 151.6 Million) is awarded to SPML Infra Limited, is the largest single order received by the company to execute an important water supply project in Rajasthan. The scope of work includes:

- 341 Kilometers of 150 mm - 1900 mm dia MS & DI Raw Water and Clear Water Transmission Pipeline
- 225 MLD Water Treatment Plant (WTP) at Isarda, Dausa
- 2 Pumping Stations (including civil work, pumping machinery, related piping, electro mechanical, instrumentation works), one at WTP and another at Bagri
- 2 Clear Water Reservoirs: 24.50 Million Litres at WTP and 21.50 Million Litres at Bagri
- Construction of 33 kV Power Substation at Intake Pumping Station
- Other civil works, office, residential buildings, crossing at National Highways, Railways, and Petroleum/Gas pipe lines etc.

The work to be completed in 2 year's time along with 1 year of defect liability period and 10 years of operation and maintenance post

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commissioning.

Commenting on the new project order, **Mr. Subhash Sethi, Chairman, SPML Infra Limited** said, *"We are very delighted that our experience of executing several hundred water supply projects has helped us in winning this large project in Rajasthan. SPML Infra has excellent track record of executing water supply projects in the state and we are sure that the trust placed on us by our esteemed client will be fulfilled in exemplary manner. We are fully committed to the cause of water and this project under the ambitious scheme of Jal Jeevan Mission will certainly help our client to provide clean drinking water to large number of rural households in the state. It will be our endeavor to develop a robust and sustainable infrastructure for providing valuable water for drinking to realize the idea of 'Har Ghar Jal' and making a good contribution towards the development of the state."*

5. Nashik Municipal Corporation to set up another STP at Gangapur

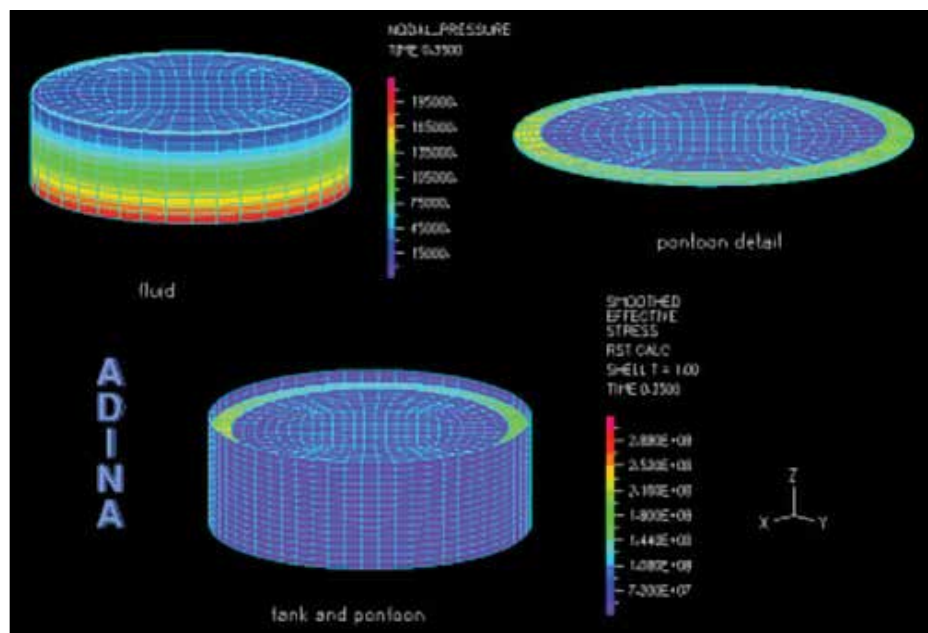


The Nashik Municipal Corporation (NMC) is planning to construct another sewage treatment plant (STP) at the existing Gangapur STP site at a cost of around Rs. 36 crore. The proposed STP will have a capacity to treat 20 million litres per day (MLD). The existing STP at was built at a cost of Rs. 50 crore, including the land cost, and was made operational last year.

Currently, the NMC has 11 STPs in the city treating sewage water with a total sewage treatment capacity of 392 MLD. The civic administration has prepared an action plan of the city's sewage treatment management considering the population growth by 2026. Hence, the NMC will have to increase the capacity of the STPs from 392 MLD to 440 MLD.

accessible, through convenient technical and commercial integration, to users of Bentley Systems' uniquely comprehensive modeling and simulation software portfolio for infrastructure engineering. As the ADINA System's nonlinear extensions are introduced to complement these existing physical simulation applications - currently spanning STAAD, RAM, SACS, MOSES, Auto PIPE, PLAXIS, LEAP, RM, LARS, SPIDA, and PLS - the scope of mainstream simulation underlying the engineering of infrastructure resilience will be valuably enhanced. ADINA's advantages also include advanced dynamics, 3D solid FEM, buckling, sub structuring, and advanced meshing for critical joints and sections.

"Incorporating ADINA and its creators is very exciting for all of our engineering simulation teams, as it will also be for existing and new users," said Raoul Karp, vice president, engineering simulation at Bentley Systems. "Dr. Bathe literally wrote the book on advancing finite element simulations, and the ADINA System provides the reference for benchmarking all other disparate analysis approaches. We will now be able to extend nonlinear realism across all of our infrastructure digital twin simulation offerings." Founder of ADINA Dr. K.J. Bathe, who will remain as a technical advisor, said, "My colleagues and I are proud to be joining Bentley Systems' broad and deep simulation team. Our aim in the development of ADINA has always been to provide a most reliable and efficient analysis tool to scientists and engineers, and it is wonderful that with Bentley, ADINA will now be used and further developed with great potential for solving the varied and interrelated challenges of infrastructure resilience."



Sloshing of an oil tank with the base subjected to horizontal ground motion with ADINA software.

3. Toshiba receives a Contract for a Large-scale Ozone Treatment System at Chandrawal Water Treatment Plant in Delhi

EXTON, Pa. - April, 2022 - Bentley Systems, Incorporated, the *infrastructure engineering* software company, today announced it has acquired Watertown, Massachusetts-based

ADINA R & D Inc., a leading developer of finite element analysis software applications used in a comprehensively diverse range of engineering fields (adina.com). ADINA was founded in 1986 by Dr. Klaus-Jürgen Bathe, professor of mechanical engineering at the Massachusetts Institute of Technology and a world-renowned leader in the field of finite element analysis and its applications.

Kawasaki, Japan - Toshiba Infrastructure Systems & Solutions Corporation (hereafter TISS) today announced that they have concluded a contract with Larsen & Toubro Limited (hereafter L&T) for three ozone generators at the Chandrawal Water Treatment Plant in Delhi, India, being executed by Delhi Jal Board. This is one of the largest-scale ozonation systems for a water treatment plant in India.

The project is funded by Japan International Cooperation Agency (hereafter JICA) under the Delhi Water Supply Improvement Project.

JICA assisted 477MLD Water Treatment Plant at Chandrawal, being constructed by L&T by replacing the existing water treatment plants, would be equipped with Toshiba's ozonation systems, having three ozone generators with each 31 kg per hour capacity.



Toshiba Ozone generator

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6. STPS EXEMPTED FROM GST: THE MAHARASHTRA APPELLATE AUTHORITY OF ADVANCE RULING (AAAR)

The Maharashtra Appellate Authority of Advance Ruling (AAAR) consisting of members Rajeve Kumar Mital and Ashok Kumar Mehta has ruled that sewage treatment plants (STP) are exempted from the goods and service tax (GST).

The appellant, Rashtriya Chemicals and Fertilisers Limited, is in the business of manufacturing and selling fertilisers and industrial chemicals. The appellant has a sewage treatment plant at its Trombay premises. The plant uses sewage water and converts it into water for use in the factory for the manufacture of the fertilisers. The appellant has set up a new sewage treatment plant, which became operational on September 10, 2019, with the objective of becoming self-reliant in meeting the daily process water requirements of the Trombay unit. The Appellant agreed to supply such treated water to Bharat Petroleum Corporation Limited (BPCL) for use in the refinery.

The appellant has sought an advance ruling on the issue of whether "treated water" obtained from STP (classifiable under Chapter 2201) will be eligible for exemption from GST by virtue of Sl. No. 99 of the Exemption Notification No. 02/2017-Integrated Tax(Rate) dated June 28, 2017 (as amended) having an entry as "Water (other than aerated, mineral, purified, distilled, medicinal, ionic, battery, de-mineralized, and water sold in-sealed container)".

The AAAR observed that the government, whether the Central Government or State Government, has never intended to tax water for general purposes. Even under the GST regime, the government has clarified its intention of not levying GST on the supply of general-purpose water by way of the issuance of Circular No. 52/26/2018 dated August 09, 2018, in which it has been clarified that the supply of drinking water, for public purposes, if not supplied in sealed containers, is exempted from GST.

GLOBAL WATER NEWS

Ozone is a powerful oxidant and has many applications, including dechlorination, deodorization, inactivation of viruses and bacteria, oxidation of organic and inorganic substances and a reduction in trihalomethane*1 formation during chlorination. In addition, ozone has hardly any adverse impact on environment because it simply reverts to oxygen after use.

In Japan, ozone treatment is commonly used at large water treatment plants especially in urban areas. Toshiba began developing and delivering ozonation systems in the 1970s. Since then, Toshiba has delivered more than 130 ozonation systems for over 100 projects. In recognition of past strong track record, Toshiba has secured this contract with L&T.

Toshiba Group endeavors to contribute to the establishment of sustainable water recycling systems and the creation of environmentally advanced communities by leveraging its water treatment and solutions technologies cultivated through years of development and extensive experience in overseas EPC*2 and O&M*3 projects.

(*1) Chemical compounds in which three of the four hydrogen atoms of methane (CH₄) are replaced by halogen atoms. THMs are also environmental pollutants, and many are considered carcinogenic.

(*2) Engineering, procurement, and construction

(*3) Operation and maintenance

4. Abengoa celebrates the inauguration ceremony of the Rabigh 3 desalination plant

April, 2022 - Abengoa, an international company that applies innovative technology solutions for sustainable development in the infrastructure sectors, was present at the inauguration ceremony of the Rabigh desalination plant, the largest reverse osmosis desalination plant in commercial operation in the world, with a capacity of 600,000 m³/day.

In an emblematic event, H.E. Eng. Abdulrahman Abdulmohsen A. AlFadley, Minister of Environment, Water and Agriculture, H.E. Eng. Khaled Al Qureshi, General Manager of the Saudi Water Partnership Company, Mr. Mohammad Abunayyan, Chairman of the Saudi Water Partnership Company and Mr. Mohammad Abunayyan, Chairman of the Saudi Water Partnership Company, met in the city of Rabigh (Saudi Arabia) to inaugurate the Rabigh desalination plant. Mohammad Abunayyan, Chairman of ACWA Power, and Mr. Faisal Al Nowaiser, member of the Board of Directors of SBCC-SAWACO, in addition to representatives of the consortium responsible for the EPC of the project, Abengoa,

SepcoIII (Power China) and Sidem (Veolia).

The CEO of Abengoa Water and Energy, Ángel Alday, highlighted that “this iconic project is a clear example of Abengoa’s interest in participating in the achievement of the strategic objectives of Saudi Arabia’s Vision 2030, with an extraordinary development of desalination in the country, and an interest in setting records in reducing water tariffs and minimizing the carbon footprint”.

Recently, the Rabigh plant was recognized as the world’s largest reverse osmosis desalination facility by Guinness World Records™, the world’s leading authority on record-breaking. Among other benefits, it has been recognized as the plant with the highest level of operating efficiency and respect for the environment, as well as the lowest electricity consumption and noise levels in the world.

Abengoa has been shortlisted also for the awards organized annually by the prestigious water sector publication, Global Water Intelligences (GWI), in the category of desalination plant of the year for the Rabigh 3 project.

Rabigh 3, a world reference in desalination

Rabigh 3, with a capacity of 600,000 m³/day, and located in Saudi Arabia, is the largest reverse osmosis desalination plant in commercial operation in the world. The plant, which is already supplying water to the network at full capacity, ensures the supply of drinking water to more than three million people in the cities of Makkah, Al-Mokarramah, Jeddah and Mastorah.



The contract for the engineering, procurement and construction (EPC) of this project was awarded in 2018 to the consortium formed by Abengoa, SepcoIII (Power China) and Sidem (Veolia), hand ACWA Power. Once the project is completed, the desalinated water is supplied to the state-owned Saudi Water Partnership Company (SWPC).

This project is a world reference as it features a design that allows it to reduce energy consumption and increase plant availability. Furthermore, it contemplated a local Saudi content of 40 % of supplies and subcontracting during construction, a great achievement reached by the consortium integrated by Abengoa. Abengoa, world leader in desalination

Abengoa, leader in the international desalination market, currently has five plants under construction and a total installed capacity of 2.4 million m³/day, distributed in more than 30 desalination plants in 13 countries, which will be increased to 4.3 million when the portfolio under execution is completed.

5. SEMIKRON and Danfoss Silicon Power join forces to establish the ultimate partner in Power Electronics

NUREMBERG / NORDBORG - SEMIKRON and Danfoss Silicon Power announced a merger to create a joint business specialized in Power Electronics focusing on power semiconductor modules. With an existing workforce of more than 3,500 dedicated power electronic specialists, the new SEMIKRON-Danfoss will provide world-class technology expertise as the leading partner in Power Electronics. The merger comes with a firm commitment to future investments, paving the way for green growth and a more sustainable, energy efficient and decarbonized future. SEMIKRON-Danfoss will be a central enabler of this transition.

The electrical power will be in the future the most important energy source. The power semiconductor module is at the heart of all power electronic solutions. The module is built of power semiconductors that makes it possible to convert and control the electrical power.

With the rise of e-mobility, the demand for electric vehicles is expected to increase by 30% each year over the next years. This speaks to the enormous growth potential of power modules as they are a key component for powering the electric motor and in vehicle chargers.

Industrial motors are consuming 50% of electrical energy in the world and only 20% of these motors are equipped with variable speed motor controls, leaving a large untapped potential to

improve energy efficiency and reduce CO2 emissions. The power module is the key component in any variable speed control for electric motors.

The ongoing global transition aiming at replacing fossil fuels by improving energy efficiency and ambitious use of renewables also increases the demand for power modules. The power module is critical in all solar installations and all wind turbines to enable the power conversion to grids and energy storage.

SEMIKRON-Danfoss will leverage its strong core business in industrial- and renewable power module applications and will utilize the partnership to target a leading position in Automotive power modules. SEMIKRON-Danfoss will set the trend and drive the technology shift into Silicon Carbide solutions in both industrial and automotive applications.

The newly formed SEMIKRON-Danfoss joint business will be owned by the current owner-families of SEMIKRON and the Danfoss Group, with Danfoss being the majority owner.

The new joint business SEMIKRON-Danfoss will be managed by one common leadership team. The joint business will be operated in the accustomed manner, retaining existing production facilities, customer and supplier relationships and distribution channels.

SEMIKRON-Danfoss will retain the two main locations in Germany, Nuremberg and Flensburg. The current factories and sales offices of Semikron and Danfoss Silicon Power will continue operations as usual.

Danfoss, President & CEO, Kim Fausing, said “The new SEMIKRON-Danfoss builds on a strong long-term partnership and more than 90 years of combined technology leadership in Power Module



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packaging, innovation, and customer application expertise. With electrification driving the green transition, SEMIKRON-Danfoss aims to become the preferred decarbonizing partner for customers. We have the passion, competences and technologies to more than double our business in five years.”

SEMIKRON CEO Karl-Heinz Gaubatz added: “This really is an exciting moment. Based on close, trusting conversations over the last months we have identified that SEMIKRON and Danfoss are a unique fit with complementing assets, a strong team and shared values. By combining SEMIKRON’s expertise as a pioneer for semiconductor technology with more than 70 years of experience in the development of top-class power modules and systems and the strength, innovativeness and fast-paced operations of Danfoss Silicon Power and the Danfoss Group we are positioned ideally to become one of the strongest players in power electronics.”

Claus A. Petersen, Senior Vice President and General Manager Danfoss Silicon Power, concludes “The new SEMIKRON-Danfoss is a great opportunity for customers, partners and our employees. Timing is perfect, with strong growth in our key markets Automotive, Industry and Renewables. With the emerging technology transition from Silicon to Silicon Carbide, we are set to become the strongest partner of our customers. SEMIKRON-Danfoss will inspire the future and offers great career opportunities”.

6. Bentley Education Announces New Student Contest: The Digital Twin Design Challenge

EXTON, Pa. - March 25, 2022 - Bentley Systems, Incorporated, (Nasdaq: BSY) the infrastructure engineering software company, today announced Bentley Education’s Digital Twin Design Challenge - a student contest that provides an opportunity to reimagine a real-world location with a structure designed with the popular Minecraft video game. Digital twin technology is set to be the next powerful tool for future engineers, and this contest is a unique opportunity for students to explore it in a creative way.

Through the Digital Twin Design Challenge, students have the chance to combine their imagination and creativity by exploring infrastructure digital twins. Students will use Minecraft to take a real-world location and design a new structure within it. In addition to gaining recognition from Bentley Education, the top 20 finalists will receive USD 500 each. The winner chosen by expert judges will receive a prize of USD 5,000, and the winner from the popular vote category will win a prize of USD 2,000.

The challenge is open to students aged between 12 years and 25 years from secondary schools, high schools, community



colleges/schools, polytechnics, technical institutes, and universities. Students can design structures that address issues like environmental sustainability, architectural aesthetics, and population growth, or solve a specific engineering challenge. These designs can be in the form of any superstructure, such as a building, bridge, monument, park, train station, or airport.

With the world and its infrastructure facing many growing challenges, future engineers will turn to digital twin technology to manage them. Because digital twins are virtual representations of the real world, they can help combine and visualize data to optimize decision-making and enable effective planning and action.

Katriona Lord-Levins, chief success officer, Bentley Systems, said, “This challenge is continuing Bentley Education’s mission of nurturing future professionals for careers in engineering, design, and architecture. We want students to show their creativity using Minecraft and explore the potential of Bentley’s iTwin technology to tackle a challenge facing the world’s infrastructure. And, along the way, we want to inspire and encourage students to learn about infrastructure engineering as a possible career and expose them to the opportunities that lie ahead, with infrastructure going digital.”

7. Mumbai to implement ‘Water for all’ policy from next month: Free drinking water for all Mumbai residents

Mumbai, March - From May 1, BMC will enable every citizen in Mumbai to have access to drinking water through formal sources.

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While it doesn't change the legal status of a type of residence, it'll enable citizens living in slums/buildings without OCs to have access to water. The announcement was made by Maharashtra tourism and environment minister Aaditya Thackeray in a meeting on the issue at the BMC headquarters.

Under the new policy, water supply will be made available to all including slum dwellers, who were previously excluded. Even people staying on footpaths and roads will be given water connections.

Mr. Thackeray further said that no one should remain thirsty in the city and hence different sources of water supply like water desalination plants are being developed. The minister also pointed out that the policy aims to curb illegal water connections and water contamination, apart from protecting an individual's fundamental rights.

8. Bentley Systems Recognized as the Microsoft Asia Pacific Region Social Impact - Sustainability Changemaker Partner of the Year

EXTON, Pa. - March 21, 2022 - Bentley Systems, Incorporated (Nasdaq: BSY), the infrastructure engineering software company, today announced that it was recognized as the Microsoft Asia

Pacific Region Social Impact - Sustainability Changemaker Partner of the Year 2021. The announcement was made at the Microsoft Singapore & Asia Pacific Partner of the Year Awards 2021 celebrations on February 18, 2022 at Marina Bay Sands Singapore.

The Microsoft Asia Pacific Partner of the Year Award 2021 celebrates and recognizes regional partners who are focused on customer and community success by delivering unique and differentiated solutions built on core technologies across the Microsoft Cloud platform. Additionally, the winner needs to demonstrate commitment to the Asia Pacific region and evidence exceptional customer experience across multiple markets in the region.

Bentley Systems was recognized for providing outstanding solutions and services in the Social Impact - Sustainability Changemaker Award category. The Sustainability Changemaker Partner of the Year Award recognizes a partner organization that excels at providing innovative and unique services or solutions based on Microsoft technologies that help customers solve challenges of sustainable digital transformation.

"We are honored to receive Microsoft's Asia Pacific Region Social Impact Recognition - Sustainability Changemaker 2021 award. This is a testament to our users' passion for sustainability and spirit of innovation empowered by our joint software solutions. Bentley's mission is to empower our users to advance both the global economy and the environment for improved quality of life, so it is especially heartening to receive the recognition in this award category in Asia Pacific," said Kaushik Chakraborty, vice president, Bentley Systems Asia Pacific.

"In Asia Pacific, we see each day our partners coming together - to build together, to innovate together - to empower not just our customers but also the communities we operate and live in. These partners replicate the impact they create across the region. Bentley Systems is one such leader of our partner ecosystem that is helping the region to emerge stronger from the pandemic with their innovation and dedication to purpose-driven technology. We are pleased to congratulate Bentley Systems as the Social Impact - Sustainability Changemaker Partner of the Year 2021," said Vivek Puthucode, chief partner officer, Microsoft Asia Pacific.

9. Danfoss strengthens its 'Make in India' commitment with new hydrostatic production line in Pune

PUNE, INDIA - Eaton Fluid Power Ltd., a member of Danfoss group, has launched an all-new production line for hydrostatics at its state-of-the-art facility in Pimpri, Pune, to cater to the demand



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of the local agriculture sector. Danfoss is the first organization to have manufacturing capability of hydrostatics transmission solutions in India.

The inauguration was presided over by **Mr. Eric Alstrom**, President of Danfoss Power Solutions, **Astrid Mozes**, President Hydrostatics Division & **rest of Danfoss Power Solutions Leadership Team** from headquarters, **India leadership team** and select Pimpri campus employees, following due Covid protocols.

*“Danfoss has a long and proud history in India, and the addition of our locations in Pimpri and Magarpatta will add to our footprint and further opportunities in India, a market which will see significant investments from Danfoss in the years to come, given its immense growth potential. Our strategic investments towards digitalization is showing great results and the new hydrostatics production line is a testimony to that. We are positive that our customers will receive an unmatched level of service and expertise from us and be well positioned to cater to the increasing demand from India market”, said **Eric Alstrom, President of Danfoss Power Solutions.***

The recent global acquisition of Eaton's hydraulics business has strengthened Danfoss Power Solutions offerings, which now include the broadest selection of mobile and industrial hydraulics products and fluid conveyance solutions available in the market. This merger has established Danfoss as a global leader in mobile and industrial hydraulics, for the construction, agriculture, and other off-highway vehicle markets.

The addition of this new hydrostatics line will help improve the energy efficiency and sustainability quotient of applications where these solutions are deployed. The fast return on investment & operational efficiency offered by the product also makes it well suited for the Indian market. This new state-of-the-art assembly line and test stand is MES integrated, very high on Safety and in-process Poka-yoke, keeping in mind the strong safety culture and zero-defect mindset. The digitalization capabilities, size and accessibility benefits of the product are also its highlight.

Danfoss's Pune facilities address the rising demand for innovation and development in India's digitalization, urbanization, agriculture & electrification journey. “In line with the government's vision towards ‘Make in India’, around 95% of all the products that are manufactured in our facility use materials and components that are made in India. The company aims to invest on increasing its product offerings in India and remains firm on its mission to ensure a minimum of 75% localization level for sourcing and manufacturing in future product lines” said **Prasanna Kumar** who leads Eaton Fluid Power Business in India.

The location also places the manufacturing facility in close proximity with its key customers across various sectors and also the Danfoss India Innovation Centre located at Magarpatta, Pune. The access and availability of land, infrastructure and skilled labor in the area have also been a key consideration for the company to strengthen its base in the city.

“It is a proud moment for us as we commence this new Hydrostatics production line to cater to the demands of the Indian market. It is a step towards our commitment of localization and making in India for India. India continues to be an integral region for the growth of Danfoss and we remain committed to engineering a better tomorrow by developing energy efficient solutions and driving long-term sustainable value creation,” said **Ravichandran Purushothaman, President - Danfoss India Region.**

10. FRAUNHOFER AND SIRUTHULI WILL SET UP A WATER INNOVATION HUB, IN COIMBATORE

Fraunhofer (German research organization) and Siruthuli (NGO based in Coimbatore) will set up an “AQUA-Hub”, a water innovation hub, in Coimbatore, Tamil Nadu. As per their press release, India's cities faced complicated tasks to meet the infrastructure needs of rapidly growing areas. Water scarcity, inadequate waste water treatment, and lack of access to and knowledge of technological solutions pose major challenges for India's water sector. Several German players have knowledge and specialised technologies that can contribute to solutions. However, the often specialised and decentralised players find it difficult to gain a foothold in the Indian market.

AQUA-Hub Water Innovation Hubs will be implemented in two Indian Smart Cities, Coimbatore and Solapur, and accompanied by pilot measures of German technology for water quality monitoring. AQUA-Hub addresses the needs of the local water sectors identified in previous projects, as well as the challenges of the German water industry to develop projects, relationships, and business on the Indian market.

Marc Beckett, senior scientist of Fraunhofer Institute for Interfacial Engineering and Biotechnology, interacted with stake holders here recently. Stefan Liehr, Head of Research Unit “Water Resources and Land Use”, Institute for Social-Ecological Research, Germany, was also present. R.S. Krishnaswamy, Convenor of Water Watch at Siruthuli, welcomed the gathering and Anandi Iyer, Director, Fraunhofer Office India, set the context for the meeting. Siruthuli was instrumental in bringing together various stakeholders.

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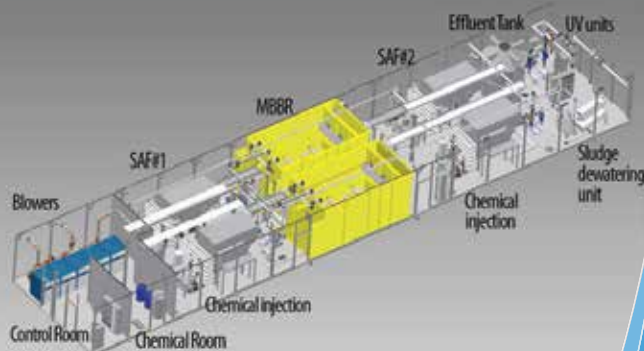
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Save Water, Save World

WORLD WATER DAY

22ND MARCH 2022

What the Industry says...

“Rising population, climate change and increasing demand for ground water leading to a depleted resource. Many water-stressed areas are struggling to get access to safe & clean potable water due to growing urbanization.

DuPont water solutions empowers industries and markets with water - treatment technologies to help reduce stress & dependency on fresh water resources. On this world water day let's come together and take small steps to conserve water and make invisible groundwater visible.”



Chrys Fernandes

Business Head

DuPont Water Solutions - India subcontinent

Save Water, Save World

WORLD WATER DAY

22ND MARCH 2022

What the Industry says...

"As we observe World Water Day 2022 to focus on the judicious use of freshwater resources, this year's theme of 'Groundwater- making the invisible visible' highlights the need to protect this critical resource from being overexploited. In February 2022, the Indian government noted a decline in groundwater levels across 30% of wells monitored in the country. Given that groundwater is a national lifeline in India for all of us and especially the rural communities and agricultural sector, it is important that we preserve and replenish this diminishing resource. The need of the hour is intervention programs, for instance a National Groundwater Renewal Mission that will combine science and traditional methods of water conservation to recharge India's groundwater. Such a renewal mission should exclusively focus on last mile implementation of ambitious programs like smart water meter installation, making efficient solar pumps available to farmers, mandatory adoption of recharging wells for farmlands, rainwater harvesting and watershed management. Most importantly, intervention programs will need to educate consumers on the need to preserve groundwater resources. Through a holistic framework, strengthened policy and a collective approach across local and national levels, India can strengthen its groundwater resources and make the country water secure for future generations."



George Rajkumar
Country President
Grundfos India

Save Water, Save World

WORLD WATER DAY

22ND MARCH 2022

What the Industry says...

According to the UN, more than 40 per cent of the world's population lives in regions where water is becoming increasingly scarce, and that figure is likely to rise. The reality is that as economies develop and populations grow, so does the demand for resources like fresh water, land, and energy.

Water shortages in India have been addressed by policymakers by looking at newer and more creative supply options, such as lakes, groundwater, and desalination plants. While these solutions must be part of a plan to tackle critical water crises, the first step should be to look at simple solutions that can help us save water.

Around 30% of current water losses around the globe are caused by leaky pipes, which underscores the need to limit water leakages to save water and reduce energy use. Unnecessary high pressure in the pipes also means that an avoidably high amount of water is pushed out during the leaks. By introducing intelligent pressure management, we can reduce pressure by 38% and minimize leaks. In this way, we can reduce water loss by 40% and energy consumption by 20-40%.

Reducing food loss and waste also holds potential for preserving our water resources. Optimizing yields at the harvest level, through modern machinery and maintaining temperatures to reduce losses across the entire supply chain, must be part of a strategy to tackle the water-energy-food nexus. If we create significant reductions in food loss, food producers will be able to provide more value while using less energy to power farming equipment, less water for irrigating crops and deforesting less land for new farms.

Thus, an integrated approach to the water-energy-food nexus allows us to unlock the enormous opportunities for resource efficiency and manage the complex interactions between water, energy, and food security. This World Water Day, a concerted effort to reimagine and reengineer our solutions to the water crisis, India and the world is currently facing, can ensure this elixir of life continues to provide for posterity. We must empower the world to do more with less.



Ravichandran Purushothaman
President of Danfoss India

Save Water, Save World

WORLD WATER DAY

22ND MARCH 2022

Groundwater: Diminishing & Stressful Resource

India with second largest population in the world and very high agriculture practices - uses more water than many other countries. It is the largest freshwater users in the world and also the largest user of groundwater. It uses an estimated 230 cubic kilometers of groundwater per year - over 25% of the world total. More than 60% of irrigated agriculture and 85% of drinking water supplies are dependent on groundwater.

Around 65% of India's total water demand is being met from groundwater sources which plays an important role in shaping the nation's economic and social development. Therefore with growing demand for water and depletion of the available resources, assured supply of good quality water is becoming a growing concern in the country.

Groundwater in India is a critical resource. However, an increasing number of aquifers are reaching unsustainable levels of exploitation. If current trends continue, in 20 years about 60% of all India's aquifers will be in a critical condition says a World Bank report. This will have serious implications for the sustainability of agriculture, long-term food security, livelihoods, and economic growth. It is estimated that over a quarter of the country's harvest will be at risk. There is an urgent need to change the status quo. SPML Infra Limited has been promoting sustainable water use practices and created robust water supply infrastructure in the country that has helped in providing clean drinking water facilities to over 50 million people per day in the country thus reducing their dependence on groundwater sources.



Subhash Sethi
Chairman, SPML Infra Limited

SEA WATER DESALINATION FOR MEETING FRESH WATER REQUIREMENT

By Hari Saran Das, Environment & Safety Advisor



Water covers about 71% of the earth's surface. 97% of the earth's water is found in the oceans 326 million cubic miles of water is on the planet out of which 320 million cubic miles of water is in the oceans.

Only 3% of the earth's water is fresh suitable for use. Out of 3% of available fresh water, 2.5% of the earth's fresh water is unavailable for use as it is locked up in glaciers, polar ice caps, atmosphere, and soil; highly polluted; or lies too far under the earth's surface

to be extracted at an affordable cost. Therefore only 0.5% of the earth's water available is fresh water that amounts to an average of 8.4 million litres for each person on earth.

Water Source and Available Water:

While the global supply of available freshwater is more than adequate to meet all current and foreseeable water demands, its spatial and temporal

Sr. No.	Water Source	Percent Water Available
01	Ocean	97.2
02	Ice Caps / Glaciers	2.0
03	Ground Water	0.62
04	Fresh Water Lakes	0.9
05	Inland Sea / Salt lake	0.08

distributions are not. There are many regions where our freshwater resources are inadequate to meet domestic, economic development and environmental needs. In such regions, the lack of adequate clean water to meet human drinking water and sanitation needs is indeed a constraint on human health and productivity and hence on economic development as well as on the maintenance of a clean environment and healthy ecosystems. Ways must be found through research to remove

these constraints in the face of multiple challenges especially given a changing and uncertain future climate, and a rapidly growing population that is driving increased social and economic development, globalization, and urbanization.

Seawater

Sea water that makes up the oceans and seas covers more than 70 per cent of Earth's surface. Sea water is too salty and cannot be used for drinking, growing crops, and most industrial uses except cooling

The salt content in seawater is indicated by salinity (S), which is defined as the amount of salt in grams dissolved in one kilogram of seawater and expressed in parts per thousand. Salinities in the open ocean have been observed to range from about 34 to 37 parts per thousand which may also be expressed as 34 to 37 practical salinity units (psu).

Seawater is a complex mixture of 96.5 percent water, 2.5 percent salts, and smaller amounts of other substances, including dissolved inorganic and organic materials, particulates, and a few atmospheric gases.

Seawater constitutes a rich source of various commercially important chemical elements. The six most abundant ions of Sea water are chlorides (Cl^-), sodium (Na^+), sulfate (SO_4^{2-}), magnesium (Mg^{2+}), calcium (Ca^{2+}), and potassium (K^+). By weight these ions make up about 99 per cent of all sea salts.

In addition, water from the sea, when desalted, can furnish a limitless supply of drinking water.

Drinking water scarcity is higher in coastal regions in comparison with the interior parts of India; in coastal areas, the groundwater is saline and not suitable for drinking. Therefore, desalination of sea water becomes an ideal solution to bridge the widening gap between growing water needs of urban population and scarcity in supply in major coastal cities in India. Extending supply from dams or transporting through tankers has been proven costlier than water supplied by desalination. Continuous efforts to amend the desalination technology have brought down the cost of

desalination technique, thereby reducing the cost per liter of desalinated water

Many large desalination plants have been built in dry areas along seacoasts in the Middle East and elsewhere to relieve shortages of fresh water.

In India, IVRCL along with Chennai Water Desalination Plant Limited, commissioned seawater desalination project by reverse osmosis process to get potable water as per IS10500:1991. Today 2.5 million residents of this city get potable drinking water from the 100 Million Litres per Day desalination plant.

The Minjur Desalination Plant is a reverse osmosis, water desalination plant at Katupalli village, a northern suburb of Chennai, India, on the coast of the Bay of Bengal that supplies water to the city of Chennai. Built on a 60-acre site, it is the largest desalination plant in India.

Desalination

It is the process of removing salt and other impurities from water and rendering it fit for human consumption. Seawater has a high percentage of salt whereas pure drinkable water should ideally contain less than 10 ppm of salt.

Natures' Desalination process

Planet gets fresh water through rain by desalination of sea water. Sun Rays evaporates the sea water and the water vapours so formed forms cloud which ultimately results in rain

Reverse osmosis

Osmosis is a natural phenomenon, without which life would be made impossible. Osmotic processes enable plants to absorb nutrients from the ground. Our kidneys purify the blood in our bodies by means of osmosis. The term "reverse osmosis" can be explained as follows:

To desalinate water, we must create a flow through a membrane, causing the water to leave the salty side of the membrane, flowing into the unsalted side. To achieve this, pressure must be created upon the water column on the salt side of the membrane; firstly, to remove the natural osmotic pressure and secondly, to create extra pressure on the water column, in order to push the water through the membrane. For the desalination of seawater, the pressure must be about 50-60 bars.

Desalination technologies

Two distillation technologies are used primarily around the world for desalination: thermal distillation and membrane distillation. Thermal distillation technologies are widely used in the Middle East, primarily because the region's petroleum reserves keep energy costs low.

The three major, large-scale thermal processes are multistage flash Distillation (MSF), multi-effect distillation (MED), and vapour compression distillation (VCD). Another thermal method, solar distillation, is typically

used for very small production rates.

Membrane distillation technologies are primarily used in the United States. These systems treat the feed water by using a pressure gradient to force feed the water through membranes.

The three major membrane processes are electro dialysis (ED), electro dialysis reversal (EDR), and reverse osmosis (RO).

Thermal technologies

Multi-stage flash distillation

Multi-stage flash distillation is a process that sends the saline feed water through multiple chambers (Fig. 1). In these chambers, the water is heated and compressed to a high temperature and high pressure. As the water progressively passes through the chambers, the pressure is reduced, causing the water to rapidly boil. The vapor, which is fresh water, is produced in each chamber from boiling and then is condensed and collected.

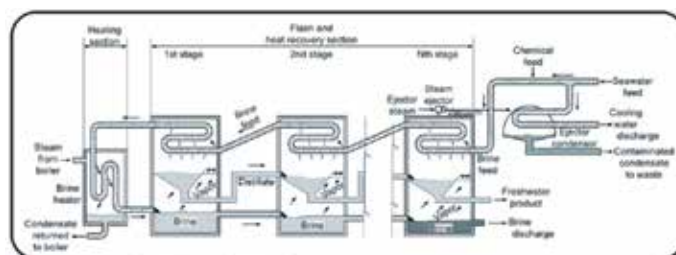


Figure 1. Example of a multi-stage flash distillation (MSF) process (Source: Buras, 1990).

Multi-effect distillation

Multi-effect distillation employs the same principals as the multi-stage flash distillation process except that instead of using multiple chambers of a single vessel, MED uses successive vessels (Fig. 2). The water vapor that is formed when the water boils is condensed and collected. The multiple vessels make the MED process more efficient.

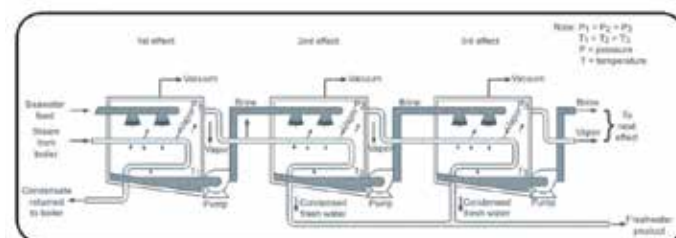


Figure 2. Example of a multi-effect distillation (MED) process (Source: Buras, 1990).

Vapour compression distillation

Vapour compression distillation can function independently or be used in combination with another thermal distillation process. VCD uses heat from the compression of vapour to evaporate the feed water (Fig. 3). VCD units are commonly used to produce fresh water for small- to medium-

scale purposes such as resorts, industries, and petroleum drilling sites.

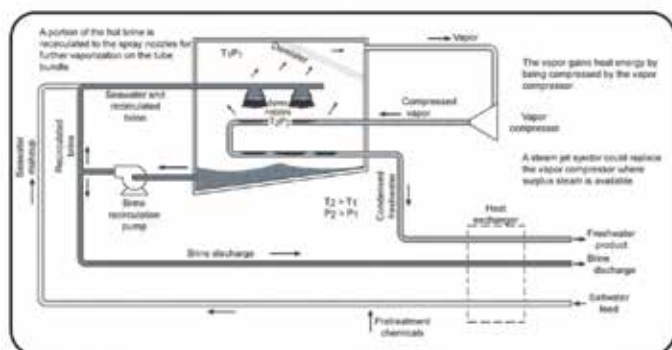


Figure 3. Example of a vapor compression distillation (VCD) process (Source: Buros, 1990).

Solar distillation

Solar desalination is generally used for small scale operations (Fig. 4). Although the designs of solar distillation units vary greatly, the basic principles are the same. The sun provides the energy to evaporate the saline water. The water vapour formed from the evaporation process then condenses on the clear glass or plastic covering and is collected as fresh water in the condensate trough. The covering is used to both transmit radiant energy and allow water vapour to condense on its interior surface. The salt and un-evaporated water left behind in the still basin forms the brine solution that must be discarded appropriately.

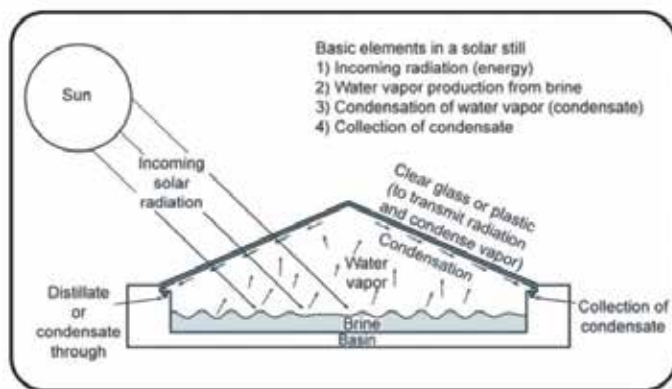


Figure 4. Example of a solar still desalination process (Source: Buros, 1990).

This practice is often used in arid regions where safe fresh water is not available. Solar distillation units produce differing amounts of fresh water, according to their design and geographic location. Recent tests on four solar still designs by the Texas Agri Life Extension Service in College Station, Texas, have shown that a solar still with as little as 7.5 square feet of surface area can produce enough water for a person to survive.

Membrane technologies

A membrane desalination process uses a physical barrier - the membrane - and a driving force. The driving force can be an electrical potential,

which is used in electro dialysis or electro dialysis reversal, or a pressure gradient, which is used in reverse osmosis.

Membrane technologies often require that the water undergo chemical and physical pre-treatment to limit blockage by debris and scale formation on the membrane surfaces. Table 1 (page 5) details the basic characteristics of membrane processes.

Table 1. General characteristics of membrane processes (Source: Metcalf and Eddy, 2003).

Membrane process	Membrane driving force	Typical separation mechanism	Operating structure (pore size)	Typical operating range, (µm)	Permeate description	Typical constituents removed
Microfiltration	Hydrostatic pressure difference or vacuum in open vessels	Sieve	Macropores (> 50 nm)	0.08-2.0	Water + dissolved solutes	TSS, turbidity, protozoan oocysts and cysts, some bacteria and viruses
Ultrafiltration	Hydrostatic pressure difference	Sieve	Mesopores (2-50 nm)	0.005-0.2	Water + small molecules	Macromolecules, colloids, most bacteria, some viruses, proteins
Nanofiltration	Hydrostatic pressure difference	Sieve + solution/diffusion + exclusion	Micropores (< 2 nm)	0.001-0.01	Water + very small molecules, ionic solutes	Small molecules, some hardness, viruses
Reverse osmosis	Hydrostatic pressure difference	Solution/diffusion + exclusion	Dense (< 2 nm)	0.0001-0.001	Water + very small molecules, ionic solutes	Very small molecules, color, hardness, sulfates, nitrate, sodium, other ions
Dialysis	Concentration difference	Diffusion	Mesopores (2-50 nm)	—	Water + small molecules	Macromolecules, colloids, most bacteria, some viruses, proteins
Electrodialysis	Electromotive force	Ion exchange with selective membranes	Micropores (< 2 nm)	—	Water + ionic solutes	Ionized salt ions

Electro dialysis and electro dialysis reversal

The membranes used in electro dialysis and electro dialysis reversal are built to allow passage of either positively or negatively charged ions, but not both. Ions are atoms or molecules that have a net positive or net negative charge. Four common ionic molecules in saline water are sodium, chloride, calcium, and carbonate.

Electro dialysis and electro dialysis reversal use the driving force of an electrical potential to attract and move different cations (positively charged ions) or anions (negatively charged ions) through a permeable membrane, producing fresh water on the other side (Fig. 5).

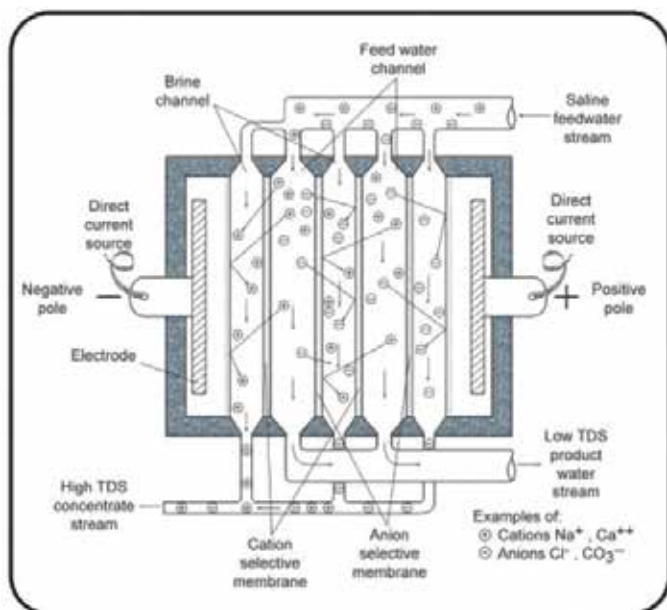


Figure 5. Example of an electrodialysis process showing the basic movements of ions in the treatment process (Source: Buros, 1990).

The cations are attracted to the negative electrode, and the anions are attracted to the positive electrode. When the membranes are placed so that some allow only cations to pass and others allow only anions to pass, the process can effectively remove the constituents from the feed water that make it a saline solution.

The electro dialysis reversal process functions as does the electro dialysis process; the only difference is that in the reverse process, the polarity, or charge, of the electrodes is switched periodically. This reversal in flow of ions helps remove scaling and other debris from the membranes, which extends the system's operating life.

Reverse osmosis

Reverse osmosis uses a pressure gradient as the driving force to move high-pressure saline feed water through a membrane that prevents the salt ions from passing (Fig. 6).

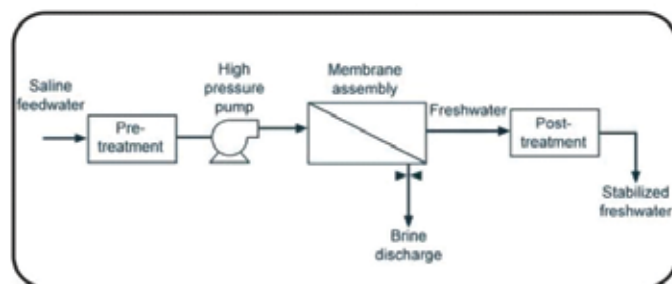


Figure 6. Basic components of a membrane treatment process.

There are several membrane treatment processes, including reverse osmosis, nano filtration, ultra filtration, and microfiltration. The pore sizes of the membranes differ according to the type of process (Fig. 7).

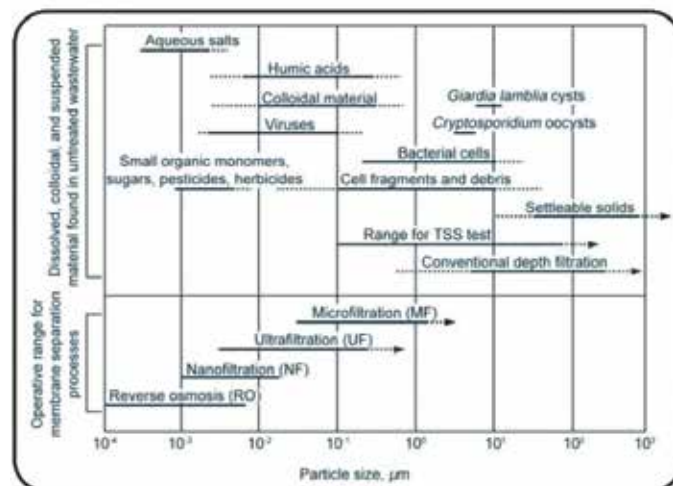


Figure 7. Range of nominal membrane pore sizes for reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF) (Source: Metcalf and Eddy, 2003).

Because the RO membrane has such small pores, the feed water must be pre-treated adequately before being passed through it. The water can be pre-treated chemically, to prevent biological growth and scaling, and physically, to remove any suspended solids.

The high-pressure feed water flows through the individual membrane elements. The spiral RO membrane element is constructed in a concentric spiral pattern that allows alternating layers of feed water and brine spacing, RO membrane, and a porous product water carrier (Fig. 8). The porous product water carrier allows the fresh water to flow into the centre of the membrane element to be collected in the product water tube.

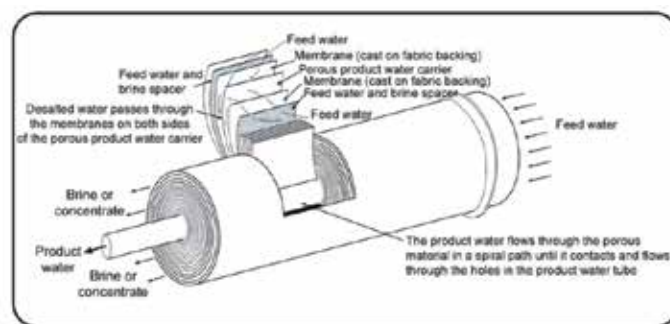


Figure 8. Cutaway view of a spiral reverse osmosis membrane element (Source: Buros, 1990).

To enable each pressure vessel to treat more water, the individual membrane elements are connected in series (Fig. 9). After the water passes through the membrane elements within the pressure vessels, it goes through post treatment. Post treatment prepares the water for distribution to the public.

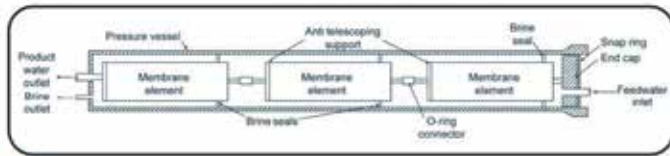


Figure 9. Cross section of a pressure vessel with three membrane elements (Source: Buros, 1990).

Concentrate management options

Both thermal and membrane desalination processes produce a stream of brine water that has a high concentration of salt and other minerals or chemicals that were either removed during the desalination process or added to help pre-treat the feed water. For all of the processes, the brine must be disposed of in an economical and environmentally friendly way.

Options for discharging the brine include discharge into the ocean, injection through a well into a saline aquifer, and evaporation. Each option has advantages and disadvantages. In all cases, the brine water should have a minimal impact on the surrounding water bodies or aquifers. Specific considerations for the water quality include saline concentration, water temperature, dissolved oxygen concentrations, and any constituents

added as pre-treatment.

Summary

As high-quality freshwater resources decrease, more communities will consider desalination of brackish and salt water to produce drinking water. All desalination technologies have advantages and disadvantages based on site-specific limitations and requirements. Small-scale desalination of brackish water using solar stills is a promising method in remote locations where good-quality water for drinking and cooking is unavailable. For more widespread implementation, desalination processes need technological improvements and increased energy efficiency.

Coastal Regions of the world have abundant saline water and scarce in fresh water. Desalination of saline water is the only method to supply fresh water to save the humanity.

Fortunately, there have been tremendous development in solar energy production and the cost of solar energy is getting reduced progressively. More desalination plants using cheap solar energy will be coming up in the coastal Regions of the world to meet fresh water requirements.

About the Author

Hari Saran Das is a Chlor-alkali professional had worked about 39 years from 1969 to 2008 in Chlor-Alkali / Process Industries dealing varied activities such Quality Control, Process Control, Environment Management, Pollution Control, Plant Safety, System Management (ISO 9001, ISO 14001), R&D and many more. He had also served as Joint Director (SHE) in the Alkali Manufacturers Association of India, Delhi since for about 10 years from November 2008 to December 2018.

He is a Post Graduate in Chemistry (M. Sc. in Chemistry) passed in the year 1969 and is having a Diploma in Management from IGNOU and a associate life member of the Indian Institute of Chemical Engineers. He is an Assessor of ISO 9001, QMS ISO 14001 EMS & OHSAS 18001.

He has published several research papers in reputed scientific journals and also several articles on water treatment and other issues in various important magazines. He also presented papers in the national & international workshops.

His one of the major contribution AMAI has established AMAI PAN-India Chlorine Emergency Response Network (CERN) and the Chlorine Emergency Toll Free Number 1800-11-1735 to help Chlorine Consumers & Transporters during any chlorine leakage incidents.

To know more about the contributor of this case study, you can write to us. Your feedback is welcome and should be sent at: deepak.chaudhary@eawater.com

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DESALINATION, SEAWATER REVERSE OSMOSIS (SWRO)

By Dushyant Jindal, Co-Founder, Hitech Enviro Solutions



The increasing population as well as unavailability of abundant Fresh Water has forced mankind to make sweet water from salty sea water. Among the various available technologies Reverse Osmosis turns out to be most economical and easy to operate technology which can be implemented very small 1000 lph capacity to mega capacity plants as 100 MGD.

Osmosis is a physical phenomenon by which two

liquids, in different concentrations, separated by a semi-permeable membrane, come into contact and tends to even themselves out. The liquid with the lower concentration crosses the membrane toward that with highest concentration.

Reverse osmosis process

In reverse osmosis desalination, water is taken from the sea and receives a first treatment to eliminate impurities, oil, seaweed, rubbish, and so on. Once free of organic substances, the saltwater can be subjected to reverse osmosis. After the filtering, we have two streams: brine and freshwater. The brine solution is diluted before being returned to the sea, avoiding high concentrations of salt which could harm the ecosystem. The freshwater passes through a remineralization and chlorination process, after which it is stored in tanks, and then sent to the distribution network for consumption.

Reverse osmosis is not only the most advanced desalination system in the world today; it is the most efficient and beneficial for the planet: it

generates up to four-and-a half-times fewer greenhouse gas emissions than all other technologies, it doesn't harm the marine environment, and it's able to recover a large part of the energy used in the process.

In the late 1960s, reverse osmosis (RO) was developed for desalting saline water supplies. This process is based on the principal of osmosis and requires a membrane barrier to separate salts from water. Because reverse osmosis technology required considerably less energy to operate than distillation, it was considered to be the technology that would make desalination much more attainable to the world's water scarce areas. Indeed, RO for water purification has become widely utilized not just for drinking water applications but for high purity industrial process applications such as manufacturing of electronic components, pharmaceuticals, chemicals, boiler feedwater, medical applications and industrial and municipal wastewater recovery systems as well.

However, in the early days of RO commercialization, historical design and operations information was not available and, as with any new technology, many problems arose. Therefore, in the initial years of RO membrane plant application, many owners and operators experienced costly downtime attributable to lack of applications experience by engineers, vendors, etc. As both membranes and applications engineering became more advanced with time, RO systems were installed and operated with greater success. Today, with the necessary understanding of feedwater source conditions, pretreatment needs and high quality system engineering, RO can be applied to almost any ground or surface water desalination/purification application. Advancements in membrane manufacturing and applications engineering have made RO the leading process in the worldwide water desalination market.

Reverse osmosis is an increasingly common method of desalination, because of its relatively low energy consumption and Modular design. In recent years energy consumption has dropped to ~ 3 kWh/m³, with the development of more efficient energy recovery devices and improved membrane materials. According to the International Desalination

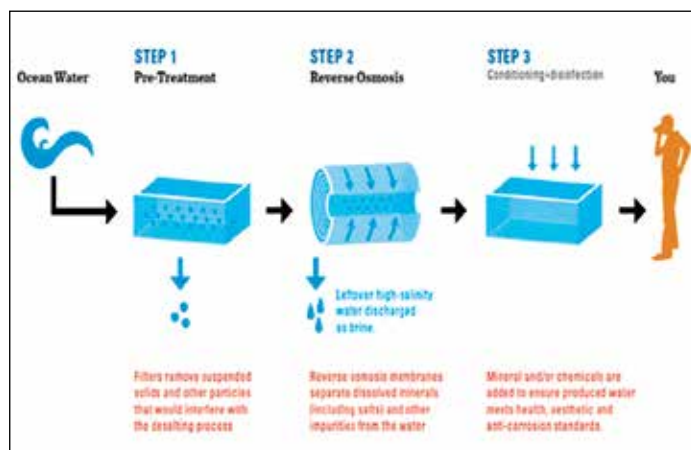
Association, for 2011, reverse osmosis was used in 66% of installed desalination capacity (44.5 of 67.4 Mm³/day), and nearly all new plants. Other plants mainly use thermal distillation methods: Multi-effect distillation and Multi-stage flash.

Sea water reverse osmosis (SWRO) is a reverse osmosis desalination membrane process that has been commercially used since the early 1970s. Its first practical use was demonstrated by Sidney Loeb and Srinivasan Sourirajan from UCLA in Coalinga, California. Because no heating or phase changes are needed, energy requirements are low, around 3 kWh/m³, in comparison to other processes of desalination.

The typical single-pass SWRO system consists of the following components:

- Intake
- Pretreatment
- High pressure pump
- RO Membrane Banks
- Remineralisation and pH adjustment
- Disinfection

Last two components are required if the product water is used for drinking purpose. There are three types of Intakes:



There are three types of Intakes:

Deep Sea Intake: As the name suggests the sea water is lifted from deep sea near the sea bed so that consistent water quality is fed to membranes. This type is normally used for large plants.

Open Channel: An open Channel is built from Sea to the plant site to deliver sea water. This water is often has lot of silt and colloids, though this is cheapest option.

Wells: Water is extracted from the phreatic water-table level, at the coast. The well intakes have the advantage that the water is of higher quality, and accordingly it is a good option for desalination plants. Through the wells, a pump sucks the water, which is then subjected to different

filtering systems so as to separate the sand and other impurities. The disadvantage of this type of seawater intake structure is that the hydraulic capacity will often be reduced by reason of the silting thereof (clogging with fine particles) that impedes the intake of the necessary flow volume.

Pretreatment normally consists of battery of filters to remove suspended matter & colloids. Sometimes DAF is also used to remove the floating oil if any. Few plants also have UF as pre-treatment to ensure consistent feed water quality.

High Pressure Pumps are required to overcome the Osmotic pressure of Saline water & have pressure ranging from 50 Bar to 75 Bar depending upon feed water TDS.

The spent energy from the reject is stream is recovered in large plant by Energy Recovery Devices (ERD). The plant size normally dictates the type of ERD. The Energy Recovery Turbine (ERT) and Pressure Exchangers (PX) are very popular.

RO Membrane Banks form the heart of the system & have piping manifolds, Membrane Housings and Semi-permeable membranes.

The permeate is often further treated by disinfecting it & remineralising it to make it stable (non corrosive), improve the taste and safe to drink.

The system is fitted with adequate instrumentation & control for safe & steady operations.

A very important aspect of SWRO is material selection. The wetted material needs to be selected carefully for long life of the plant. High grade stainless steels like SS 904L, Duplex, Super Duplex, Bronze are some of the preferred materials for valves & piping.

Principles of Salt Water Reverse Osmosis

Desalination by RO requires the use of an osmotic membrane (i.e., one that allows water to pass through it at much higher rates than dissolved salts). Osmotic membranes occur naturally in living organisms everywhere. The osmotic membrane also is referred to as a semipermeable membrane because of its capability to allow some constituents to pass through it while holding back others. The osmosis phenomenon in nature is one where a dilute solution is transported across a semipermeable membrane toward a concentrated solution on the other side. The process of RO is just the opposite of osmosis. In osmosis, the solvent water passes through the membrane until the pressure difference across the membrane is equal to the osmotic pressure (approximately 350 psig for a fresh water/seawater interface). In the reverse osmosis desalination process, a pressure greater than the osmotic pressure applied to the saline water will cause fresh water to flow through the membrane while holding back the solutes (salts). The higher the applied pressure above the osmotic pressure, the higher the rate of fresh water transports across the membranes.

System Design Consideration

When designing a seawater RO system, many factors must be considered.

First and extremely important is the feedwater source. Salt water from the sea either will be drawn from a surface water supply, a beach header-lateral face well system or a borehole well system. Typically, seawater well systems are preferred because they provide a low turbidity feedwater requiring less pretreatment. However, even well systems produce varying seawater quality depending on the origin of the strata they are constructed in.

Once the best feedwater source (i.e., the system that requires the least amount of pretreatment) is selected and characterized, both chemically and physically, the pretreatment system must be designed to create the optimum conditions for membrane operation and performance. With a high quality feedwater (one with low colloidal, microorganism, organics and iron content), a seawater RO system needs only five micron cartridge filtration for pretreatment.

Lower quality feedwater may require much more pretreatment including any and all combinations of the following:

- Infection coagulation;
- Clarification;
- Multi-media filtration;
- Sequestering and dispersant chemical feeds; and
- Five micron cartridge filtration

After the pretreatment system, a pump pressurizes the feedwater salinity and recovery rate. Typical seawater ranges between 28,000 to 35,000 ppm total dissolved solids (TDS). However, some saline surface waters are much higher such as the Red Sea at 40,000 to 45,000 ppm TDS. The feedwater then enters the membrane system where organic and inorganic contaminants are separated into a product water stream and a concentrated reject water stream.

Optimum performances are obtained by hydraulically balancing velocities and flows of water along and through the membrane surfaces. System water recovery rates range from 20 to 40% for small to large systems, respectively, for typical 36,000 ppm feedwater.

A properly designed plant, from the aspects of feed water source, pre-treatment, and hydraulic balancing, will reduce organic, inorganic and biological membrane fouling tendencies, thereby minimizing membrane-cleaning requirements. To say that a membrane plant will never need cleaning is not an accurate statement. Thus, all land-based plants should be designed with an in-place cleaning system that also will act as a sanitizing system when needed.

On shipboard systems, especially small yachts and boats, there is very limited space, so membrane-cleaning systems are not sold with the desalination system. Instead, membranes generally are replaced each year.

Pumps

The two most basic individual components in a seawater reverse osmosis system are the high pressure feed pump and the RO membranes. These

components comprise the heart of any RO system and require careful selection and application for successful operation.

There are two types of high pressure pumping units on seawater RO systems: centrifugal and positive displacement (PD) plunger pumps. Because plunger pumps operate at much higher efficiencies, these most often are the pumps of choice for plants less than 150,000 gpd and where high-energy costs exist. In larger plants, the centrifugal pumps are used most often because these pumps may approach 80 percent efficiency, are less costly and require less maintenance. However, the majority of RO desalination systems are in the 1,000 to 100,000 gpd capacity range. PD pumps are most common due to the lack of availability of higher pressure, low flow centrifugal.

Plunger pumps produce large output pressure variance (pulsation) due to their reciprocating action, which translates to vibration. This vibration not only is potentially damaging to the pump but to all other system components as well especially plumbing, instrumentation and the systems framework. In order to minimize vibration damage to system components, the pump requires a discharge pulsation dampener and, in some cases, a suction stabilizer (depending on the acceleration head attributed to systems feed plumbing). Another important factor is pump speed in RPM. The slower the pump speed, the less vibration transfers. Mechanical design for vibration isolation is also a key to minimizing vibration damage from the pumping system.

Because seawater RO pumps can generate pressures in excess of 1,000 psig, it is recommended that a safety switch, in combination with a pressure relief valve, be incorporated in the design. Severe damage or injury could occur if the pump pressure exceeds material strengths of the RO design.

Membranes

Membranes are the largest single consumable cost factor in RO desalination. Therefore; increasing membrane life will contribute significantly to lowering operating cost. Membranes most often require replacement because of reduced capacity, which in most cases is attributable to colloidal and/or biological fouling. Fouling is a direct result of either an inadequate feed source or pretreatment equipment. As previously mentioned, installing the correct feed source and corresponding pretreatment system is critical in minimizing foulants.

It also was mentioned that a well-type feed source normally is the best source for reducing colloidal content in the feedwater. However, in some circumstances, either because of well development cost or lack of permeability of the ground structure, well systems are not feasible or therefore surface intake systems will be required. When surface water is utilized as a feed source, pretreatment systems can become extensive in order to reduce feedwater colloid load. Even then, stormy weather conditions will make operation of the RO plant ill advised due to increased turbidity of the feed source.

Colloidal fouling tendency of an RO membrane is relative to the feedwater's Salt Density Index (SDI), an ASTM method for measuring

small particulate/colloidal loading in water. Typical borehole well systems that have been constructed correctly produce SDIs less than 3.0 and many times less than 1.0 Header/lateral beach wells have produced SDIs less than 3.0.

However, it is advisable to expect a range of 2 to 5 for beach well systems. Surface water will produce SDIs much greater than 5 and, with an excellent pretreatment system; this can be lowered to 3 to 5. However, adverse weather conditions and upsets in clarification systems can make these intake systems unreliable. Intake systems, pretreatment and SDI must be stressed because membrane life and warranties are directly correlated to these parameters. Spiral-wound membranes have a maximum allowable operating SDI of 5.0, which is why they often are chosen.

The last item needing discussion relative to plant equipment longevity is corrosion of materials. Systems should be constructed with plastics and nonferrous components wherever possible. All low-pressure components should be constructed from PVC, fiberglass or plastics in general. High-pressure components that require the use of metals should be of an acceptable alloy to their location and application in the system. Seawater environments are highly corrosive, and only the highest quality of material is acceptable. As an example, welded pipe should not be any grade lower than super austenitic stainless steel.

Seawater RO system equipment capital costs range from \$ 10/gpd production capacity to \$ 2/gpd capacity for systems ranging from 500 to 1.0 million gal per day.

Intake and pretreatment costs can be substantial when considering a surface water source adding anywhere from \$ 0.50 to \$ 2.00 per gallon

to the system capital cost where pretreatment costs predominant. Intake and pretreatment costs for a well system will add anywhere from \$ 0.20 to \$ 0.80 per gal where intake costs predominate. Systems that can utilize a well-feed source that produces a SDI of 3 or less are the least capital-intensive systems.

Operating costs will vary most predominately with varying power cost for the system as identified earlier. Typical operating costs will range from \$2/Kgal of product to \$ 8/Kgal of product for the land-based systems. When energy recovery equipment is incorporated, overall operating costs can be reduced by roughly 20 to 30 percent. Operating cost includes system consumables such as power, filter cartridges, chemicals, RO membranes and miscellaneous mechanical maintenance items and does not include labor or plant capital cost amortization.

Marketplace

An RO desalination system marketplace is justifiably anywhere there is a lack of adequate fresh water supplies, insufficient brackish water for lower pressure brackish RO operation and a good source of available seawater. This tells us that anywhere there is growth and development in water shortage areas, there is a candidate for desalination by RO. Historically, the world market has been in the equatorial zone, arid environments and island coastal communities. Remote resort developments have lead the way with this technology, but as quality water sources become more and more scarce, both industry and municipalities are recognizing the need for RO desalination. In California, Florida, The Caribbean, Central and South America, the Mediterranean, Middle-East and the Pacific Rim (i.e., anywhere there's an ocean and a need), RO desalination is a viable resource for the world's fresh water production requirements.

About the Author

Dushyant Jindal is an Engineer with MBA has an extensive experience working on environmental project for different sectors of Government and non-government organizations in India. He is the Co-Founder at Hitech Enviro Solutions, engaged in environmental monitoring services and consultancy.

To know more about the contributor of this case study, you can write to us. Your feedback is welcome and should be sent at: deepak.chaudhary@eawater.com



DESALINATION: GROWTH PATTERN AND DECISION MAKING

By Manoj Nainani, Executive Director, Egis India



As the water scarcity is increasing at an alarming rate, evaluation of alternate water supply source is intensifying. As per United Nations Environment Program [UNEP] 2015, by 2030 the world could face a 40 percent shortfall in water supply if no changes are made how water is managed. Major interventions include improving the efficiency and managing demand in industry and households. However, the efficiency improvement is very slow as compared to increasing gap in demand and supply.

With advances in desalination technology and reductions in production cost, desalination is playing considerable role in closing the gap between supply and demand in future years.

However, despite significant reduction in cost, desalination remains expensive as compared to conventional water supply sources.

Today more than 150 countries are already using desalination in one form or another to meet particular segments of demand, supplying over 300 million people with potable water.

Desalination Methods

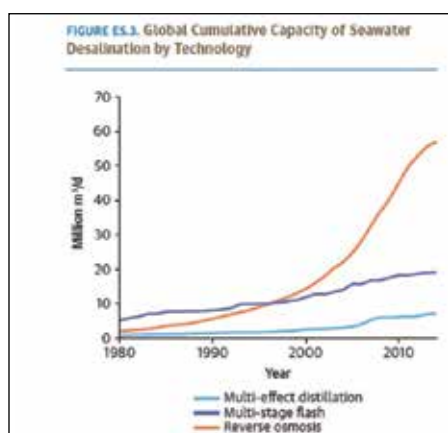
There are two main desalination methods, thermal and membrane, which can be combined as a hybrid. Thermal desalination is a process of boiling and evaporating salt water and condensing the resulting vapours. The two commonly used thermal processes are

multistage flash distillation (MSF) and multiple effect distillation (MED). Both processes work in a way similar to the evaporation process: the saline water passes through a series of chambers, with each successive chamber operating at a progressively lower pressure. Membrane methods adapt the natural process of osmosis, and reverse osmosis (RO) is the most commonly used form because the seawater actually passes through the RO membranes they can easily be clogged. Seawater reverse osmosis (SWRO) plants usually build in pre-treatment facilities not used in thermal systems to pre-treat the source seawater. Membrane technologies can also be used for treating wastewater.

Growth Patterns of the Commonly Used Desalination Technologies

SWRO has overtaken thermal technology and now accounts for two-thirds of installed capacity worldwide.

In 2014, SWRO technology represented about 63 percent of the global desalination capacity, followed by MSF (23 percent) and MED (8 percent). The remaining 6 percent of desalination capacity was largely from hybrid technologies. However, thermal is still a leading technology in the Middle East, especially in the GCC. In 2015, just over half (53 percent) of all desalination plants in the Middle East used thermal technology, whereas SWRO accounted for the balance (47 percent).



Global Cumulative Capacity of Seawater by Technology (Source: World Bank. 2019. "The Role of Desalination in an Increasingly Water-Scarce World.")

TABLE ES.1. Summary of Worldwide Seawater Desalination Costs

Desalination method		Capital costs (million US\$/MLD)		O&M costs (US\$/m ³)		Cost of water production (US\$/m ³)	
		Range	Average	Range	Average	Range	Average
MSF		1.7-3.1	2.1	0.22-0.30	0.26	1.02-1.74	1.44
MED-TVC		1.2-2.3	1.4	0.11-0.25	0.14	1.12-1.50	1.39
SWRO Mediterranean Sea		0.8-2.2	1.2	0.25-0.74	0.35	0.64-1.62	0.98
SWRO Arabian Gulf		1.2-1.8	1.5	0.36-1.01	0.64	0.96-1.92	1.35
SWRO Red Sea		1.2-2.3	1.5	0.41-0.96	0.51	1.14-1.70	1.38
SWRO Atlantic and Pacific oceans		1.3-7.6	4.1	0.17-0.41	0.21	0.88-2.86	1.82
Hybrid	MSF/MED	1.5-2.2	1.8	0.14-0.25	0.23	0.95-1.37	1.15
	SWRO	1.2-2.4	1.3	0.29-0.44	0.35	0.85-1.12	1.03

Note: Costs are at 2016 values. MED-TVC = multiple effect distillation with thermal vapor compression, MLD = million liters per day, MSF = multistage flash distillation, O&M = operation and maintenance, SWRO = seawater reverse osmosis.

Summary of Worldwide Seawater Desalination costs (Source: World Bank. 2019. "The Role of Desalination in an Increasingly Water-Scarce World.")

Desalination Costs

Overall costs have been rapidly decreasing. Recent typical costs of water production show considerable reductions for both thermal technologies (MSF and MED), but particularly for SWRO, which is now registering costs as low as US\$ 0.64 per cubic meter in favourable physical and business environments. For the purposes of this study, a database was built containing over 50 desalination projects from around the world constructed over the last two decades.

Summary of Key Cost Criteria

Key criteria for choice include the following:

- RO desalination is the most cost-competitive technology for less saline environments, but thermal technology is more competitive for higher salinity environments.
- MSF is the most expensive desalination technology in terms of CAPEX, but it is easier to operate and yields higher economy of scale benefits for mega size projects than RO.
- MED-TVC technology is more competitive than MSF for small and medium-size desalination projects.

Choosing Desalination

National Water Commission, 2011 has proposed a five Step decision-making process

Step One: Assessing sustainability of water source in long Term at the Basin Scale

- Sustainability of water supply source must be evaluated in an integrated approach
- Service area and planning horizon to be defined. Generally, the planning horizon covers several decades.
- Development of various scenarios based on planning horizon.
- Supply-demand balance and gap to be evaluated considering resources, constraints, risks and institutional context.
- Evaluation of various scenarios

Step Second: Evaluation of needs at local level

- Evaluation of local need for urban/ industrial development
- Assessment of water supply and demand for long term
- Identification of options for demand management and supply pattern
- Cost evaluation and Funding options planning
- Risk assessment of existing and proposed water supply options
- Policy guidelines and recommendations

Step Third: Detailed Assessment of existing Infrastructure and Framework

Subsequent to feasibility of desalination as possible water supply source, detailed assessment of Physical, Economic, and

Institutional framework.

Suitability of desalination as water supply source:

- Demand gap is for high value market, particularly urban and industrial uses
- High Political or Climatic risks to water supply
- Higher willingness to pay
- Concentrated Demand
- Availability of suitable location for desalination technology
- Good quality feed water

Step Four: Feasibility and Risk Screening for Desalination Options

- Selecting the most appropriate technology
- Assessing and quantifying risks and their mitigation
- Assessing the external and internal political economy
- Evaluating the policy and institutional framework.

Step Five: Decisions

Subsequent to successful completion of above-mentioned steps, the authorities shall be in a position to compare the desalination options with alternatives in terms of feasibility, cost & financing, risk, political economy and institutional readiness. Techno-economic evaluation can be elaborated along with economic, social and environmental implications prior to finalization of desalination option.

Conclusion:

With the advancement of technology, the cost of desalination continues to fall across existing technologies. Desalination is increasingly becoming viable water supply source to plug demand supply gap in water sector.

Egis Experience in Desalination:

1. Supervisory Consultancy Services for Shuqaiq 3 IWPP Project (450,000 m³/d)
2. Works supervision for the construction of the Salalah plant (150,000 m³/d)

1. Supervisory Consultancy Services for SharqiyahIWP Project (80,000 m3/d)
2. Works Supervision of BarkaWater Desalination Plant (281,000 m3/d)
3. Detailed Design and construction services for the extension works of the desalination plant at PetiteTerre in Mayotte (5,300 m3/d)
4. Building and Operating a Desalination Plant for Producing a Drinking Water Supply for theTown of Sur (3500 to 10,000 m3/d)

About the Author

Manoj Nainani has been with Egis since October 2015 and holds the position of Executive Director - Infrastructure (Water, Ports ,Energy& Specialized projects and he is also IOSIS partner and holding position in Management team of Egis India. He is in charge of Pradhan Mantri Awaas Yojana (PMAY), DRIP, AMRUT (Water Project) which are largest projects of Egis in India

Manoj is a dynamic professional with over 28 years of rich experience in Strategic Planning, Business Development, Sales & Marketing and Key Account Management. He has held various senior positions in Essel Infra projects and SPML, before joining Egis.

To know more about the contributor of this case study, you can write to us. Your feedback is welcome and should be sent at: deepak.chaudhary@eawater.com

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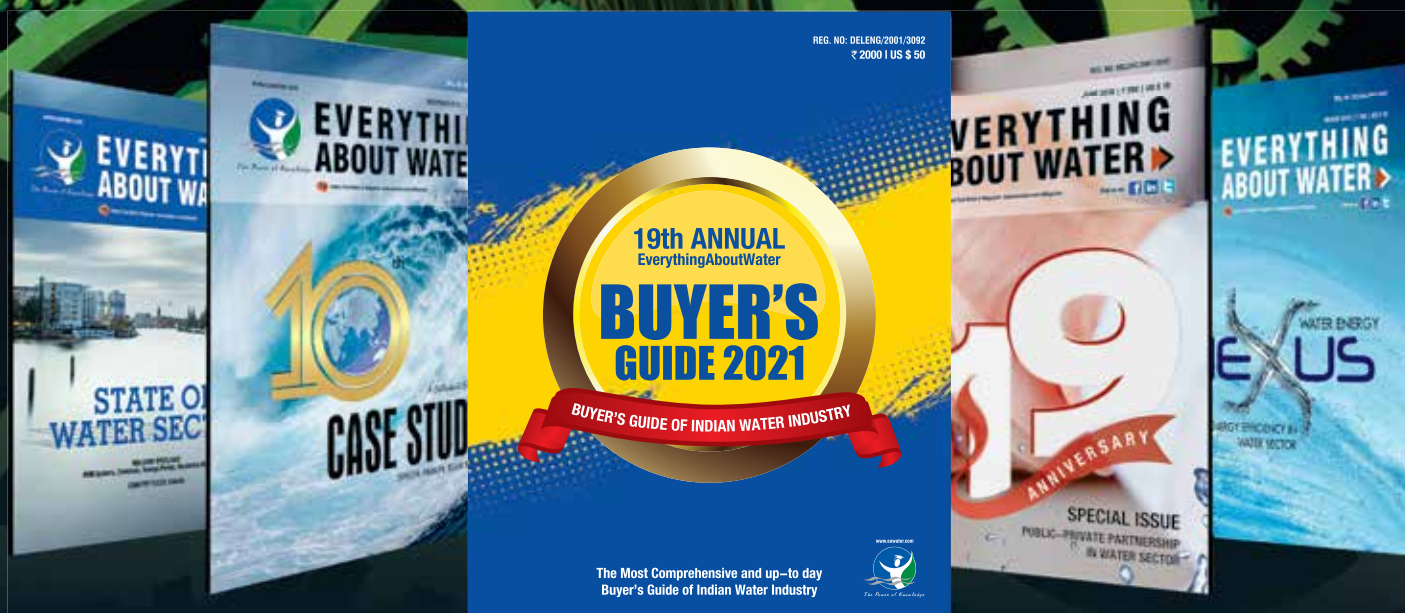
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OVERVIEW ON WATER DESALINATION

By Dr. Mayur J. Kapadia, Retired - Additional General Manager, Quality Control, GNFC Ltd.



Approximately only 3 % of the water available on earth is suitable for domestic purposes. The rest 97% is unsuitable for human consumption due to salinity of water. Sea Water comprises around 99% of this unsuitable portion of the water on earth, the remainder is saline groundwater. 40% of the world population currently lives in arid areas or islands where fresh water is scarce. The 6th goal of the United Nations Sustainable Development Goals (SDGs) seeks to guarantee availability and sustainable management of water and sanitation for all by 2030. Therefore, purification of this unsuitable saline water holds good promise to meet with ever increasing water requirement for human consumption, though the process of purification of seawater is expensive, energy intensive and often has adverse impacts on ecosystems. Despite these drawbacks, water desalination can be an appropriate technological choice when combined with various technological advancements that reduce adverse impact on environment *vis a vis* improve cost economics.

Since a great majority of earth's water is found in the seas and oceans, desalination creates an opportunity for coastal communities to access virtually unlimited freshwater sources. In addition, desalination techniques can be used to purify brackish water in areas with seawater intrusion.

Desalination

Desalination is a process in which salt and other constituents are removed to produce pure water useful for various domestic purposes by human kind. Broadly, there are two basic methods of desalination:

- **Evaporation (Thermal process):** A method to obtain fresh water by condensation of vapor produced from evaporation of seawater.
- **Membrane Desalination:** A method to obtain fresh water by filtering seawater, under applied pressure, electric current or temperature, through a semi-permeable membrane through which seawater cannot pass. Reverse osmosis (RO) is the most widely used membrane desalination technology. Other membrane technologies include Forward Osmosis (FO), Electrodialysis (ED), Membrane Distillation (MD), Nano filtration (NF), Microfiltration (MF), Ultra filtration (UF).

The third method of desalination is based on the Emerging & Hybrid technologies that combine different processes together depending upon purpose of desalination, kind of water available, size of the plant, cost and environmental aspects.

Desalination of water results into two streams:

1. a pure product water and
2. a high-concentration waste stream or brine.

THERMAL DESALINATION

Thermal desalination processes generally use heat to evaporate water, leaving dissolved constituents behind. The water vapour is then condensed and collected as product water. Water distillation is a phase change process, which is the simplest form of thermal processes. Among various thermal processes like vapour compression distillation, freezing, crystallization, salting out; 2 technologies named multi-stage flash distillation (MSF) and multi-effect distillation (MED) stand out. The rest of the techniques have high capital and operational costs.

Multi-Stage Flash (MSF) Distillation:

MSF distillation process is based on the principle of flash evaporation. The economy and energy efficiency of this process are achieved by regenerative heating where the seawater flashing in each flash 'chamber' or 'stage' gives up some of its heat to the seawater going through the flashing process. Different from the approach of raising the temperature, the MSF desalination process, thus, evaporates water by reducing the pressure in a series of low-pressure chambers. MSF can be operated at even greater efficiency by utilising the waste heat from an adjacent power plant.

Multiple-Effect Distillation (MED):

The MED process takes place in a series of 'effects', which are a kind of evaporators, and

uses the principle of reducing the ambient pressure in different 'effects'. This process permits the water to undergo multiple boiling without supplying additional heat after the first 'effect'. The water enters the first 'effect' and is raised to the boiling point after being preheated in tubes. The evaporation and condensation are repeated from 'effect' to 'effect' each at a successively lower pressure and temperature. It is possible to achieve much greater efficiency in MED than in MSF.

Vapour Compression Distillation (VCD):

The compressor compresses the vapor taken from the evaporator and condenses it inside a tube bundle to give product water. The heat for evaporating the seawater comes from the compression of vapor. For smaller operations with volume needs of around 3000 M³/day, vapour compression distillation (VCD) can be an appropriate thermal distillation option. VCD is a technically simple, reliable and efficient process that is popular for resorts, industries and work sites where adequate freshwater is unavailable.

Freezing & Crystallization:

It is also possible to desalinate water by freezing at temperatures slightly below 0° C. The salts are removed from salty water by the formation of ice crystals, which do not contain any salt. The process includes cooling of the water feed, partial crystallization of ice, separation of ice from seawater and melting of ice to produce fresh water. Difficulties in movement of solid and liquid phases makes this process complicated and is therefore not commonly practiced. However, in a cold climate, natural freeze-thaw cycles have been harnessed to purify water at costs competitive with RO.

MEMBRANE TECHNOLOGIES

Due to the high values of the vaporization enthalpy of water, desalination technologies with phase changes consume substantial energy amounts. Rises in energy costs and growing regulations regarding greenhouse gas emission control have led to establishment of desalination plants that use membrane technology, which is a filtration operation through a semi-permeable membrane which retains the water with ions, and allows the passage of pure water molecules. The driving

force in membrane-based technologies can be an electrical potential, a concentration difference, a temperature difference or a pressure, leading to establishment of different kind of membranes, viz.

1. electro-driven membranes [(Electrodialysis (ED) and Membrane Capacitive Deionization (MCDI)],
2. concentration-driven membranes [Forward Osmosis (FO)],
3. temperature-driven membranes [Membrane Distillation (MD)] and
4. pressure-driven membranes [Micro Filtration (MF), Ultra Filtration (UF), Nano Filtration (NF) & Reverse Osmosis (RO)].

While the first decade of this century was dominated by thermal phase change technologies, the second decade has been characterized by the increase in membrane-based desalination for treating sea water, brackish waters, tertiary wastewater, and saline surface waters. Approximately, 70% of desalination plants use membrane systems due to high effectiveness, relatively lower energy consumption and costs compared to thermal phase change technologies. Among membrane technologies, Reverse Osmosis (RO) is the fastest growing technology in the world, which is estimated to assume a market in the tune of 9000-10,000 million USD by end of this year.

1. Electro-Driven membranes

Electrodialysis (ED):

Electrodialysis is an electrochemical process that uses a system of different chambers separated by ion selective membranes. Ions are driven by the potential generated by a direct electrical current applied by electrodes immersed in saline water. The negative ions pass through the anion-permeable membrane and move towards the anode, whereas positive ions pass through the cation-permeable membrane and move towards the cathode. Thus, ions are concentrated in some of the chambers, leaving desalinated water in others. ED is used for the wastewater treatment in the pharmaceutical, chemical, and food industries. The water recovery is higher than that of RO. Also, it does not call for pre-treatments or extensive post-treatment.

Reverse Electrodialysis (RED):

In this process, a salt solution and fresh water are held through a stack of alternating cation and anion exchange membranes. The chemical potential difference between salt and fresh water generates a voltage over each membrane. The process works through difference in ion concentration instead of an electric field, as in case of ED. RED has a good potential for industrial and domestic wastewater processes, desalination as well as energy recovery in RO / ED systems. RED is also applied for simultaneous generation of electrical energy, as well as energy storage leading to development of flow batteries. Large-scale RED industrial applications are economically not viable for natural waters as its power requirement is not achievable with natural waters.

Membrane Capacitive Deionization (MCDI):

Membrane capacitive deionization (MCDI) cell compartment consists of two porous electrodes of commercial activated carbon fibre in parallel, wherein one is having anion-exchange membrane and the other is having cation exchange membrane. Under an electric field between two porous electrodes, the cations and anions of water are removed by electrical migration. It is an energy-efficient and environment-friendly desalination technology. It is especially advantageous for treatment of low concentration salt solutions (lower than 5 g/L).

2. Concentration-Driven Membranes

Forward osmosis (FO):

Water molecules diffuse from the 'feed' solution of higher chemical potential to a 'draw' solution of lower chemical potential. The driving force for mass transport across a semi-permeable membrane is coming from the difference in osmotic pressure between the 'feed' solution and a 'draw' solution, which is caused by the concentration of solutions. FO is one of the most promising emerging technologies for desalination and wastewater treatment operations. It also has the lowest environmental impacts among electrodialysis / reverse electrodialysis (ED/RED), and membrane distillation (MD).

3. Temperature-Driven Membranes

Membrane Distillation (MD):

Membrane distillation is a second-generation low-grade thermal separation technology having excellent performance for sea water desalination. The difference in vapor pressures caused by a temperature gradient across the membrane drives the diffusion of water vapor to the permeate side. Due to the membrane's hydrophobic properties, only the vapor can pass through its pores. Membrane fouling is a widespread problem that reduces both useful life and productivity of this system.

4. Pressure-Driven Membranes

The name of the process stems from the fact that pressure is used to drive water molecules across the semi-permeable membrane in a direction opposite to that they would naturally move due to osmotic pressure. In this process, the high-pressure pump raises the pressure of the feed water to the pressure appropriate for the semi-permeable membrane such that the osmotic pressure of feed water can be overcome. As a result, the water flows across the semi-permeable membrane in the reverse direction of the natural flow taking place during osmosis process. This leaves the dissolved salts behind with an increase in salt concentration of the feed water and passes pure water to the other side of the membrane.

Microfiltration (MF): MF is widely used in concentrating, purifying or separating macromolecules, colloids and suspended particles from solution, therefore is a useful process in pre-and post-treatment in desalination process. The pore size of an MF membrane is in the range of 0.05 - 10 μm . It needs operating pressure below 2 bar.

Ultrafiltration (UF): This is useful for pre-and post-treatment of water. The pore size of UF membrane ranges from 10 to 50 nm, which falls between NF and MF. As the pore size is larger than RO and NF membranes, UF operating pressure is low and in the range of 2 - 5 bar.

Nano filtration (NF): NF membranes cannot reduce seawater salinity to potable levels but they have been used to treat waters with salinities below 1000 mg/L, with high hardness levels, organic content and bivalent ions. Nano filtration (NF) membrane has a pore

size ranging from 1 to 10 nm and cut off ability between RO and ultrafiltration (UF).

Reverse Osmosis (RO):

This is a key technology in Desalination process. Because osmotic pressure must be overcome, the energy needed to drive water molecules across the membrane is directly related to the salt concentration. RO membranes have pore size of < 1 nm. Therefore, operating pressure of 60 - 70 bar is generally necessary for sea water. No heating or phase separation change is necessary in this process. However, pre-treatment of feed water is needed to eliminate undesirable constituents in the seawater, which would otherwise cause membrane fouling. As the water permeates through membrane, approximately 99.5% of the dissolved salts of feed water are removed and produces fresh water with minimal impurities. The concentrated stream from membrane - Brine - is discharged into ocean after following guidelines to ensure minimal impact on ecology of the sea.

The improvement in energy efficiency, more durable polymer membranes and pre-treatment steps have made it a leading technology in desalination operations as, in many cases, RO is more economical than thermal methods. It also has high flexibility to work under different salinity conditions, takes up little space, and is easy to operate and automate. RO units are commercially available in varied sizes, from household applications with capacities of around 100 litres / day to around 1000 million litres / day (MLD) suitable for industrial and municipal use. This is currently the most reliable technology for seawater desalination at the lowest capital costs and lower energy consumption. It has, however, significant costs towards pre-treatment operations and membrane replacement. According to the water quality to be processed, RO operations are classified into brackish water plants (BWRO), with salinities between 500 and 10,000 mg/L and seawater plants (SWRO), with salt contents close to 30,000 mg/L. This process is growing at an annual average growth rate between 9-10% currently.

RO membranes have seen transformations from the initial asymmetric cellulose acetate (CA) membranes, followed by thin film composite (TFC) membrane, and now thin

film nano composite membrane (TFN). RO can remove all colloidal material and dissolved solids with a size greater than 1 nm from feed water. The obtained water quality by RO process is relatively inferior (400-500 mg/L TDS) to thermal technologies (25-50 mg/L TDS). But RO water quality is generally acceptable for most agricultural, industrial, and human consumption applications. Advancements towards transfer of hydraulic energy from the brine to the feed water has reduced energy consumption of high-pressure pumps. Various other Energy Recovery Devices (ERD) have helped in significantly curtailing the costs of RO process.

Hybrid systems

Each of the membrane technologies employ different driving forces. They also have their own advantages and disadvantages. Therefore, hybridization of different membrane technologies can overcome limitations associated with the physical and economic nature of the separate processes. Adequate selection of the hybridization of different technologies leads to reduction in energy consumption and environmental impacts, increasing the efficiency of desalination processes. The hybridization of thermal systems with RO systems gained popularity rapidly due to their efficiency. MSF-RO& MED-RO hybridization is widely used in plants in the Middle East due to low fuel prices and establishment of thermoelectric plants, in which waste thermal energy and low-cost electricity are available. Hybridization of thermal desalination technologies with renewable energy sources is one of the trends in research and development.

Advantages of water desalination

- Desalination can greatly aid to diversification of water supply and resilience to water quality degradation. Diversification of water supply can provide alternative or supplementary sources of water when current water resources are inadequate in quantity or quality.
- Desalination can also help combating with reduced per-capita water availability due to short-term drought and longer-term climatic trends in parallel with population growth, land use change, and

groundwater depletion.

- Desalination can provide access to fresh water for potentially water stressed or arid areas since it helps converting abundant saline waters into fresh water of quality desired for various domestic and industrial applications.
- When combined with post-treatment steps, desalination can also provide very pure water sources for industries like pharmaceuticals.

Challenges to water desalination

- The major challenges of current desalination processes include costs, energy requirements and environmental impacts.
- The environmental impacts include disposal of the concentrated waste stream and the effects of intakes and outfalls on local ecosystems.
- Brines are usually dispensed as discharges into surface and marine waters or in the sewage system causing change in salinity, pH, heavy metals levels in the marine environment. The brine also possesses other residual chemicals used in water pre-treatment and post-treatment stages, such as anti-scalants, coagulants, flocculants, and halogenated disinfection by-products. All these chemicals have their own toxic effects on aquatic life.
- The contribution towards increased greenhouse gas emissions could set back climate-change mitigation efforts.
- Countries such as Kuwait consume half of their oil production for seawater desalination and energy cogeneration, with environmental impacts on air quality, abiotic depletion, acidification and eutrophication of waters, depletion of the ozone layer, photochemical oxidation and release of compounds toxic to humans and marine life. Environmental aspects are important limitations for the expansion of RO.
- High salinity and brines generated increases the hydraulic pressure required to overcome the osmotic pressure difference between the feed and permeate in Desalination process. Energy cost is, thus, higher. Due to high energy cost, typical recovery in single stage RO system for seawater is 50% to 60%.

- Scale formation from less-soluble salts on membranes calls for additional costs in RO systems.
- Another major challenge with seawater reverse osmosis desalination (SWRO) is rejection of Boron, which is found relatively high in sea water. As Boron causes health problems in humans and plants, WHO recommends limit of 2.4 mg/L. Due to low retention of Boron by commercial RO membranes, Boron levels prescribed by WHO are sometimes not achieved, which necessitates post-treatment of the fresh water produced by RO, which can raise the cost of treatment by approximately 0.75 USD/M³.
- Precipitation of inorganic salts, accumulation of particulate material, and bio fouling formation are the main causes of RO membrane fouling, increasing maintenance costs, making disinfection operations more difficult, and reducing their life time.
- Environmental impacts of the technologies used to fulfil energy requirement of RO system and noise pollution during operation and construction of RO plants are also important considerations.
- To avoid brine disposal in sea, Saline solids are generated by evaporation of brine and used for sanitary landfills. Such activity can cause changes in land use and groundwater contamination due to leaching of ions.

Financial costs

Costs are very much site-specific and can vary widely. Some of the factors affecting the cost per M³ include:

- Cost of energy,
- Scale of the plant, and
- Salt/TDS content of the source water
- Capital costs of construction

The operation cost of membrane desalination decreases sharply as the salt concentration decreases. Higher capacity plants have substantially lower costs.

SWRO plants of > 10,000 M³/day have been reported to cost in the range of 0.5 to 1.5 USD/M³. Thermal methods of almost identical capacity plant could cost in range of 0.5 to

2 USD/M³. Operating cost of BWRO plants of 10,000 to 50,000 M³/day is reported to range from 0.25 to 0.5 USD/M³, since TDS in feed water is drastically lower than seawater. The lower capacity BWRO plants (<1000 M³/day) could cost from 0.75 to 1.25 USD/M³. The operating cost indicated here are tentative and does not include cost of intake water, concentration discharge, capital and maintenance cost of plant and labour cost.

Organizational considerations and opportunities

Desalination enables access to a nearly unlimited and stable water supply of water for households and industry. However, in view of various challenges and barriers, water desalination should not be considered a panacea of the water scarcity. Desalination should remain the last resort, and should only be applied after having carefully considered cheaper alternatives in terms of supply and demand management. Wherever considered for implementation, desalination plants should be considered in water sectors that are functioning well, have well-defined water policy, well-characterized water resource availability, accurately estimated demand over a period of time, technical expertise, and relatively little waste and inefficiency. The institutions, organizations and the governments must consider some very crucial and important points before pushing the efforts toward water desalination :

- Institutions should use an integrated water resources management (IWRM) approach to determine accurately the renewable freshwater resource potential, demand and consumption.
- They should develop a clear water policy.
- Desalination should be considered only when the inadequacy of conventional water resources is clearly established.
- Should implement conservation and water demand management in all sectors.
- Reduction of non-revenue water in piped systems, limited subsidies, and prevention of groundwater pollution should be addressed.
- Water desalination should be combined with other non-conventional efforts like reuse of treated wastewater, transportation of water across geographical boundaries,

- rainwater harvesting and creation of micro catchment areas.
- Should ensure an abundant source of brackish water with low salt / TDS for membrane systems.
- For thermal systems, the plant location should preferably on a coastline with an adjacent facility for power availability. The vicinity of a power plant can synergise the thermal desalination since power plant yields abundant waste heat.
- Consumers of water should be educated and convinced not to oppose the reuse of treated wastewater.
- Should constantly strive for technological advances for reducing the economic and environmental impacts of desalination.
- Should make sure that sustainable energy utilization and safe discharge methods are deployed.

Scenario

In 2017, there were almost 18,500 plants installed in around 150 countries to handle desalination of around 100 million M³/day, according to the International Desalination Association (IDA). The ever-growing technology has been raising the installed capacity year on year. Approximately, 60% of the units take seawater as feed water, whereas almost 30% corresponds to brackish water. More than 60% use of Desalination technology is towards municipal purposes and around 30% for industrial use.

Almost half of the desalination plants are concentrated in The Middle East and North Africa, with North America having approximately 12% of the capacities. East Asia and the Pacific add up to approximately 18-20%. It is estimated that the world desalination market will grow at a speed of 9-10% in the coming years, most of which is likely to come from Europe, the Middle East, and Africa.

Reverse osmosis (RO) is the dominant technology in membrane processes (70%), followed by multistage flash systems (18%) and multi-effect desalination (7%) of the installed capacity in large-scale desalination plants. Other membrane technologies such as Nano Filtration (NF) contributes 3% to desalination, while electro dialysis (ED) 2%, and reverse electro dialysis (RED) 1%. In the

Middle East, thermal desalination technologies continue to be overriding, due to their integration with power plants and useful life of more than 30 years.

Historically, Kuwait was the first country in the world to commission first distillation plant in 1951 to supply water for large-scale domestic use. Currently, there are some 20,000 desalination plants in the world. From scale viewpoint, the large capacity plants are located in the Middle East. The Ras-Al-Khair plant of Saudi Arabia is considered to be one of the largest hybrid desalination plants of world. This 1036 MLD plant uses both MSF and RO technologies to produce fresh water and power in the tune of 2400 MW. Saudi Arabia's Shuaiba3 and JWAP plants handle 880 and 800 MLD water respectively. DEWA Station plant of UAE produces 636 MLD of potable water and is one of the largest power and desalination plants of UAE with a power capacity of > 2800 MW. UAE's Fujairah plant has a capacity of 591 MLD, out of which 450 MLD is thermal plant and rest is RO plant. This plant produces 2000 MW power. While Ras-Al-Khair is the largest hybrid plants of the world, the Sorek plant of Israel is the largest membrane plant of the world, which handles 624 MLD water. Taweelah and Umm Al Quwain plants of UAE will be of 900 & 683 MLD capacities respectively and are expected to be commissioned by this year end. It is believed that mega desalination plants in future will override Ras-Al-Khair plant, since Saudi Arabia is planning for a 1500 MLD plant. IDA believes that plants of such capacities will also come up in future in China, India and Abu Dhabi depending upon governments policies.

Future prospects

- Economies of RO desalination can be improved by use of renewable energy resources like Solar energy to facilitate direct evaporation and wind energy to supply electricity or mechanical power.
- The nuclear energy offers a higher energy density compared to other conventional and renewable energy sources.
- Other emerging technologies such as capacitive deionization, freezing, humidification-dehumidification, and use of gel hydrates for desalination have not reached enough maturity at this stage for extensive use.

- Desalination through carbon nano pores is a promising future technology for desalination.
- Development towards artificial intelligence can aid towards efficient design and management of desalination plants, increasing productivity, reducing errors, optimizing operating costs, and freeing human beings from carrying out repetitive tasks.
- Energy storage systems and automated decision-making for production based on real-time demand analysis holds high potential for the future of the desalination industry.
- Ample research opportunities exist in new membranes development and hydrodynamics process to bring about solutions to some of the present technical problems.
- Conversion of brines into valuable products will be crucial to reduce environmental impacts.
- Research towards achievement of Zero Liquid Discharge and Minimal Liquid Discharge will boost membrane desalination.
- Energy Recovery Devices for small-scale RO units can substantially save energy costs.

Conclusion

The population and economic growth, increased need of fresh water as well as deterioration of conventional water sources have put a great pressure towards fulfilment of good quality water for domestic and industrial consumptions. Therefore, Desalination of sea and brackish water has shown a significant increase in recent decades. Among desalination technologies, RO is the most advanced technology due to its relatively low energy consumption, flexibility, ease of operation, economy of operation and high efficiency. On the other hand, low boron retention of RO membranes, membrane permeability loss, fouling, and requirement of high operating pressures for desalination of high salinity water are some of the technical limitations. Brine disposal, noise pollution, impacts on the marine environment, and generation of GHGs are some of the environmental difficulties of this technology. However, advances in new membrane materials, improvements in high

pressure pump efficiency, and development of energy recovery devices (ERD) have pushed implementation of RO process.

RO desalination is a knowledge, technology, and energy intensive process. Optimal utilization requires training, regular maintenance and access to spare parts. For water desalination to be successful, there has to be strong water policies, well-defined water resource availabilities and demand, and strong technical expertise. Monitoring and environmental impact assessment should also be instituted, depending on plant size and waste disposal methods. A multidisciplinary vision and on-going research are crucial aspects for

industrial implementation and future growth of water desalination technologies.

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About the Author

Dr. Mayur J. Kapadia, MSc, PhD, is a retired Add General Manager & Laboratory Head of GNFC Ltd - a large sector chemical & fertilizer manufacturing company located at Bharuch, Gujarat, India. He possesses professional industrial experience of > 38 years in the fields of Quality Control of Chemicals / Fertilizers / FMCG products, New Laboratory Set up, Cooling Water Management, ISI certification, Technical Education, Research, Effluent Treatment, Supplier development, Cost Reduction and Administration. He has to his credit technical suggestion awards, 16 publications in journals and > 10 presentations in conferences. He is a technical expert for recruitment / promotion interviews, external examiner for Ph D / CBSE board. He is presently a member in technical committee of Bureau of Indian Standards rendering immense contribution for establishing and improvising various Indian Standards. He has been assisting various organizations for process trouble-shooting, report preparation, publication and training purposes.

To know more about the contributor of this article, you can write to us. Your feedback is welcome and should be sent at: deepak.chaudhary@eawater.com

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VONTRON SEAWATER MEMBRANES ENABLES HIGH-PURITY WATER FOR RABIGH POWER PLANT

By Dr. Liang Songmiao, Director, Time Vontron Technology Co., Ltd.



RO Membrane Usage in Power Generation

Thermal power generation is the most important type of power generation, accounting for more than 60% in the world, report from the International Energy Agency (IEA).

The stable operation of thermal power plants is inseparable from high-purity water. At the same time, the increasing pressure of environmental protection and energy-saving policies poses a challenge to high-quality membrane products.

VONTRON tech provides complete solutions for each process of water treatment in power plant:

1. Boiler makeup water for steam generation
2. Cooling tower makeup water
3. FGD (Flue Gas Desulfurization) process makeup water
4. Treatment of cooling tower blowdown
5. Condensate polishing
6. Nox cooling water

RABEC Rabigh Independent Power Plant (IPP)

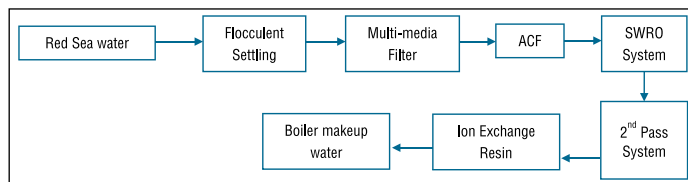
Rabigh IPP 2 × 660 MW subcritical oil-fired power plant project is located 150 kilometers north of Jeddah, a port city in western Saudi Arabia. This power plant was officially put into commercial operation in early 2013.



Picture 1 & 2. Rabigh factory photos

Rabigh IPP mainly consists of pre-treatment section, sea water RO unit, brackish water RO unit and post Treatment section as demineralization plant. The final consumer is steam turbine unit boiler to produce the steam very extreme high-quality steam. The Sea water consist 4 number of SWRO streams.

Figure 1. Water treatment system process



Sea water RO system

There are four single-stage trains in the SWRO system, 20 pressure vessels per train and 7 elements per pressure vessel, all the SWRO systems operated under 43% recovery rate and 26-34°C temperature, Table 1. Show the feed water quality.

For seeking a SWRO membrane with highly productive, high quality (Low TDS) and less price for long term stable operation. Many competitors have

Table 1. Feed sea water stream quality (mg/L)

Calcium (Ca ²⁺)	436.69	Bicarbonate (HCO ₃ ⁻)	144.04
Magnesium (Mg ²⁺)	1,432.36	Carbonate (CO ₃ ²⁻)	7.53
Sodium (Na ⁺)	12,878.02	Sulphate (SO ₄ ²⁻)	3,311.58
Potassium (K ⁺)	362.36	Chloride (Cl ⁻)	22,588.58
Barium (Ba ²⁺)	0	Fluoride (F ⁻)	1.26
Strontium (Sr ²⁺)	0	Nitrate (NO ₃ ⁻)	0
Boron (B)	6.80	Silica (SiO ₂)	0.29
TDS	41162.00	pH	8.2

conducted field comparison tests in cooperation with Rabigh power plant. At last, VONTRON membranes won the competition.


Picture 3. Sea water RO system

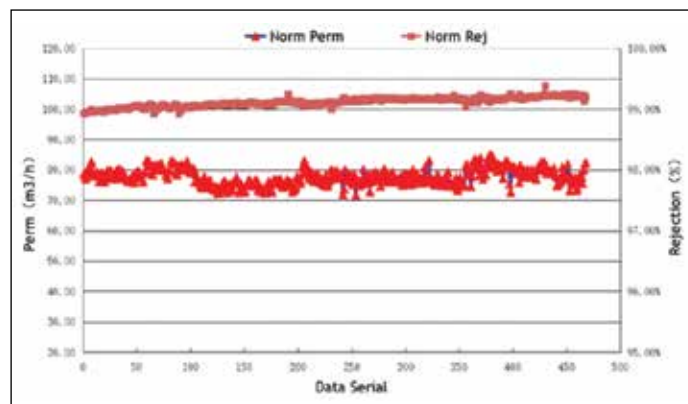
Picture 4. 2nd Pass RO system

VONTRON Seawater Membranes Performance

Since VONTRON SW8040HR-400 membranes began operations on the Rabigh IPP SWRO system in November 2019 (Picture 5).

The seawater reverse osmosis permeate has been well within specifications. Figure 1. Shows the normalized permeate flow and rejection.

After 450 days operation, at expected, all the parameters are still under customer's first year permeate water requirements (Table 2.)


Picture 5. VONTRON membranes being loaded

Figure 1. Normalization Permeate Flow and Rejection

Permeate water parameter	unit	Design value	Actual value
TDS	ppm	< 390	230-280
Cl	ppm	< 230	132-170
Boron	ppm	< 1.45	0.98-1.11
Flow rate	m ³ /h	≥78	78-82
Differential pressure	Bar	< 1.6	1.0-1.4

Table 2. First year permeate requirements and actual value

Red Sea input water can be high in SDI and TSS sometimes, may cause serious organic pollution on the surface of the feed end, chemical cleanings are done every 4 months.

After chemical cleaning, the feed pressure and differential pressure recover to original figures.



Picture 6. SDI film full of colloid

Conclusions

Since the first day operation in November 2019, VONTRON membranes provide stable high-purity water for Rabigh IPP, and now VONTRON latest 440 ft² SW membranes are proceed orderly at Rabigh IPP.

About the Author

Dr. Liang Songmiao, born in November 1977, graduated from Wuhan University, major in polymer chemistry and physics, doctor of science, professor-level senior engineer. From October 2007 to November 2008, he was a post doctor at the State University of New Jersey (Rutgers University). From November 2008 to November 2009, he was a postdoctoral researcher at Hokkaido University in Japan. From December 2009 to January 2020, he served as senior design and development engineer, director of the technical center, deputy general manager and director of the technical center, executive deputy general manager and chief engineer and director of The Time Vontron Technology Co., Ltd. Since January 2020, he has served as general manager, chief engineer and director of Time Vontron Technology Co., Ltd.

To know more about the contributor of this article, you can write to us. Your feedback is welcome and should be sent at: deepak.chaudhary@eawater.com

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BRAHMAPUTRA-TISTA-GANGA LINK FOR HYDRO-POWER DEVELOPMENT TO MEET ENERGY REQUIREMENT FOR DESALINATION OF SEA WATER

By S.K. Mazumder, Former AICTE Emeritus Professor of Civil Engineering, Delhi College of Engineering (New Delhi Technology University)



Introduction

India is surrounded by Bay of Bengal on the east, Arabian Sea on the west and Indian Ocean on the south. It is protected by the Himalayas on the north separating India and Tibet/China. Out of a total 1869 billion cubic meter (BCM) of water resources potential of India, water resources potential of Brahmaputra-Ganga basin is 1162 BCM i.e. 62% of the country (IWRS, 2007). Hydro-power potential of Brahmaputra-Ganga basin is

1,12,366 MW i.e. 76% of India's total hydro-power potential of 1,48,701 MW as per Table-1 (CBIP, 2022)). It may be noticed from table-1 that untapped hydro-power in Brahmaputra and Ganga basin are 54,329 MW and 26,859 MW respectively which corresponds to 93.1% and 51.4% of the potential available in the respective zones.

There are no major technical obstacles to desalination as a means of providing an unlimited supply of fresh water from sea, but the high energy requirements of this process pose a major challenge. Theoretically, about 0.86 kWh of energy is needed to desalinate 1 m³ of salt water at 34,500 ppm (AMTA-2017). This is equivalent to 3 kJ per kg of brine. The present day desalination plants use 5 to 26 times as much as this theoretical minimum depending on the type of process used in desalination. Clearly, it is necessary to make desalination processes as energy-efficient as

possible through improvements in technology and economies of scale.

Desalination as currently practiced is driven almost entirely by the combustion of fossil fuels. These fuels are not only in finite supply, they also pollute the air and responsible for global climate change. The whole character of human society in the 20th century in terms of its history, economics and politics has been shaped by energy obtained mostly from oil. Almost all oil produced to date is what is called conventional oil, which can be made to flow freely from wells (excluding oil from tar sands and shale). Of this vast resource, about 1600 billion barrels have so far been discovered and just over 800 billion barrels had been used by the end of 1997. It is estimated that there may be a further 400 billion barrels of conventional oil yet to be found. With current annual global consumption of oil being approximately 25 billion barrels, and rising at 2 per cent per annum, the "business as usual" scenario would suggest that the remaining oil will be exhausted by 2050.

The present paper deals with development of hydro-power potential through linking of Brahmaputra with Ganga via Tista for hydro-power development in order to meet the energy requirement for desalination.

Advantages of Hydro-Power

Power can be generated by different means e.g. thermal power by burning coal and fossil fuels and nuclear power from uranium. But they have several drawbacks and non-sustainable. They cause atmospheric pollution and rise in temperature which is responsible for climatic changes. As per IPCC forecast, a rise in temperature by 1.5° C by 2030 will result in severe floods and draughts with rise in sea level causing devastation in many parts of the world. Hydro-power like solar, wind and tidal power are renewable, sustainable and do not cause atmospheric pollution. The greatest advantage of hydro-power is its flexibility in operation. There are

countries like Norway and Sweden where entire energy supply comes from hydro-power. As on 31.12.2019, installed capacities of the different power sources in India are as follows (CBIP, 2020):

Sources	Installed Capacity	Percentage
Thermal	2,30,701 MW	62.55%
Hydro-Power	45,399 MW	12.32%
Nuclear Power	6,780 MW	1.84%
Solar & wind	85,908 MW	23.29%
Total Installed Cap.	3,68,789 MW	

Hydro-Power Potential of India

Hydro-Power power potential available in different parts of the country is given in table-1 (CBIP, 2022). It may be noticed that the highest hydro-power potential of India lies in the Ganga (53,395 MW) basin in the northern region and Brahmaputra (58,971 MW) in the North - Eastern region (NER) in India. It may also be seen that capacity yet to be developed are 51.39% and 93.10% in Ganga and Brahmaputra basins respectively.

Table-1 Hydro-Power Potential of India (Above 25 MW only) as on 30.9.2020

Region/State	Identified Capacity as per reassessment study		Capacity In Operation		Capacity Under Construction		Capacity In Operation + Under Construction		Capacity yet to be taken up under construction	
	Total (MW)	Above 25 MW (MW)	(MW)	%	(MW)	%	(MW)	%	(MW)	%
NORTHERN										
Assam & N. Cachar	11769	11497	3360	28.23	2589.5	22.26	5949.5	51.49	5577.5	48.51
India	2177	2046	59.0	4.35	0.0	0.0	59.0	4.35	1987.0	95.65
Uttarakhand Pradesh	15520	15540	9809.00	52.91	2125.00	11.45	11934.00	64.37	6606.00	35.63
Uttar Pradesh	971	971	1695.00	112.90	205.00	21.22	1900.00	134.12	0.00	0.00
Haryana	64.90	64.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rajasthan	196.00	182.00	41.00	56.09	0.00	0.00	41.00	56.09	0.00	0.00
Uttarakhand	18779	17998	3766.40	20.85	1490.00	8.28	5256.40	29.13	12742.60	70.87
Uttar Pradesh*	723	664	500.60	75.54	0.00	0.00	500.60	75.54	162.40	24.46
Sub Total (NER)	53395	52265	19023.30	36.40	5580.50	12.41	24603.80	48.81	25861.20	51.19
WESTERN										
Madhya Pradesh	2243	2970	2235.0	100.0	0.00	0.00	2235.0	100.00	0.00	0.00
Chhattisgarh	2242	2202	120.0	5.45	0.00	0.00	120.0	5.45	2082.0	94.55
Uttarakhand	660	590	590.00	100.0	0.00	0.00	590.00	100.00	0.00	0.00
Maharashtra	1759	1314	2647.0	79.87	0.00	0.00	2647.0	79.87	647.0	36.83
Goa	52	52	0.00	0.00	0.00	0.00	0.00	0.00	52.00	100.00
Sub Total (WR)	3923	8121	5522.0	68.23	0.00	0.00	5522.0	68.23	2571.0	31.77
SOUTHERN										
Andhra Pradesh	2266	2241	1610.0	68.77	965.0	41.01	2575.0	109.78	0.00	0.00
Telangana	2035	2019	800.0	39.62	0.00	0.00	800.0	39.62	1219.0	60.38
Karnataka	6602	6176	3644.0	56.42	0.00	0.00	3644.0	56.42	2932.0	44.58
Kerala	3504	3378	1850.0	54.99	100.0	2.93	1950.0	57.92	1428.0	42.08
Tamil Nadu	1918	1593	1775.0	100.0	0.00	0.00	1775.0	100.00	0.00	0.00
Sub Total (SR)	16125	12390	9680.0	60.47	1065.0	6.67	10745.0	67.15	5440.0	32.85
EASTERN										
Bihar	723	582	170.0	29.24	0.00	0.00	170.0	29.24	552.0	70.76
Odisha	79	40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
West Bengal	20992	20981	2142.0	71.86	0.00	0.00	2142.0	71.86	8839.0	28.14
Bihar	2841	2829	1412.0	50.00	120.0	4.24	1532.0	54.24	2297.0	85.76
Sub Total (ER)	4286	4248	2162.0	50.66	120.0	2.82	2282.0	53.48	2066.0	46.52
NORTH EASTERN										
Mizoram	3294	2595	329.0	14.00	0.00	0.00	329.0	14.00	1966.0	59.59
Manipur	15	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nagaland	1784	1764	105.0	5.95	0.00	0.00	105.0	5.95	1679.0	94.05
Assam	630	595	350.0	55.45	0.00	0.00	350.0	55.45	280.0	44.55
Nagaland	1574	1452	73.0	5.17	0.00	0.00	73.0	5.17	1501.0	94.83
Uttarakhand Pradesh	50348	50044	815.0	1.63	8300.0	4.59	9115.0	1.82	49133.0	9.78
Mizoram	2896	2131	60.0	2.82	0.00	0.00	60.0	2.82	2831.0	97.18
Sub Total (NER)	58971	58356	8727.0	2.96	2300.0	3.94	11027.0	1.90	47329.0	80.10
ALL INDIA	148701	143320	40913.0	28.13	1530.5	1.03	42443.5	29.16	100976.5	68.84

Brahmaputra-Tista-Ganga Link

Indira Gandhi set up the National Water Development Agency (NWDA) in 1982 to study the possibility of water transfer from surplus basins in the Ganga-Brahmaputra basins to deficit basins in the south and west of India. NWDA, under the Ministry of Water Resources, River Development

and Ganga Rejuvenation (now Ministry of Jalshakti), Govt. of India, proposed the National Perspective Plan (NPP) consisting of 14 river links under the Himalayan component and 16 river links under the peninsular component (IWRs, 1996; Mazumder, 2011; Parashar, R.K., 1999). National Commission of Integrated Water Resources Development was of the opinion that long distance river links may be taken up later (due to exorbitant costs) and suggested that execution of short links like, Ganga-Brahmaputra Link-1 be taken up initially on priority basis. (NCIWRD, 1999).

India advocated inter-basin water transfer from the Brahmaputra basin to the Ganga basin through a link canal to augment the dry season flow in the Ganga basin downstream of Farakka barrage in order to address the grievances of Bangladesh. India's 1978 proposal consisted of a barrage 2,460 m long across the Brahmaputra river at Jogigopa (Fig. 1) in Assam with a link canal 324 km long, 274 metre wide and 9 metre deep passing mostly through Bangladesh up to a point upstream of Farakka barrage in West Bengal as shown in Fig.1 in dotted green Line. This proposal was the shortest link between Brahmaputra and Ganga. It had no lift component and the flow was entirely through gravity. However, the proposal was rejected by the Bangladesh Government due to political reasons. (Crow et al, 1995).

In its revised proposal, Govt. of India decided to connect Jogigopa barrage with Tista and Ganga by-passing Manas and Sankosh rivers as shown in Fig. 1 in full green line (NWDA, 2005). The proposal envisages the construction of three storage reservoirs (Subansiri, Dihang and Tipaimukh dams) in the eastern foothills of the Himalayas to supplement the dry season flow of the Brahmaputra at Jogigopa. The idea is to divert water from these storages to the Ganges basin in the months of February to April when water is abundant in Brahmaputra and scarce in the Ganges basin due to late arrival of Monsoon in Ganga basin as compared to Brahmaputra basin. The Dihang and Subansiri reservoirs are estimated to lower the flood peak in Bangladesh by 1.3 m while the Tipaimukh dam will reduce the flood in the Meghna basin in Bangladesh, especially in Dhaka (Rahman, 2009). The new link is exclusively within Indian territory and passes through a 32 km narrow belt (Known as Chicken Neck) separating India from Nepal and Bangladesh as shown in Fig. 1 in green full line.



Fig.1 Brahmaputra-Tista-Ganga Link-1 (Under NPP by NWDA)

Benefits of India and Bangladesh from Brahmaputra-Tista-Ganga Link

Primary objective of the proposed Brahmaputra-Tista-Ganga link-1 is to transfer excess water of Brahmaputra basin to Ganga basin for augmenting dry weather flow of Tista and Ganga rivers for hydro power, irrigation, water supply, navigation and flood moderation (Verghese, 1999). Tista barrage project has an irrigation potential of 9.22 lakh ha-m in six northern districts of West Bengal, namely, Cooch Bihar, Darjeeling, Jalpaiguri, Uttar Dinajpur, Dakshin Dinajpur and Malda. Apart from the proposed storages in Subansiri, Dihang and Tipaimukh, water stored in three storage dams on Teesta river in Sikkim will be diverted from barrages on Teesta, Mahananda and Douk rivers. The dams and the barrages on Tista are already completed and the construction of distribution canals are in progress. First part of the proposed Brahmaputra-Tista link will be of immense benefit for both India and Bangladesh ensuring firm water supply during lean season. Tista project started in 1975 is yet to be completed partly due to land acquisition problem and partly due to inadequate lean season flow from Tista to meet water demand of a huge command of 9.22 lakh ha in West Bengal on a firm basis.

Second part of the link canal connecting Tista with Ganga upstream of Farakka barrage on Ganga river will bring excess water of Brahmaputra basin to Ganga basin to augment dry weather flow at Farakka for transmission to Bhagirathi-Hoogly river system for survival of Kolkata port, navigation (National Waterway-1 and 2), industrial use and water supply to Kolkata Metropolitan city and other innumerable towns on either side of Bhagirathi-Hoogly river. Link no.1 is proposed to be connected with other links downstream of Farakka for transfer of water from surplus basins of Brahmaputra and Ganga and other eastern rivers to the water deficit basins through links 21 and 22 as proposed under NPP to address the severe water crisis in Cauvery and Pennar Basins in the south.

Besides sharing of Ganga water in the lean season, Bangladesh wants agreement for sharing of Brahmaputra and Tista river water too. Construction of dams on Subansiri, Dihang, Lohit rivers and a dam at Tipaimukh will be highly useful for water storage for firm water supply for hydro-power, irrigation and navigation. It will help tapping the huge hydro-power potential remaining unutilized so far in NER. It will resolve the dispute between India and Bangladesh about water sharing of Ganga, Tista and Brahmaputra rivers and possible sharing of hydro-power also to Bangladesh. At the 36th JRC meeting, India assured Bangladesh that it would implement the Brahmaputra-Ganga link and storage dams on Subansiri, Dihang and other tributaries of Brahmaputra river after consultation with Bangladesh (Daily Star, 2005). India, however, rejected the Bangladesh proposal to have a trilateral agreement between India, Bangladesh and China (Uppermost Riparian Country of river Brahmaputra) who has constructed large numbers of high dams on river Brahmaputra called Yarlung Zangbo and its tributaries in Tibet (Fig.1) without any agreement with either India or Bangladesh.

Share of hydro-power in the hydro-thermal mix is only 19% today against an ideal share of 40%. It is only 12% of India's total installed capacity consisting of thermal, hydro, nuclear and other renewable powers (like solar, tidal and wind power). The NER states in the Himalayas is attractive for hydro-power generation because the rivers in this region descend an

elevation around 3,500 m to 500 m in a short distance of 200-km stretch. The water wealth and terrain head in NER are nature's gift and a bounty for the relatively underdeveloped states in the NER. Some of the tributaries of Brahmaputra river are indicated in Fig. 2 showing average annual run-off of Brahmaputra and its tributaries (Mahanta, 2016). Needless to mention that apart from the main Brahmaputra and its tributaries, there are innumerable sub-tributaries in the Brahmaputra catchments (lying in Arunachal Pradesh and Assam states of India) where available water and terrain heads can be utilized for hydro-power development either by storage type or run-off the river type schemes for feeding the National Power Grid.

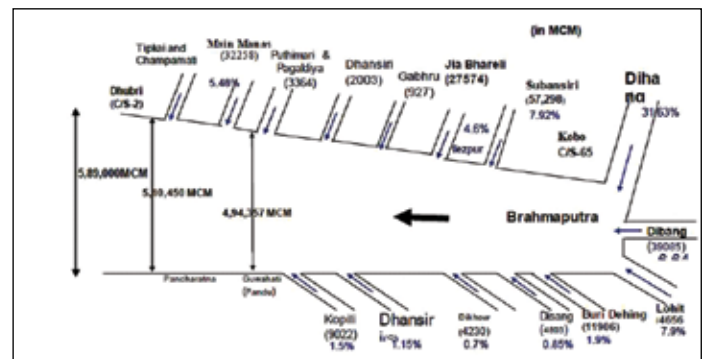


Fig. 2 Average Annual Runoff of the Brahmaputra and its Tributaries (NDMA, 2012)

Conclusions

Desalination of sea water either by reverse osmosis or other means require huge energy. Conventional methods of energy generation by thermal, oil and nuclear plants are not sustainable and cause atmospheric pollution, climate change and global rise of temperature resulting in disasters like floods, draughts and submergence of coastal areas due to rise in sea level. Hydro-power is a renewable source of energy like solar, wind and tidal powers. India has an enormous source of hydro-power potential in the northern and north-eastern regions. The potential yet to be developed are 53,395 MW and 58,971 MW in the Ganga and Brahmaputra basins respectively. Govt. of India has an ambitious plan of water transfer from the surplus basins of Ganga and Brahmaputra to water deficit basins in the south and north-west for development of irrigation, hydro-power, navigation and municipal supply. Brahmaputra-Tista-Ganga rivers (Link-1 under NPP) should be executed on priority basis to satisfy the water and power need of both West Bengal and Bangladesh. The Proposed link with storage reservoirs as well as numerous other storage and run-off the river type hydro-power schemes will help in augmenting dry weather flow and tapping of huge hydro-power potential of the region in particular and the country in general.

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About the Author

Born in 1938, **Prof. S.K. Mazumder** graduated in Civil Engineering in 1959 from B.E. College, Shibpur, Calcutta University (now IEST, Shibpur). He was Assistant Engineer, (Irrigation & Waterways Dte), Govt. of West Bengal, during 1959-62. He obtained his M.Tech. and Ph.d. in Civil Engg (Dam &Hydro-power Engg) from IIT, Kharagpur where he was a lecturer during 1962-67. He was Assistant professor in Civil Engineering at R.E.C. (now NIT), Durgapur, during 1967-75 and Professor of Civil Engineering (Hydraulics & Flood Control) at Delhi College of Engineering (now Delhi Technology University), during 1975-98. He was AICTE Emeritus Fellow during 1998-2000. During Feb-Nov, 1991, he was a visiting professor at EPFL, Switzerland. He was Head of Civil Engg. and Dean of Faculty of Technology, University of Delhi. He is Fellows of CBIP, IE (I), ISH &IWRS and members of IAHR, IRC, ISCA, IPHE, CDC, CEAI. He was principal Investigator of several research schemes sponsored by a number of Govt. and Pvt. Organizations.

Prof. Mazumder has published/presented more than 210 technical papers in National and International journals and conferences, written two books, editor in chief of the proc. of a national conference, contributed a chapter in two books by Kluwer and Springer publications. He got several awards for his papers from the Institution of Engineers (India) and Indian Roads Congress. He received life time achievement award in 2009 and best Reviewer Award in 2019 - 20 from Indian Society for Hydraulics for his immense contribution in hydraulics and water resources engineering.

After retirement, Prof. Mazumder served several consulting companies in Delhi e.g. ICT Pvt. Ltd., Aquagreen Engg. Pvt. Ltd, Scott- Wilson-India Pvt. Ltd., Mahendra Raj Consultants, B&S Consultants, NOIDA, Rambol India, Infinite Civil Solutions, Ahmedabad and currently retained by Maccaferri India, Gurgaon in the area of his specialization i.e. Hydraulics and Water Resources Engineering. He is currently, a faculty member of Indian Academy of Highway Engineers (IAHE), NOIDA. He is Member/convener of several committees of IRC and BIS, Govt. of India. For three years, he was an expert member of EAC (Hydro & Irrigation group), Min. of Env. & Forests, Govt. of India. He was a member of NIH Society, Roorkee, as a nominee of the Minister of Water Resources, Govt. of India. He is a reviewer of several journals published by several societies e.g. Institution of Engineers (India), Indian Society for Hydraulics, ASCE, IRC etc.

To know more about the contributor of this article, you can write to us. Your feedback is welcome and should be sent at: deepak.chaudhary@eawater.com



INNOVATION: HDPE PIPES USED AS A SEAWATER INTAKE FOR DESALINATION PLANT

By Dilip Yewalekar and Manisha Kinge, Jain Irrigation Systems Ltd, Jalgaon India



Introduction

Every human has the prime right to have safe drinking water on the earth. A safe water supply is the backbone of a healthy economy, yet is woefully prioritized, globally. Less than 50 percent of the population in India has access to safely managed drinking water. Two-thirds of India's 775 districts are affected by extreme water depletion and water shortage for drinking because of a lack of planning on water management.

Another problem is the fast rate of groundwater depletion in India and other countries. Groundwater from over 30 million access points supplies 85% of drinking water in rural areas and 48 percent of water requirements in urban areas. (Source: JMP 2017)

Many National & international agencies (UN, Unicef, Unesco, FAO) are working to meet the challenges of WASH (Water, Sanitation & Hygiene) for humans. Glasgow, 10th Nov 2021, The UNEP, and India signed an agreement on climate change and committed to achieving the target of SDG 6.3, and water conservation, energy conservation, environmental

protection, and green energy are the task to achieve. In 2015, Sustainable Development Goals (SDGs) assessed, that less than 49% of the rural population is using safely managed drinking water (improved water supply located on-premises, available when needed, and free of contamination). (Source: JMP 2017). Till other districts are suffering from water shortage. Seawater is an option to overcome the shortage of water at least in the cities located along the coast.

It is not safe and advisable to use seawater directly for drinking purposes, because seawater contains a lot of salts, harmful chemicals & pathogens for humans. After desalination of seawater, the seawater can make potable for humans. But setting up the seawater desalination plant is a costly affair. Countries like Israel, USA, Gulf, have set up seawater desalination plants to serve potable water for the community. Because of the lack of technology and awareness only a few seawater desalination plants have been set up in India in Chennai & Gujarat. Now Government of India has geared up to set up a number of desalination plants in many places.

The said article addresses one component, the use of HDPE Pipes as a seawater intake pipe, to source raw water from the sea to the desalination plant, as an innovative option against RCC or Metal pipes.

HarGharNal Scheme - JalJeevan Mission

In 2019, The Ministry of Drinking Water and Sanitation (MDWS) was restructured under a new ministerial organogram, under which the MDWS's mandate became one of two pillars under a new ministry named 'Jal Shakti', which focuses on the provision of 24 x 7 piped water supply to many cities.

The Perspective of the water in India

India has only 4% fresh water available (figure 1) and is not sufficient to meet the demand for drinking water in the cities. India is among the world's

most water-stressed countries according to the World Bank (figure 2). Water availability today has fallen down to 1/3rd of the water we had in the 1950s. The National Commission for Integrated Water Resources Development

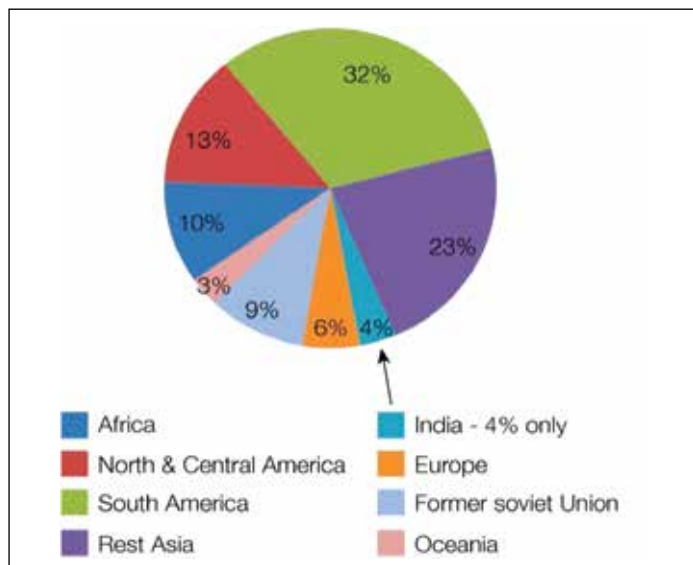


Figure 1: Freshwater available in the world. (Source: CWC, NCIWRD)

Plan has estimated overall water demand of 1180 billion cubic meters which was 710 in 2010. Niti Aayog in their report has declared the current

water scarcity as 'the worst water crisis in Indian History where about 60 crore people are facing high to extreme water stress. By 2030, the country's water demand is projected to be twice the available supply. This may affect our country in terms of food security, farmers' livelihoods, and the nation's economic development. Over the past few decades, groundwater has been exploited exponentially in India. As a result, India is the second-largest user of groundwater, digging out 25% of the total water extracted in the world. In terms of wastewater, we are not at all good enough to manage it.

India's Water Resources

(Source: The National Sample Survey Office-NSSO Aug 2014)

- Water resources in India include information on precipitation, surface and groundwater storage, and hydropower potential. India experiences average precipitation of 1,170 mm per year or about 1,720 cubic meters of fresh water per person per year.
- One option to solve the country's water woes is to create Rivers Inter-link & another option is to desalinate the seawater for drinking.
- Most of the rains occur during its monsoon seasons (June to September), with the northeast and north receiving far more rains than India's west and south.
- The main source of groundwater is the recharge from monsoon precipitation. About 58% of countries' annual rechargeable groundwater is contributed by monsoon rainfall. Other sources of recharge viz. seepage from canals, tanks, ponds, and other water structures and irrigation account for about 32%.
- The water crisis is imminent in villages because of the over-harvesting

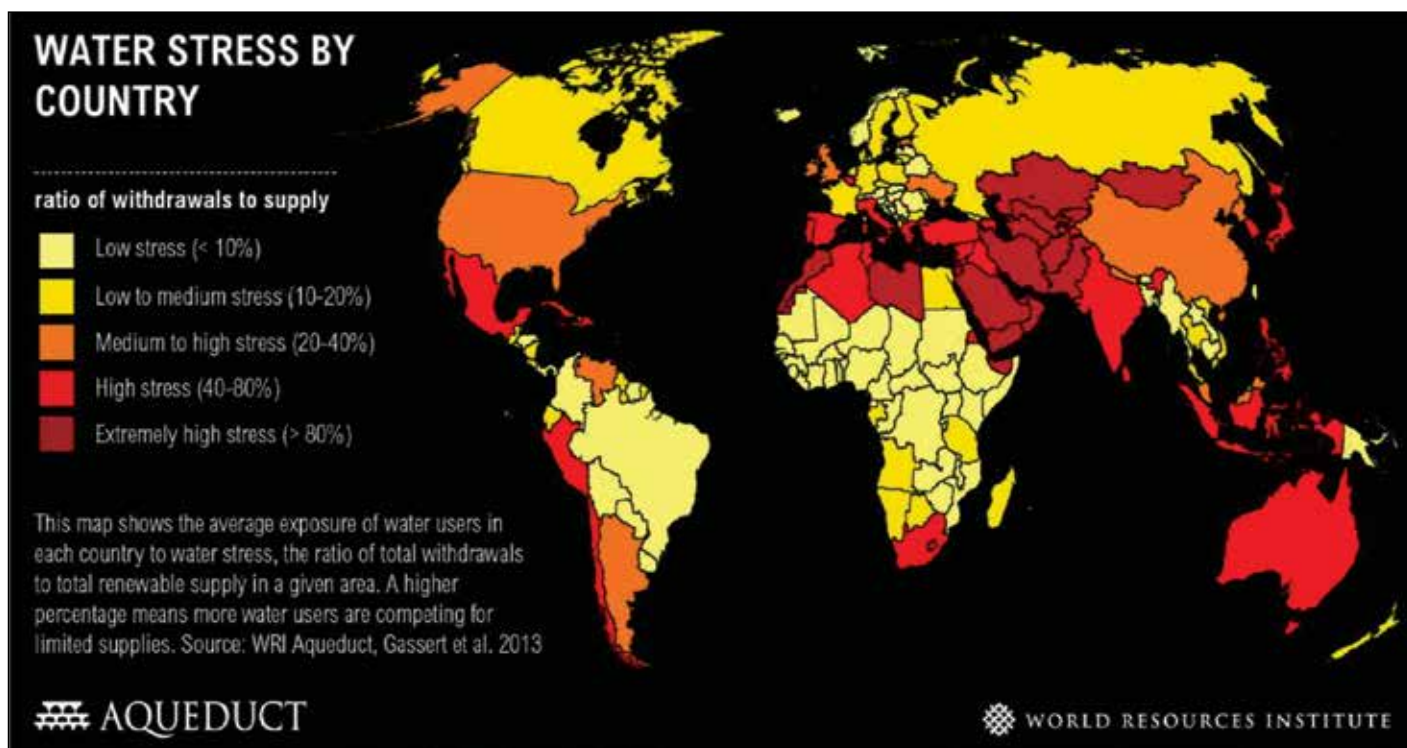


Figure 2: Water Stress countries (Source: WRI, Aqueduct, Gassert et al. 2013)

- of ground-water resources.
- India records the world's highest per capita water-borne diseases because of unsafe water even more than some of the least developed nations.
- In most large cities about one-third of water never reaches the consumer because of leaks and poor maintenance. According to the Centre for Science and Environment, over 35% of water in Delhi and about 30% in Mumbai is lost because of leakage.
- About 70% of surface water resources in India are polluted.
- The major contributing factor to water pollution is wastewater from different sources, intensive agriculture, industrial production, infrastructure development, and untreated urban run-off.
- Every day 2.9 billion litres of wastewater from industrial and domestic sources are dumped into the river Ganga without treatment.
- Domestic effluents contribute a substantial proportion of water pollution in India. More than 70% of domestic untreated effluents are disposed-off to the environment.
- Countries with per-capita water availability of fewer than 1700 m³ per year are categorized as water-stressed, with per capita available water of 1545 m³ India is definitely a water-stressed country (India-WRIS wiki 2015, Census, 2011).
- The projected per capita water availability will become 1401 m³ and 1191 m³ by 2025 and 2050 respectively and eventually India is likely to become a water-scarce country (India-WRIS, 2015).
- 700 million people worldwide could be displaced by intense water scarcity by 2030.
- More people in rural India have access to phones than to safe drinking water. It is estimated that only 18 percent of the total rural population of 833 million have access to treated water. (Forbes India, 2015).

Seawater Desalination

Seawater desalination is considered a solution to resolve water shortage in the world and helps to overcome the problem of at least drinking water in the majority of cities. Few of them are functional in India, Chennai, and abroad. It is not a new technology in the world but is not taken as a serious option.

Seawater Desalination plant

Seawater desalination plant comprising of the intake structure located in the sea bed, intake pipe placed at sea bed from sea to the water tank, filtration unit, desalination plant, finish water storage tank and main water distribution tank and distribution network to community. The schematic layout seawater desalination plant is shown in figure 3.

HDPE Seawater Intake Pipe

Seawater intakes systems are a fundamental part of a desalination plant and they have to be designed with due care to cater to all conditions of operation and stoppage and also to prevent the carry-over of materials like seaweed and sand. Each coast has its own specific typical problems for seawater intake.

This article, highlights the HDPE (High-Density Polyethylene) pipe as a

seawater intake, to source raw water from the sea to the pre-treatment storage tank. After pre-treatment storage water is passed via a filtration unit and desalination plant for onward distribution to the city. In many places, RCC or Metal pipes are used as seawater intake pipes. The use of RCC or Metal pipes has many disadvantages as compared HDPE Pipes.

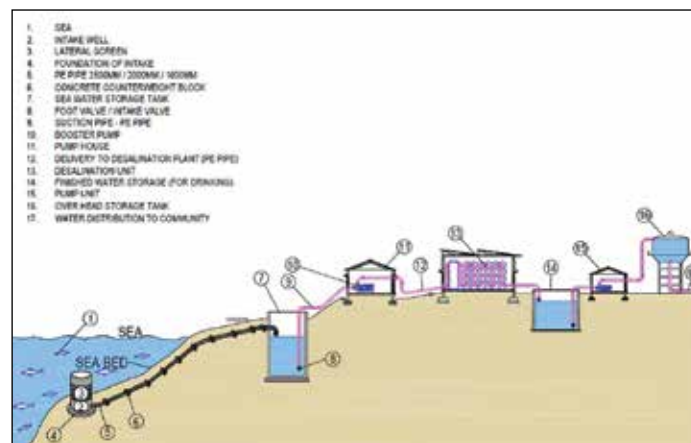


Figure 3. Schematic layout of a seawater desalination plant.

Saline water?

Seawater is a complex mixture of 96.5 percent water, 2.5 percent salts, and smaller amounts of other substances, including dissolved inorganic and organic materials, particulates, and a few atmospheric gases. Seawater contains a high concentration of dissolved salts and is expressed in parts per million (ppm). Sodium, Chloride, Magnesium, Calcium, Sulphates, and Bromides, are present in seawater. Those chemicals are very reactive with metal in presence of Oxygen and cause corrosion. Based on concentration level appropriate treatment is performed to reduce its corrosive effects.

Drawbacks of RCC or Metal Pipes

The exchange of electrons happens when metal pipes come in contact with seawater & Oxygen and causing corrosion in the sea as well as on the surface. Two types of preventive protection are needed for metal pipes. viz. 1. Pipes on the surface (exposed atmosphere) and 2. Pipes undergo in the sea. Periodic corrosion preventative treatment to intake Metal pipes on the surface as well as undersea are costly affairs. Whereas HDPE pipes are not corrosive and remain inert to all chemicals thereby the overall cost of maintenance is very less as well as there is no need to provide preventive treatment on the surface and undersea to HDPE Pipes.

Cathodic Protection

Metal pipes require cathodic protection for the surface and undersea pipes to prevent damage to pipes from corrosion.

Reduction in strength of Metal Pipes

Because of corrosion, the thickness of metal pipes decreases hence resulting in a reduction in engineering strength by 15% and a reduction in

the overall life of materials.

Drawbacks in RCC Pipes

1. RCC pipes are available in a short length of 3 m or 6 m, thus the number of joints is more, and takes more time for laying and jointing.
2. Joints of RCC pipes are not homogenous and fixed and likely to displace & open due to sea wave & tide time.
3. A rubber ring used at joints will react with the salt present in seawater and get disintegrated over the period.
4. Because of the movement of debris, sand particles, objects, inside-outside surface erosion take place faster and reinforcement gets exposed to seawater and corrosion happens over the period.

Advantages of HDPE Sea Intake Pipes

A subsurface water intake consists of pipes and wells set beneath the ocean floor and shoreline. The intake pipe draws seawater through the subsurface. It can be either infiltration galleries or intake wells.

- High-Density Polyethylene materials (HDPE pipes) are non-reactive to chemical or saline seawater.
- Jointing of HDPE Pipes are welded but-fusion method, so the strength of joints is similar to original materials.
- HDPE pipes do not corrode hence strength of materials remains unchanged and thereby gains more life.
- HDPE Pipes are available in lengths of 12 m or even more (as long as the feasibility of transportation.) Thereby the number of joints is less and requires less time to complete the work.
- The density of HDPE pipes is 7.5 times lesser than Metal pipes, so helps for easy transportation, handling, jointing, and maintenance.

Case study

Tamil Nadu currently boasts of two functional desalination plants churning out 200 million liters of water per day (MLD) to quench its capital's thirst. Chennai is almost entirely dependent on the monsoon for its water supply, the failure of which puts the city in a tight spot. The state government,



Photo 1. PE Pipe 1600 mm, Seawater intake pipe at Chennai, Desalination plant.

back in 2003-04, decided to go in for desalination to augment the municipal water supply. The two 100 MLD plants, one in Minjur and the other in Nemmeli, now contribute close to one-third of the city's total water supply. Sustained governmental support has enabled Tamil Nadu to contribute 24% of the total desalinated water capacity in India, making it the second-best in the country after Gujarat. Jain Irrigation has installed an HDPE Pipe of 1600 mm as a seawater intake pipe at Chennai Municipal Corporation for a desalination plant. (Photo 1).

Conclusion

Having all studied and compared all engineering parameters, properties, workability, and usages, HDPE Pipes gain more marks on the techno-commercial ground than RCC or Metal pipes. Hence, it is better to use HDPE Pipes as sea intake pipe for seawater desalination plants.

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About the Author

Dilip Yewalekar is the Senior Vice President of Jain Irrigation Systems Ltd. He has over 36 years of experience. He has done M.Tech - Civil - Structural Engg, PG Diploma in Piping Engg, AMIE,UK, ASAE, USA. He is a Google scholar, Member of ICID.

He also has Fellowship of World Bank and Mashav, Israel and is a Faculty at Govt College of Engg, Jalgaon. He is also a faculty at Micro Irrigation Course of ICID & CWC, Govt of India. He has been awarded the EEF Global Water Leadership Award - Global Water foundations. Strategic Leader in Micro Irrigation - ABSA Award, Professional Excellence Individual Award - Aqua foundations and Best Innovative Article in Sabujeema International Magazine. He has 70+ papers/publications at national/international conference/magazines/books to his name.

Manisha Kinge is an M.Tech - Agri Engg. She is the Manager - Design & Projects (Dom/Export), at Jain Irrigation. She is also the Faculty: Micro Irrigation Course of ICID & CWC, Govt of India. She has an overall experience of 16+ years in Water Management - Irrigation, Agriculture - Planning, Designing, Execution, Management & marketing in India and Abroad. She has 20+ papers/publications at national/international conference/magazines/books to her name.

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WASTE WATER - (SHOULD NOT BE) WASTED WATER SUSTAINABLE WATER INFRASTRUCTURE FOR THE CITIES OF INDIA

By Vikas Brahmavar, Director, Transwater System Private Limited



India as a country is blessed with enormous resources and all the problems related to water can technically be solved by better management of water and better use of known and proven technologies to increase the water availability.

Urban cities in our country feed from the rivers near the city. Example Bangalore city feeds from the Cauvery River which is 100 Km away with more than 65

sub stations to pump water to the city and it's the similar case for most of the cities in India. Logically it makes a sustainable case to have most of the river water catering to river belt region and urban regions away from the river use the best measure to catch every drop of rain water and reuse any available waste water generated within the city and resort to river water (being pumped from far away) to cater to emergency fresh water need.

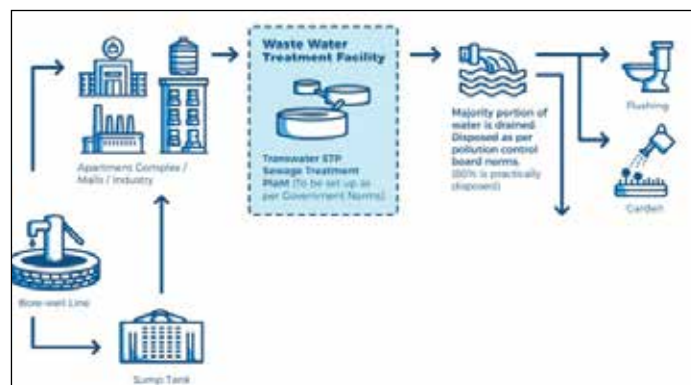
Water Infrastructure planning:

All our cities have the water management planning based on water coming into the city as rain, we measure the level of water in our dams and decide and plan our water distribution. However, advanced cities plan their water management based on the volume of water going out of the city. Say a city in India has a population of 20 million needs about 4 billion litres of water everyday out of which 3 billion litres of treated STP water could be reused whereas currently less than 0.4 billion litres is reused.

Our water distribution should be planned based on the 3 Billion litres of partially treated waste water which would go out of the city to the drain contaminating our fresh water resources.

Current Waste water setup for Cities:

Cities currently have government norms to reuse only 20% of their Waste water for secondary application. Majority of treated waste water is still drained and this water get polluted again when it mixes with other untreated sewage and together the waste water enter our lakes, creating chaos in the fresh water infrastructure.

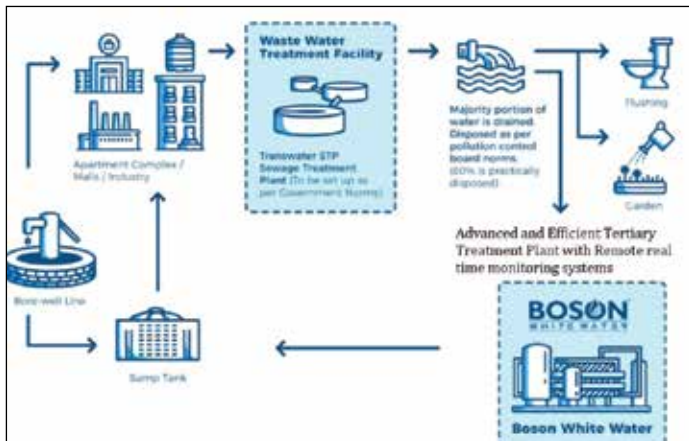


Reference: Trans Water System Pvt Ltd. (www.transwaters.com / www.bosonwhitewater.com)

Some Industries have the ZLD norms, however majority do not come under ZLD as for Sewage there is no ZLD norm yet.

Future Water Management for Cities:

Cities should have the infrastructure to manage the treated STP water better. The industrial Water requirement is almost equivalent to or more domestic water requirement. Bangalore's Industrial water need is estimated to be about \$1 Billion USD market. If we are able to map apartments waste water to Industrial water requirement, we can have a sustainable and economically viable solution to solve city's water infrastructure.



Reference from: www.bosonwhitewater.com / www.transwaters.com

However, if cities move towards Indirect Potable Reuse (IPR) / Direct Potable Reuse (DPR) norms by using advance technologies to recover potable water from the waste water, the cities become sustainable. When such technologies are employed the technology should have the capability to digitally measure, monitor and CONTROL systems to ensure best quality of water comes out of tertiary treatment.

Challenges:

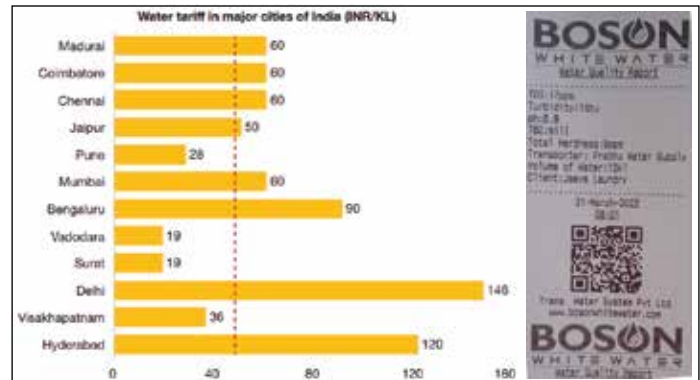
Direct and Indirect Potable reuse of Tertiary treated water comes with a huge MINDSET barrier to handle. As a society we are still gripping to understand and come to terms in reuse of secondary treated water for Gardening and flushing. Looking at reuse of STP treated water for potable reuse looks like impossible task in hand for government and private players trying to solve the impending water crisis.

How can we overcome Challenges?

Few key market factors which can help overcome MINDSET barrier to reuse STP water for potable reuse.

- A. The Water pricing is a critical area which directly depends on unstable supply and demand and varying at different seasons. Reference: PWC report - Closing the Water loop.

Logical thinking and assessing technology benefits begins only when the other sources of water is costlier. Imagine the "WHITEWATER - Potable water recovered from STP water" is almost the cost of tanker water people



buy and Whitewater comes with the benefit of each batch Water Report (A small slip which indicates the water quality for the water in the tanker). Reference image below from "Boson - Whitewater"

- B. Natural doomsday case when water availability becomes real challenge.

This should never happen, however few regions have faced this for short periods of time and when we are pushed to this, we have to look at alternatives. However, this cannot be actionable item to implement. Government sectors, NGO, Social Organization can have more measurement and can create awareness campaigns to prevent such disasters happen. Planning for doomsday of not having water for supply can still be beneficial than be completely clueless on what to do on such massive natural scenario's occur.

- C. Government norms enforcing for Zero Discharge from apartments

Our country works on penalties and fear. Government enforcement helps in implementation of such water reuse norms like DPR / IPR. However, this measure helps in some way but is not a citizen inclusive mechanism for quick success of such water reuse programs. Large citizens forum come against such initiative as government also does not have the framework to enable such activities. Norms should have inclusive of citizens and we have to ponder our on how can we make norms that can be called the citizens initiative.

- D. Flexibility for people to choose to use or not to use the water and making it commercially viable.

Enabling and giving people the option to reuse treated waste water for potable application is the best method to start the process of Reusing water for potable application. However, this can be enabled by Government or Private sector at the cost of spending time and effort to map the industry requiring high quality water and the apartment which is producing waste water. Private player can enable setup of Tertiary treatment plants at apartment complexes and government can play the role of enabling Industries to purchase the treated Tertiary water. Industries should commercially benefit from purchasing this tertiary treated water and apartments should benefit from the sales of waste water together with private player to have a commercial case to keep it sustainable. Over time,

when generator of waste water is fed with data on quality of water being produced in house will eventually decide to use the water for primary application. Once such entity solving this is Trans water system Pvt Ltd. In Bangalore.

Summary:

The only way forward for cities of India to become sustainable in terms of water is recovery of potable quality water from waste water. This would make our country water abundant. We are used to hearing the word water scarcity and if our mindset changes from scarcity to “abundance” we have better infrastructure for the city.

About the Author

Vikas Brahmavar - A Water Entrepreneur and Passionate about water and water reuse. Recently own the MISSION PAANI award by CNBC TV18 (Top 4 in India) and have also been called Water Warrior by publication like Times of India, HAR EK BOON (Republic TV), BetterIndia. He has been in the Water Industry from 2008 and hold multiple patents. He is a leader who is convinced that the only way for cities of India to sustain in terms of water is to reuse every drop of waste water generated from the city.

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REMOTELY MONITORED PALEO-CHANNEL SIGNATURES AND THEIR IMPLICATIONS ON GROUNDWATER RESOURCES

By Riddhish Chetan Soni | Karan Behar | Dr. Kapil Dev Sharma



Advancement in radar technology has opened new vistas in field of subsurface groundwater exploration, targeting and prospecting. The active imaging radar technique offers an opportunity to detect underground resources to comprehend the origin, evolution and composition of the prior buried water channels known as paleo-channels. We have evaluated the utility of satellite-based, UAV-based and ground-based radar technology to analyse the spatial distribution of paleo-channels and groundwater resources in the **Banda District of Uttar Pradesh, India**.

The Banda District (4413 km²) of Uttar Pradesh situated in the Bundel Khand Region is home to about 800,000 farmers. Nearly 48% cultivable area is dependent on groundwater irrigation. Targeting reliable and good quality source of underground clean water is a big challenge in the region, without a technology driven approach, and conventional methods rely on inaccurate, time consuming, costly and pseudo scientific water dowsing methods. The Nationalized banks end up accumulating NPA's when a farmer ends up drilling a dry well in 72% of the cases. Unlike the developed countries such as USA, UK, etc., the application of radar technology for groundwater targeting still remains a challenge in India.

Radar Technology for Exploration of Groundwater

Using a combination of multi frequency satellite radar, UAV-mounted radar and ground penetrating radar, a joint effort was made by Aumsat Technologies Limited Liability Partnership, iSenses Incorporation Private Limited and Greenfield Eco Solutions Private Limited to detect groundwater resources in parts of the Banda, Naraini, Baberu, Palani and Atarra Tehsils of the Banda district. Satellite based Synthetic Aperture Radar (SAR) having penetration depth up to 30m in dry soil was used to detect groundwater presence in subsurface fissures and cavities. Radar interferometry technique was also used to detect cm level ground displacement due to the overexploitation of groundwater resources and finally UAV based passive microwave radiometer and ground penetrating radar were used for field validation and truthing.

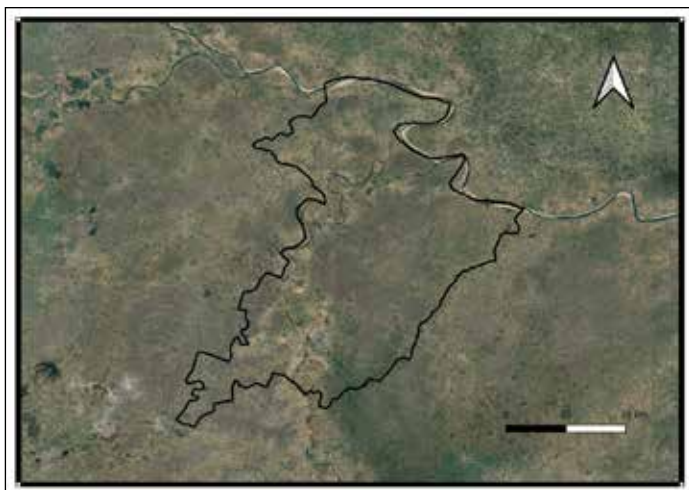


Image 1: Optical image, Banda district, Uttar Pradesh, India

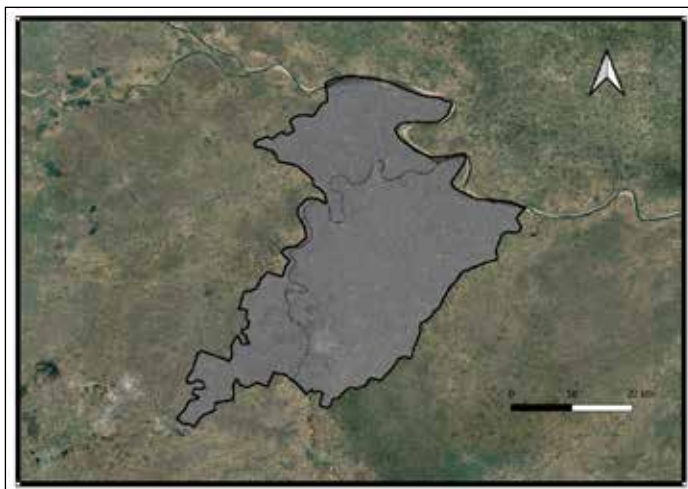


Image 2: C Band Radar image, 5 cm penetration depth, Banda district, India

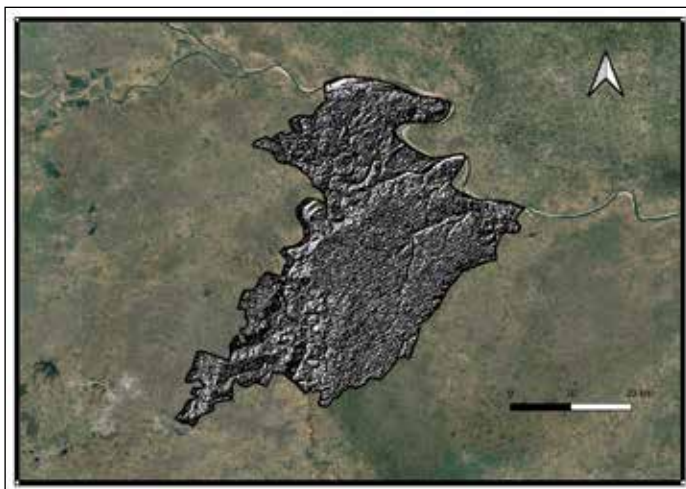


Image 3: L Band Radar image, 30m penetration depth, Banda district, India

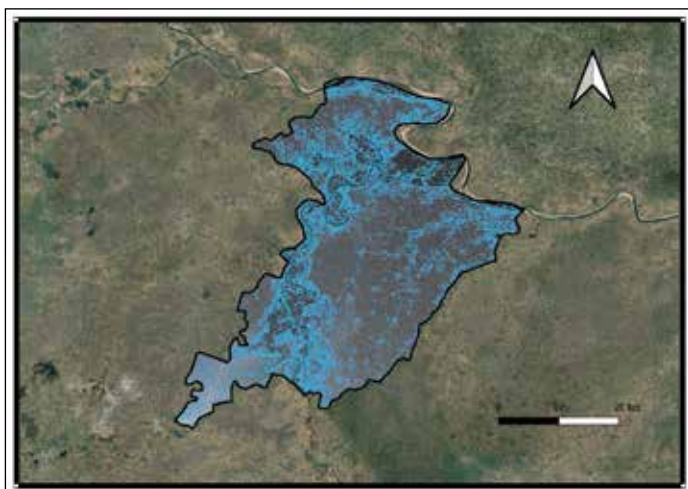


Image 4: Radar image showing groundwater resources in the Banda District during February 2022

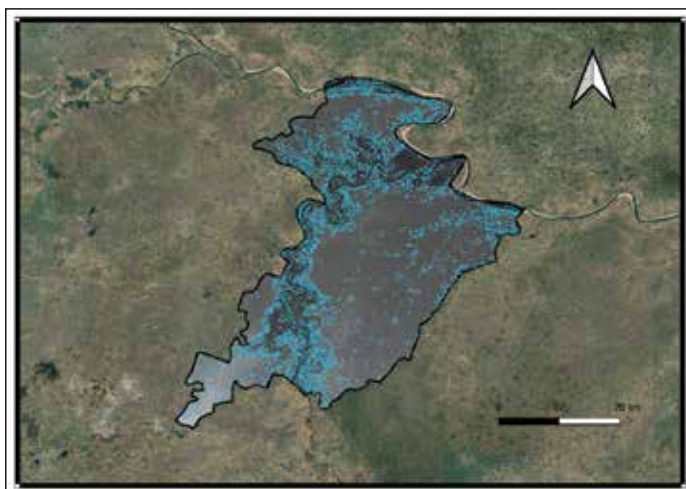


Image 5: Radar showing depleting groundwater resource forecast in Banda District for February 2025

It could be seen that radar was able to penetrate the sub surface and detect buried paleo-channels which may be a possible relict of the ancient buried paleo channel. Satellite gravimetry revealed that the groundwater table in the district is declining at 1.76cm per year.

These field trials were further validated using UAV-based passive microwave radiometer and ground penetrating radar in the Naraini, Baberu, Palani and Atarra Tehsils in the District. Passive microwave radiometer measures the natural microwave radiation emitted from the subsurface objects. The subsurface cracks containing the groundwater aquifers displayed a relatively lower signals of emissivity whereas the dry regions showed higher emissivity. The results were further validated using 2D-dipole resistivity survey techniques where subsurface water signatures were also detected in cross sectional areas of the paleo channel.

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Image 6: UAV mounted Radiometer



Image 8: Ground Penetrating Radar

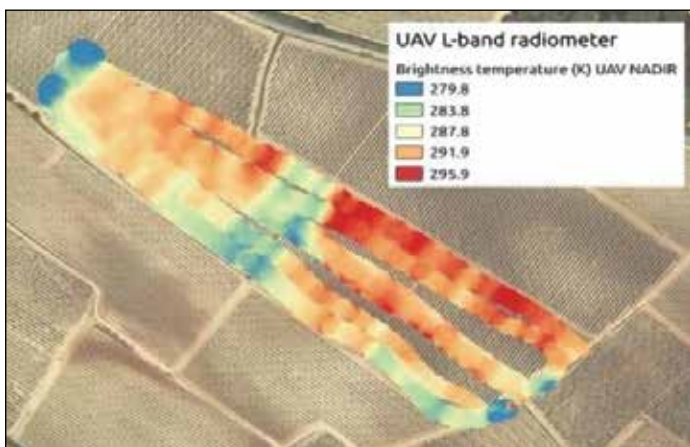


Image 7: UAV pass over aquifer, 20m height



Image 9: UAV pass over 50m height.

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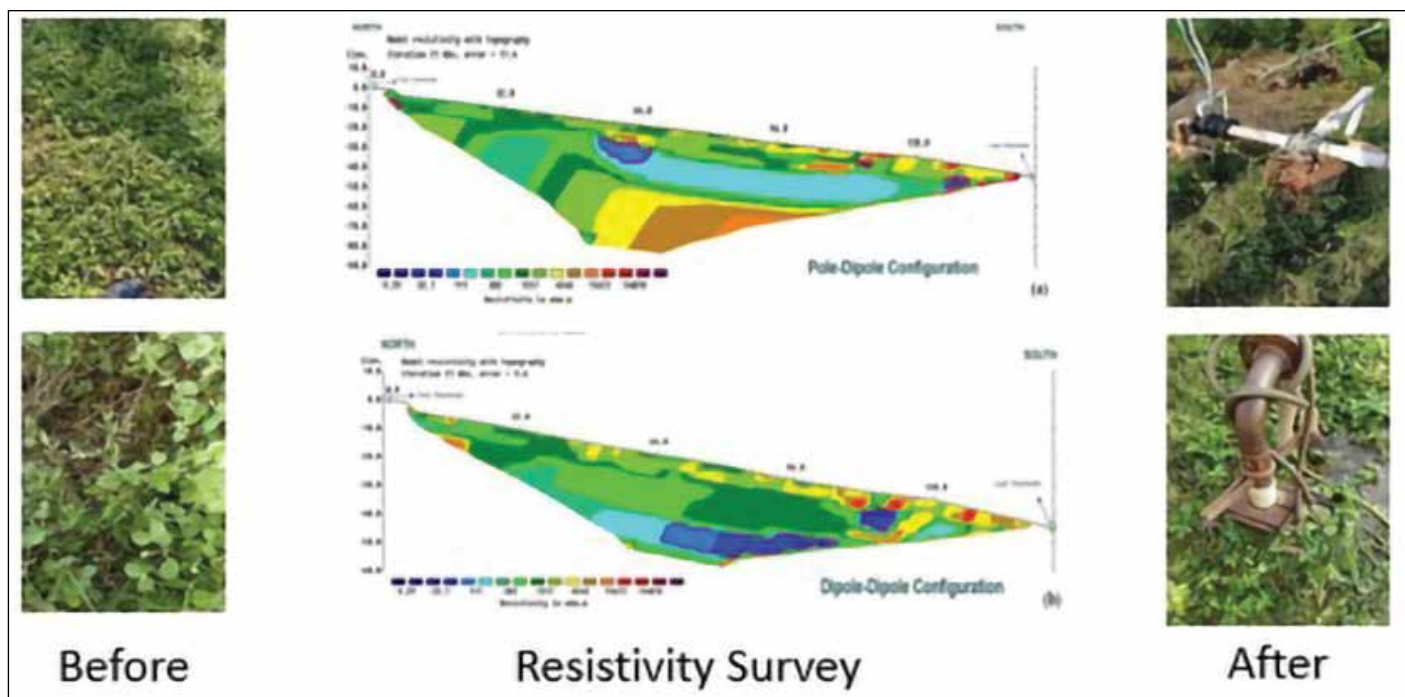


Image 10: Resistivity Survey Conducted in Poon Village, Baberu

Hunger, poverty, water scarcity and farmer suicides are on the rise again in the Banda District, India and climate change continues to affect thousands of inhabitants. Small-scale food producers and farmers require much greater support and increased investment in infrastructure and technology for sustainable irrigation. Incorporating radar technology for groundwater exploration would improve basic socio-economic and water demand-supply scenario thereby enabling an equitable distribution of

water resources due to more accurate groundwater forecast and precise assessment of crop damage due to disease, natural disasters such as drought and flood, etc. Further investments will provide employment and education in rural areas, improve environmental sustainability and finally help incorporating new tools and technologies for betterment of the people.

About the Author

Riddish Chetan Soni is CEO, Aumsat Technologies LLP. He has 7 year's experience in Satellite Technology and Applications. He has worked with UN, ISRO and Chandrayaan 2 Lunar Mission.

Karan Behar is Technical Head, iSenses Incorporation Private Limited. He holds a US patent in object detection. He has 12 year's experience of working with Google, JP Morgan Chase USA, DRDL, Agni Missile Labs.

Dr. Kapil Dev Sharma is Director, iSenses Incorporation Private Limited and Technical Head at Greenfield Eco Solutions Private Limited. He has been former Additional Secretary to PMO office and former Director of the National Institute of Hydrology, Roorkee. He comes with a 40 year's of field experience in hydrology.

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CASE STUDY: CONSTRUCTION OF URBAN STORMWATER AND FLOOD MANAGEMENT PLATFORM BASED ON 3D REALITY MODEL AND HYDRODYNAMIC MODEL

By Sandra DiMatteo, Industry Marketing Director, Water Infrastructure, Bentley Systems



User Name : Shanghai Investigation, Design & Research Institute Co., Ltd.

Project Name : Construction of Urban Stormwater and Flood Management Platform Based on 3D Reality Model and Hydrodynamic Model

Location : Jiujiang, Jiangxi, China

Overview : SIDRI created a CNY 8 billion hydraulic analysis system that can determine how to eliminate

flooding and waterlogging problems in Jiujiang, Jiangxi, China.

Year in Infrastructure Award 2020 Nominee, Going Digital: Advancing Water, Wastewater and Stormwater Networks

Impact of Severe Flood Events Led Impetus for Change

In 2020, significant flooding along the Yangtze River killed 141 people and displaced 38 million more. For the city of Jiujiang, the disaster was the latest in a string of overflow and waterlogging incidents caused by accelerated urbanization, and officials initially could not determine how to prevent them. To better prepare for future flooding events and minimize disruption to city life, China Three Gorges Corporation directed Shanghai Investigation, Design & Research Institute (SIDRI) to create a hydraulic analysis system that can simulate a variety of water conditions in the city. However, they lacked adequate data for the current state of the flood control and drainage system.

Seeking More Detailed Data

To provide the information, the hydraulic analysis system would need to clearly display detailed data, plan flood control tasks, and pinpoint emergency events. Frequently updated hydraulic data needed to be easily accessible to shorten the time needed to dispatch emergency services. SIDRI determined they had to create a reality model to provide them with crucial information. However, the technological leap would require software that could also move beyond traditional hydraulic modeling methods and incorporate Internet of Things data, providing the insight necessary to determine how to reduce flooding risk.

Linking Hydraulic Models within a Reality Model

SIDRI determined they could create a reality model that could support all the city's flood prevention goals with Bentley applications. They first captured images and created a reality model of the 21 square-kilometer area with ContextCapture. Within that model, they used OpenFlows FLOOD and OpenFlows SewerGEMS to create and link one-dimensional and two-dimensional hydrodynamic models. With IoT sensors, the models can provide real-time calculations. Lastly, they integrated the 3D reality model into the hydrodynamic models with LumenRT for dynamic animation of flooding events.

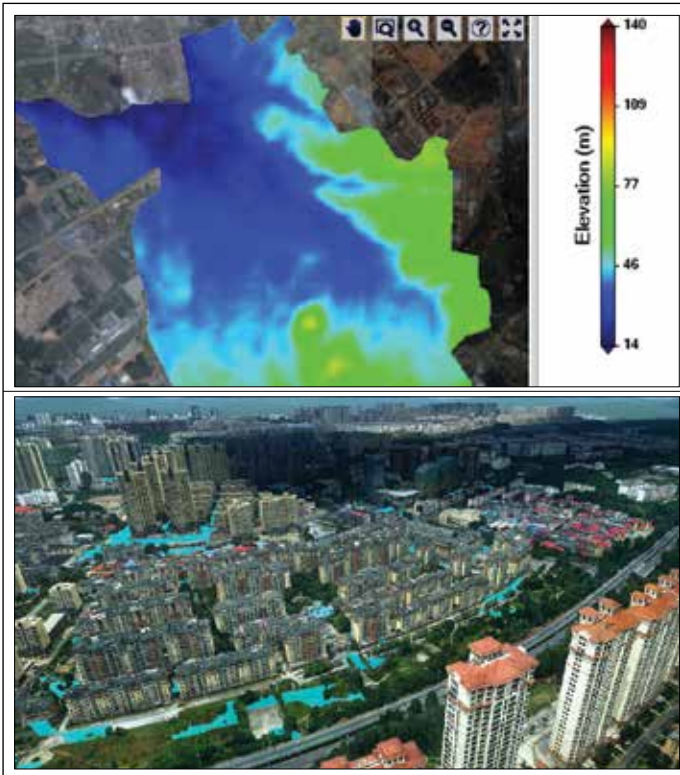
Improving Emergency Response with Real-time Data

With the ability to predict potential waterlogging, officials can now identify and address critical drainage problems in advance. Real-time data overlaid onto the reality model allows the city to make emergency responses to flooding in a timely manner. The intuitive and accurate analysis has helped the city to optimize their emergency response plan and determine the type of infrastructure they need to improve water flow, protect residents, and prepare the city for future weather-related events.

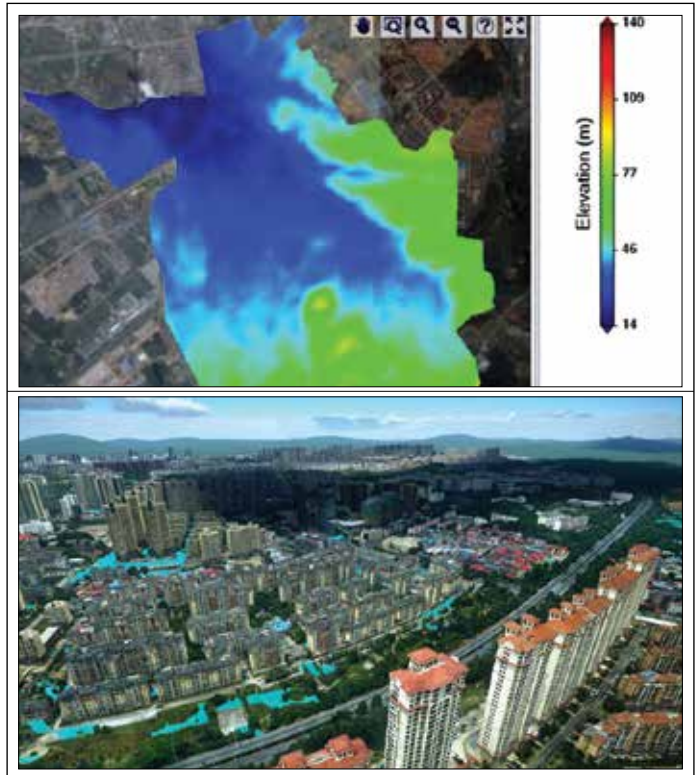
Project Playbook: ContextCapture, LumenRT, OpenFlows FLOOD, OpenFlows SewerGEMS

Outcome/Facts:

- As a result of significant flooding along the Yangtze River, the city of Jiujiang needed to prepare for future flooding events and minimize disruption to city life.
- By combining hydraulic analysis and real-time data with a reality model, city officials have greatly improved the response time of emergency services.
- The analysis helps the city determine the type of infrastructure they need to improve water flow, protect residents, and prepare the city for future weather-related events.



As a result of significant flooding along the Yangtze River, the city of Jiujiang needed to prepare for future flooding events and minimize disruption to city life. Image courtesy of Shanghai Investigation, Design & Research Institute Co., Ltd.



By combining hydraulic analysis and real-time data with a reality model, city officials have greatly improved the response time of emergency services. Image courtesy of Shanghai Investigation, Design & Research Institute Co., Ltd.

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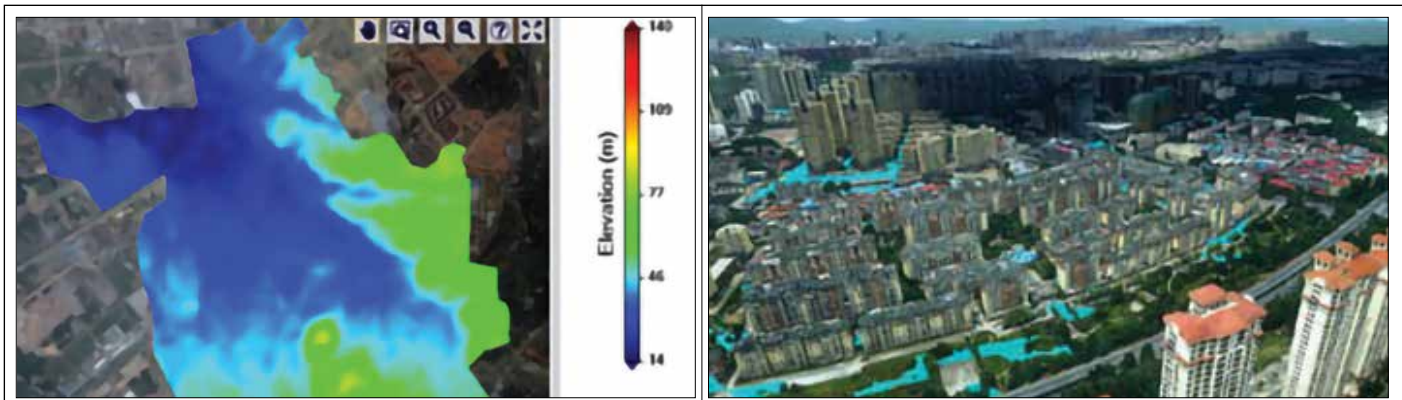
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The analysis helps the city determine the type of infrastructure they need to improve water flow, protect residents, and prepare the city for future weather-related events. Image courtesy of Shanghai Investigation, Design & Research Institute Co., Ltd.

About the Author

Sandra DiMatteo is the Director, Industry Marketing, Water at Bentley Systems. Sandra DiMatteo is the Industry Marketing Director, Water Infrastructure at Bentley Systems. She has more than 25 years of experience in reliability and asset performance management software, asset lifecycle information management, and is an expert in digital twin cloud solutions in the water and wastewater, energy and process industries. Sandra holds an honors degree in accounting and is a Certified Reliability Leader. She sits on the Reliability Leadership Institute Board of Advisors and founded the Ontario Chapter of the Society of Maintenance and Reliability Professionals.

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BETTERMENT OF CANAL COMMAND AREA THROUGH PARTICIPATORY MANAGEMENT PRACTICES: A CASE STUDY OF ASSAM, NORTHEAST INDIA

By Mridusmita Debnath, Scientist, Land and Water Management Division, ICAR-Research Complex for Eastern Region Patna



India's fourth minor irrigation census in 2014-2015 showed that more than 50% used open channel flow for irrigation and only 1.9% and 3.3% used drip and sprinkler irrigation system, respectively. However the irrigation due to 42.6% water through open unlined / kutchra and open lined/ pucca water channels respectively are about 42.6% and 10.4%. The Government of India has launched the Command Area Development program to bridge or narrow the gap between irrigation potential created and actually utilized in major and medium irrigation schemes. Warabandi system is one of the major programmes of CADA. It is a 'system of equitable water distribution by turns based on

a predetermined schedule specifying the day, time and direction of supply to each farmers' (Wara means turn and bandi means fixation). In spite of this there are various reasons for failure including. Assam is an agricultural state of India and has a significant share of the state's net domestic product compared to the country average. With Brahmaputra river and its tributaries flowing through the state numerous major and minor irrigation projects are built. The state has faced a significant challenge of food

security since the post-independent period and it requires better irrigation facilities and other inputs. Jamuna Command area is one of the major irrigation project started in the year 1969 for providing irrigation facilities to Culturable Command Area of 27705 ha spreading over two districts of Assam: Karbi-Anglong and Nagaon. A diversion weir on river Jamuna river is constructed for the purpose. The command area falls in a rain shadowed area of the Khasi hills and the Barail ranges and receives a relatively lower



Fig 1. Jamuna Irrigation project of Assam

average annual rainfall of 117 cm, and belongs to the drought-prone area of Assam. Rice is the principal food crop cultivated and farmers of these villages experience moisture-stressed rainfed conditions during rice cultivation while achieving a potential yield of about 5 - 6 t/ha yield. Decreasing rainfall due to climate change in the rainshadow area is a primary constraint for the inhabitant and less effective irrigation systems or water harvesting structures

aggravates the people's vulnerability (Datta and Bose 2020). Further, monsoon rainfall in this zone declines due to climate change, resulting in the future water crisis (Deka et al. 2016). Hence it is high time to increase the efficiency of the irrigation project to maintain the potential yield. Several measures are required to prevent water wastage through percolation and evaporation. It was found that large number of irrigation projects about 25.8% and 15%, distribute

water through surface and underground pipes respectively (MOWR 2017). Nevertheless better communication among the farmers and officials are necessary for active management and increased efficiency of the irrigation project through participation in meeting. Further, continued presence of officials is necessary for proper implementation of decisions taken by the Command Area Development Association (CADA) and awarding works.



Fig 2.: Farmer's agricultural field in (a) post monsoon season (b) monsoon season

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About the Author

Mridusmita Debnath is Scientist at Land and Water Management Division, ICAR-Research Complex for Eastern Region Patna. She is pursuing PhD from Civil Engineering Department, Indian Institute of Technology Guwahati, Assam, India. She is M.Tech from the Indian Institute of Technology, Kharagpur.

To know more about the contributor of this article, you can write to us. Your feedback is welcome and should be sent at: deepak.chaudhary@eawater.com

HIGH TDS WASTEWATERS OF INLAND MSM INDUSTRIES-THE DEVIL AND DEEP SEA SYNDROME NON-THERMAL NET EVAPORATOR AS THE POSSIBLE SAVIOR 'CASE STUDY' AT CHENNAI

Dr. S Saktheeswaran and Dr. S Sundaramoorthy

Abstract

High TDS Wastewaters in Zero Liquid Discharge (ZLD) is dealt with by large industries with thermal evaporators but the micro, small and medium (MSM) industries see it as between the *devil and deep sea syndrome*. The reasons are perpetual vendor dependence, impossibility of cannibalization, corrosion of calendrias and the operational cost of almost Rs. 200 per kilo liter of the feed to these evaporators. The result is the MSM industry follows the familiar practice of installing the thermal evaporators for going through the “consent to establish” and the “consent to operate” but in actual practice, the thermal operator is brought on-steam only when the inspecting authority lands up and rest of the times, it is the “*Chaltha Ha*” or “the usual surreptitious disposal, which is, less said, the better. This article takes the cue from an Israeli technology of non-thermal wind assisted net evaporation and presents a simulated case study in India for a textile industry with wastewater of total dissolved solids (TDS) of as high as 65,000 mg/l (Seawater has 40,000). This system can be the said savior for MSM industries.

1. The Wind Assisted Intensified Evaporation (WAIV) of Israel

This system is traced to M/S Lesico Cleantech and Ben Gurion University at Israel consists of contiguous drapes of nettings and allowing the high dissolved solids laden rejects to glide down as a film on sides of the drapes suspended over an impervious basin. The high dissolved solids liquid is continuously pumped up and sprayed onto the drapes as thin layered sprays and induces a two phase mass transfer between the water vapour in the liquid and the ambience regulated by the temperature and humidity as shown in Fig. 1.



Fig. 1. The WAIV System demonstrated at Israel.

This is reported as wetted evaporation surfaces packing densities of 20 sqm per sqm of footprint and studies with 31 - 43 sqm evaporation surface showed evaporation rates reaching thirteen fold based on a footprint to footprint for mere open pan evaporation. In addition, the materials do not demonstrate plugging. More details can be seen in references (1) and (2)

2. The Net Evaporator of Chennai and its Operation

The facility was encouraged by a textile fabric dyeing industry on the outskirts of Chennai for evaporating the textile spent dye bath which has Sodium Chloride with TDS in the range of 45,000 to 65,000 mg/L, temperature 45 to 55 deg C and volume of up to 40 cubic meters / day. The Installation with hanging drapes of greenhouse nettings suspended into a basin handles the spent dye bath pumped and recirculated over the drapes as in Fig 2 and Fig.3.



Fig. 2. The Net Evaporator System at M/S Suntex Processing Mills, Chennai. The nettings, basin and feed grid pipe on the top is fed by submersible pump inside the basin.

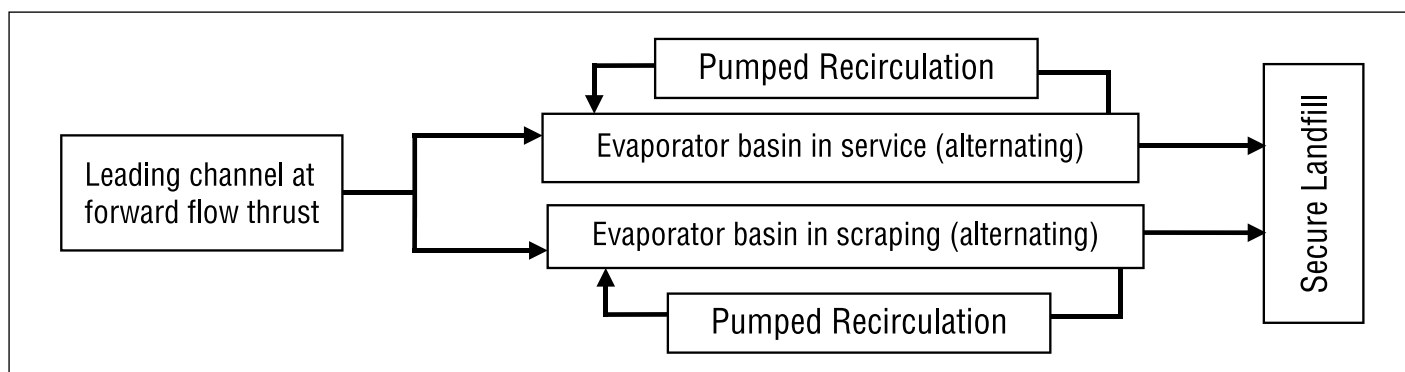


Fig.3. Schematic of the Parallel Alternating Net Evaporator Basins Studied in the Field

3. The Operational Scheme, Testing Protocol and the Results

The setup has two basins of each 11.5m*8.45m foot print with one in use for evaporation and the other for drying and scraping. The spent dye bath was pumped by a 15 Cubic meters per hour recirculation pump over the 22 nylon net fabrics of each 6m*3m at 10 cm centers. The distribution grid is downward angled holes of 3 mm at 30 cm centers directing the jets on the netting. The spent dye bath temperature was 45 to 55 Degree C, humidity was about 75 %, rainfall was nil and ambient temperature was 33 to 36 Deg C during the day time of 10 AM to 6 PM. The dry bulb was 35.8 to 36.4 and wet bulb was 24.6. Wind speed was 15 to 17 km/hr.

The cloudiness factor was nil. Samples of basin were tested for electrical conductivity (EC) as an index of TDS. The spent dye bath is added during above operating hours.

The plan area of the basin was 97.2 sqm and the area net evaporator was twice of 22*6m*3m or 792 sqm. The Packing Density (PD), a parameter adopted for sizing such evaporation systems works out to = $792 / 97.2 = 8.15$. The Flux in liters per minute per square meter was $15,000/60/792 = 0.32$ lpm / sqm. The results are in Table-1 and the daily log is in Table-2

Table-1
Evaluation of the Results of the Testing Protocol

1	Initial volume, cum	61.22	9	Evaporation in cum/hr	2.39
2	Added Volume, cum	97.05	10	Evaporation, cum/day	57.48
3	Total volume put through, cum	158.27	11	Area in netting, sqm	792
4	Total volume remaining, cum	14.58	12	Area in basin, sqm	97.18
5	Volume evaporated in cum	143.69	13	Total surface, sqm	889.18
6	Hours operated per day	10	14	Evaporation, mm//sqm/day	64.64
7	Number of days operated	6	15	Pan evaporation mm / sqm/day	5.00
8	Total hours operated	60	16	Index, row 14/ row 15	12.9

Table-2
Daily Log of the Performance of the Study Net Evaporator

Day-1	Spent dye bath added; 15650 lit / day; dye bath EC, average 62500						
	9:00 AM	11:00 AM	1:00 PM	3:00 PM	5:00 PM	7:00 PM	Average
1	132000	132500	133800	140100	141000	142500	136983
2	131000	131800	134100	140200	139100	141700	136317
3	132400	133100	136800	141900	143000	143050	138375
depth, cm	63	60	56	52	47	41	
Day-2	Spent dye bath added; 13750 lit; dye bath EC, average 62500						
1	106000	107500	111400	108200	106800	100100	106667
2	111800	108900	108700	107700	106000	102000	107517
3	111000	107300	108700	107700	106600	102900	107367
depth, cm	50	43	39	36	33	25	
Day-3	Spent dye bath added; 17500 lit, dye bath EC, average 62500						
1	102000	100700	103300	103000	104800	103800	102933
2	101700	100600	102900	104700	104900	103900	103117
3	102200	100700	102400	104700	104800	103900	103117
depth, cm	53	48	41	36	31	25	
Day-4	Spent dye bath added; 16600 lit, dye bath EC, average 62500						
1	104800	104700	106800	107700	109200	107000	106700
2	104500	104500	106500	107500	109200	107500	106617
3	105000	104800	106900	107900	109200	107700	106917
depth, cm	53	47	41	54	29	26	
Day-5	Spent dye bath added; 17100 lit, dye bath EC, average 62500						
1	107000	107700	110000	112100	109000	107900	108950
2	107700	107800	110500	112200	109700	108300	109367
3	107800	108100	111100	112000	109700	108700	109567
depth, cm	58	43	38	33	30	27	
Day-6	Spent dye bath added; 16450 lit, dye bath EC, average 62500						
1	114700	114200	115700	118200	119200	118500	116750
2	116230	116320	116830	118230	118690	118200	117417
3	118200	118450	119420	119650	120370	119890	119330
depth, cm	43	38	31	24	19	15	

4. Performance Evaluation

Compared on a footprint to footprint basis, the WAIV system is reported as able to evaporate nearly 13 times more than in the conventional solar pond. Clearly, this technology holds great promise under the inland conditions in India, but similar studies are not traceable in literature. Hence local validation studies were carried out one in an arid coastal setting and the other in desert conditions inland. When, the dissolved solids of the applied liquid concentrated to about 80000 mg/L, the netting will be moved to a stand in basin for continuity of operation. The facility can serve for both chloride and sulphate laden wastewaters. The evaporation index (EI)

as equivalent of pan evaporation rate is at 12.93 times the pan evaporation.

5. Cost Considerations in O&M

The operational cost of not evaporator is only about Rupees 2 to 5 per cum of feed for the circulation pump. By comparison, the thermal evaporator operating cost per cum of feed to it as reported by a tanner CETP is Rupees 36 for chemicals, Rupees 60 for power, Rupees 87 for steam totaling Rupees 183 as of 2014 (3) and Rs 250 per cum of feed to evaporator by Central Pollution Control Board (CPCB) (4) as of 2007. The other cost of staff are extra.

6. Relative Evaluation with Other Reported Systems

There are other systems as in Fig. 4 and evaluated relative to the Net Evaporator in Table-4

The UNIDO Rooftop Spray system (5) was evolved, evaluated and documented by a resident mission for the Tanneries at Chennai. It pumps up the soak liquor after filtering the hairings etc and sprays it on the inclined rooftop spray nozzles at controlled height and the evaporation comes through. The thickened soak liquor is drained to a ground level solar evaporation basin. The system was found successful for micro and small tannery dyeing industries and could be brought on as and when needed. The system was found to be 2 to 3 times more effective than a conventional solar evaporation pan and the salt obtained from the downstream pan was found to be fit for preserving the skins/hides.

The Oriented Spray Cooling System (OSCS) (6) is actually an advanced and yet simple system in its physical configuration. First proposed by M'S Eclair Condenser Company (ECC) in the late 1970s, the system was constructed, operated and thoroughly tested at the Ingersoll-Rand pump and turbine factory in Phillipsburg, New Jersey. The outstanding feature is the circular centripetal arrangement of the spray nozzles on spray trees and oriented at an angle from the vertical toward the center of the hollow. In this design, both the bulk drag force of the water droplets on the air and the buoyant force promote ventilation of the spray region and ambient airflow to the spray nozzles is not obstructed. The result is an improved cooling of the droplets as they fall through the spray region. An analytical spray pond model was reported on correlations to predict enthalpy change in a drop during evaporative cooling and the experimentally derived drop spectrum for the particular spray nozzle. The model is reported as validated by independent full-scale testing at the CGS near Richland, Washington, where two OSCS are employed as the safety-related UHS for the nuclear

plant. As compared to conventional spray ponds, there are no aerosol carryover in this implosive sprays. So much so, it is a moot point as to how this system has not blossomed itself even at this distance in time in our country as a make in India R&D this far.

The German Gladierwerk Woodstack or "A graduation tower" or "A thorn house" (7) is a structure used in the production of salt which removes water from a saline solution by evaporation, increasing its concentration of mineral salts. The tower consists of a wooden wall-like frame stuffed with bundles of brushwood (typically blackthorn) which have to be changed about every 5 to 10 years as they get encrusted with mineral deposits. The salt water is sprayed on the top and trickles down the tower and partly evaporates; at the same time some minerals from the solution are left behind on the brushwood twigs. Graduation towers can be found in a number of spa towns, primarily in Germany but also Poland and Austria. The mineral-rich water droplets in the air are regarded as having beneficial health effects. A large complex of towers is reported as located in Ciechocinek and Inowrocław, Poland and the entirely wooden construction in Ciechocinek is reported erected in the 19th century for 2 km as resort for sea breeze at inland locations. In fact a pilot plant was carried out by M/S GlZ at Anna University as part of a Doctoral Study here by the German expert and was followed by a prototype erected and tested at Erode, India with the assistance of IIT Madras (7) way back in 2011 with Babul tree (*Prosopis Juliflora*) twigs and Detailed monitoring of air quality around the natural evaporator was carried out and PM10, PM2.5 and VOC concentrations were well within the ambient air quality norms and the system was recommended for adoption but then something concrete has never been heard ever since.

An innovative caged evaporator with flexi rings was also designed and evaluated by IIT Madras (8). It was concluded that the important parameters which affect the evaporation rate was the humidity of the



Top (in pairs)-UNIDO Rooftop Spray for Tanneries in Tamilnadu; Oriented Spray Cooling System of plumed mist and peripheral angled implosion of jets of M/S CBA and Misty Spray Pond; Bottom (in pairs) German Gladierwerk Woodstack and Pilot at Chennai by M/S GlZ; Prototype at Erode and caged evaporator with Pall Pack both by IIT

Fig. 4. Some of the Reported Systems Idealized to India for high TDS Wastewaters

ambient air, temperature of the air, temperature of the applied water, and the wind velocity. The most important variable affecting the evaporation rate was the difference between the vapour pressure at water temperature and the partial pressure of water vapour at air temperature. It was concluded that the rate of evaporation was significantly reduced when the ambient relative humidity was high and solar pre-heating significantly increased the evaporation rate.

There is also the new technological development in the membrane distillation (MD) technology (9) powered by commonly used solar thermal collectors, thereby reducing the need of boilers that will only be used during monsoon, when the solar option is limited. The basic operating principle is that by reducing pressure in a closed chamber, the boiling point of water is reduced in each successive chamber and the boiling point is reduced and hence the rejected heat from the previous stage is used as input heat in the next stage. Thus, the same input heat is recycled almost five times and is stated to be available as in 40 feet shipping containers in a plug-n-play model and are claimed as more resistant to corrosion than multiple effect evaporator. Once membrane distillation has and sent to cement kilns as part of cradle-to-cradle economy. In India, an MD system has been developed by the IIT Gauhati as a pilot plant within the campus. As the technology is nascent, even by global standards, there is a need for more demonstration plants with significant amounts of operational data.

Considering the above, the relative advantages of net evaporator can be rated as in Table-4

Table-4
Relative Evaluation of Other Reported Systems as Compared to the Net Evaporator

No.	System	A	B	C	D	E	F	G	H	I	J	K	L	M
1	UNIDO Rooftop Spray	5	5	5	3	5	5	3	3	5	5	3	5	3
2	Oriented Spray Cooling System	1	1	1	3	5	1	1	1	1	1	1	1	5
3	Misty Spray Pond	5	1	1	3	5	1	1	1	3	1	1	3	1
4	German Gladierwerk Woodstack	5	5	5	5	5	3	3	1	3	3	3	3	1
5	Caged Falling Film Ring	5	1	1	3	5	3	5	1	1	1	1	3	3
6	MD based MEE System	1	1	1	3	3	3	3	1	3	3	3	3	1
7	Net Evaporator	5	5	5	5	5	5	5	3	5	5	5	5	5

Subjective Evaluation Criteria

A-Locally Possible to Assemble, operate and maintain; B-Import components are mandatory; C-Cannibalization of parts from other vendors; D-Corrosion Issues of metal parts; E-Switch-on & Switch-off with production; F-Skilled Operation; G-Environmental VOC/aerosols release ; H-Odourous; I-Need to dwell into theoretics like humidity etc; J-Dependency on Universities and R&D institutions perpetually; K-Innovation and refine by the industry itself; L-Dependency on electricity to operate the system, M-Dual power source from Solar to fuel

Rating Criteria

Scale. 5 is best preferable and 1 is least preferable

7. Pointers

The Net Evaporators promise a true ZLD for MSM industries at inland locations. This is also corroborated in another doctoral study of the same aerator (10). The mute point is this system as also the IIT Madras studied systems are yet to be endorsed by the local authority for the MSM industries and there hangs a tale. A significant factor for the thermal evaporators is the corrosion of calendrias (Fig. 5) which are got over recently by synthetic sheetings inside walk through shells of mechanical vapour recompressors (Fig. 6) and are good for large industries but then clearly beyond the ability of MSM industries to inherit and more so to sustain.

8. Conclusion

The ZLD Technology Guidance Manual, 2016 released by the Gujarat Pollution Control Board GPCB (11) records in its final section titled "Way Forward" that Material of Construction for ZLD Technology Products need to be long lasting with minimum maintenance requirement. This approach is more than asserted in favour of Net Evaporators for MSM industries at inland locations struggling with high TDS wastewaters. However, the cited industry at Chennai has since been prevailed upon to provide



Fig.5. Left-Typical Calendria Evaporator. Middle and Right Spalling and scaling due to inconstant feed qualities in an evaporator for which the authors were PMC.

Fig.6. The lead author was the with modern multiple vapour compression evaporator doing away with calendrias by synthetic non-corrosive drops

thermal evaporator and thereby hangs a tale. Clearly, it is high time for a renaissance.

Acknowledgements

Heartfelt acknowledgements are recorded in the authors' capacities as PMCs to M/S Suntex Processing Mills Chennai for their coming forward to install the facility and allowing the authors to carry out the performance evaluation of their installation and the textile CETPs at Tirupur where the authors did the pre-treatment and color removal for RO and were part of discussions on the overall ZLD for the rehabilitated thermal evaporators and an insecticide and pesticide industry in Tamilnadu (name withheld) for which the authors were PMC for their calendria based thermal evaporator.

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About the Author

Dr. S Saktheeswaran is former Urban Sanitation Expert of World Bank in India and former Waste Management Expert Swatch Bharat Mission in Ministry of Housing & Urban Affairs and author of the chapter on sewage reuse in the GOI-MoUD annual on Sewerage and Sewage Treatment Systems and PMC for the case study here.

Dr. S Sundaramoorthy is Former Engineering Director, Chennai Metropolitan Water Supply and Sewerage Board, Indian Team Leader and counterpart to Japanese team leader for GOI Manual on Sewerage and Sewage Treatment and Member, Expert Committee of GOI for Revision of Water Supply & Treatment Manual and PMC for the case study here.

To know more about the contributor of this article, you can write to us. Your feedback is welcome and should be sent at: deepak.chaudhary@eawater.com

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WATER FOR INSTITUTIONAL PRODUCTIVITY

By Mohammed Naser Azeez, Managing Director, Aquality Water Solutions Pvt. Ltd.



As water is increasingly being recognized a high-value commodity, aging assets present a major threat to organizations that treat and deliver it. Improving asset performance is one of the most effective strategies water and wastewater plants and networks can implement to reduce costs and protect quality.

Water is increasingly recognized as a limited, high-value resource. The United Nations projects that if current water usage trends continue, by 2030 the world will have only 60% of the water it needs. The water industry in the world has reached to a turning point. The industry is focusing more on resource sustainability with value and innovation, a new water economy is emerging globally to address the current and forthcoming challenges. Water Utilities, industries and institutional clients are embracing new technologies and putting valuable resources for infrastructure development and management in new methods to maximize efficiencies in scale and operation.

The urban water cycle (from water treatment and distribution to wastewater treatment and management) has been a challenge. With considerations of water as a public good, necessity for everyone and the economic value of providing universal access remains challenging across the countries in the world, differing between developed and under developed nations, but the major water challenges remain a concern for everybody.

- The global population will reach 10 billion by 2050, and potentially 16.5 billion by the end of the century, accompanied by a enormous increase in demand for water and food

Efficient water management is increasingly becoming a primary objective in the backdrop of severe water scarcity and water pollution.

- Increasing urbanisation - 66% of the world's population will be living in urban areas by 2050, increasing pressure on water networks and infrastructure
- Access to clean water and sanitation is often reduced by urbanisation, with cities unable to cope with the needs of rising and ageing populations
- Attitudes towards water are changing, with citizens willing to save water when public authorities demonstrate that they are fixing leaks, spending money wisely and ensuring that bills are affordable
- To feed the ever increasing population suggests that the world economy will need to continue growing rapidly to keep pace, adding to the demand for water and energy and, where unregulated, contributing to increased pollution and reduction of natural water sources
- The effects of climate change are now clear, with extreme weather events, increased risks of flooding, droughts and water stress
- Groundwater is the most extracted raw material in the world - and supplies are diminishing very fast
- Feeding a growing population requires more water and energy for food production and transportation, at a time when reducing carbon emissions is essential to meet tougher environmental standards and slow down climate change.

In order to address the challenges, as well as take advantage of the opportunities, the water sector will need to continue to embrace change. Adoption of digital approaches, techniques and thinking has the potential

to play a pivotal role in the journey of innovation and change. It can transform how services are delivered, enhancing capital investment and operational efficiency, and benefitting customers, environmental performance, and resource sustainability.

A rapidly urbanizing India faces severe deficits in water and sanitation, with transition to universal access remaining a challenge. In 2019, an estimated 600 million people lacked access to safe drinking water and more than that lacked basic sanitation. The situation is further being challenged with water supply and ground water sources decreasing in quantity and deteriorating in terms of quality with greater threats of extensive pollution. Over 72% of generated wastewater in the country is not being collected and treated before disposing into sacred water sources, contaminating the limited quantity further. We need to recognise the urgency of this challenge - water will be scarcer as rainfall becomes more variable and erratic. We need to manage this stress, not only by capturing the rain in our water bodies, but also by making sure that not a single drop of water gets polluted.

The challenges also offer the opportunity for us to do things differently and more effectively to address the water scarcity and contamination issues. There are excellent records of the management of water resources and successful reuse facilities being adopted by the industries and institutions in India. Integrated water resources management has become essential for long-term sustainability.

Institutional Water Management

Aquality Water Solutions Pvt. Ltd. is doing pioneering effort in solving institutional water problems for more than a decade and has executed several projects in India. The company has been a trusted partner with industries and institutions across the sectors in providing tailor made water treatment solutions in almost all possible application of industrial and institutional water treatment. Aquality, an ISO 9001:2015 certified company have an accomplished record of delivering cost effective and innovative water treatment solutions to its clients with modern technology intervention.

Operational efficiency and water security are more critical objectives in institutional and industrial water management with adequate investment.

With exceptional experience in designing and implementing suitable water treatment solutions for industries across different sectors and many institutional clients on pan India basis, Aquality Water Solutions has come a long way for becoming a trusted name in the industry. The company provides innovative and cost effective solutions for all size of water treatment plants with most appropriate engineering solutions. It has recently executed a drinking water supply project for Facebook India for its offices based in Gurgaon and Hyderabad.

Case Study

Project: Clean Water Supply for Drinking and Production

Client: Facebook India



Project Challenges: The requirements were to place the water treatment plant within space constraints in a modular commercial kitchen with imported ice machines, steam makers, coffee machines, dishwashers and other facilities.



Project Scope: All equipment having NSF certification / IS standards for drinking water quality have been supplied installed and commissioned by Aquality Water Solutions Pvt. Ltd. All equipment and treatment machineries were procured of EVERPURE brand made in USA. The company installed the following system at two institutional premises of Facebook India.

- 11 systems each of 600 gallon per day with hydro-pneumatic storage facility at Gurgaon facility
- 7 systems each of 600 gallon per day with hydro-pneumatic storage facility at Hyderabad facility
- Water treatment system at Hyderabad facility is being maintained under operation & maintenance and other systems will be under the same very soon.

From safe drinking water to ultrapure water for industrial use, Aquality Water Solutions delivers high quality, cost-effective and sustainable water solutions anywhere in India.

Way Forward

Universal access to water supply is critical for improving people's quality of life and efficient industrial output in every part of the world. Tackling



water deficits in an ecologically and financially sustainable manner amid the rapid population growth and heightened industrial and institutional activities presents a formidable challenge. However, several studies suggest that when effective water governance, policies, and institutional mechanisms are put in place, it is possible to attract investment and expertise to accelerate the provision of access to quality water supply services.

About the Author

He is the Managing Director of acclaimed Aquality Water Solutions Pvt. Ltd. that provides technologically advanced solutions for water treatment. With ardent interest in providing clean drinking water facilities, he contributed immensely that has helped in improving quality of life of citizens with commitment, technological innovations and quality excellence.

To know more about the contributor of this article, you can write to us.
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DESIGN & ENGINEERING OZONATION IN PHARMA INDUSTRY

Pure water Ozonation in Pharma requires careful consideration of design aspects to ensure reliability of the process. The water quality should pass 10 out of 10 times with no relaxation what so ever. Some of the important aspects that require careful consideration are:

a) Selection of the right equipment: This is important since the equipment selected must ensure that it generates the sufficient quantities of ozone. Any less production of ozone means that the process will have difficulties in providing total removal of pseudomonas from the water. The equipment should be accompanied by tests certificates for ozone production. This is particularly important in India, since most equipment do not generate the promised quantities of ozone

b) Recommending the right dose: This is important since this will determine the residual ozone in the water. The dose will depend on the quality of water, the pretreatment upstream, the temperature of the water and the type of ozone injection used. The ozone mass transfer techniques should be able to achieve a mass transfer of at least 96-99%. The ozone dose will vary on the location of the ozonation depending a lot on the raw water treatment and subsequent processes.

c) Selection of the right venturi: This is important as this will totally determine the ozone mass transfer. Locally manufactured venturi, locally fabricated SS venturis do not achieve even close to 50-60% ozone mass transfer. All the ozone will be lost during the process. the venturi must be from a good manufacturer who specialized in these activities. The venturi should be accompanied by performance data, at various motive flow rate and pressures. This aspect is mostly ignored by the technology provider since either the ozone supplier is ignorant or the client never asks these questions.

d) Contact time, contact tanks and pipe lines: This is very important and the requisite contact time must be recommended. Pseudomonas requires higher contact time even for ozone.

Sufficient tanks are to be in place to achieve this. Since pseudomonas are also notorious to form bio fouling, only the right dose will avoid these biofilms in the tanks, pipelines etc. The size of the contact tanks is to be carefully designed to enable the reliable measurement dissolved ozone measurements.

e) CIP process must be in place: A good system must also include a good CIP process. Though most process industries have these in their validation process for water quality, the use of ozone would simplify this process since, ozone itself is used as a CIP disinfectant, replacing steam, hot water and other forms of CIP.

f) Residual ozone destruction: Destruction of residual ozone in the water is a must, since this water may be used as a source for RO, UF processes. RO and UF membranes are very sensitive to ozone and can be destroyed in the long run since most of them are organic based. Destruction process will include a very carefully designed UV system. For ozone destruction the dose required is different and depends on the residual ozone expected in the water. Designing a normal UV dose for water treatment, as the dose for ozone destruction is not a correct way to go about

g) Control systems and dissolved ozone monitoring: The system must include a good and accurate dissolved ozone monitor and control systems to allow only water without zero ozone downstream. There are only a very few dissolved ozone monitors available around the world and they are all very expensive. They cost more than the ozone system put together. The dissolved ozone system with the required features, relay contacts etc. is to be selected for the process. Sensors are to be of amperometry type. Since the sensors are very sensitive to high pressure waters, it is recommended that flow cell arrangements be in place to control the water flow, so that the sensors can read accurately.

h) Safety: ozone is the plant room need to be monitored. In case of leakages, there should

be a warning to the user. A good ambient ozone sensor should do this work. Ozone is toxic at levels of 0.1 ppm exposed for 8 hours. This by far is a very high limit. In normal cases we fix the limit to 0.05 ppm in the plant room and set the ambient ozone sensor accordingly. The sensor hoots when the ozone in the plant room exceeds the limit fixed

i) MOC of pipes, NRVs, wet parts of pumps and solenoid valves are all have to be ozone resistant. UPVC pipes is quite suitable for raw water treatment. However, the NRV for the transfer pumps, ozone injection pumps are to be at least SS 304 with ozone resistant diaphragm and gaskets. The solenoid valves should be SS with Teflon diaphragms. All the pump wet parts are to be SS 304 or 316 (depending on the ozone dose being recommended).

pH control: Though ozone works at a wide range of pH, it has been noted that for pseudomonas control, molecular ozone is a more effective disinfectant than OH free radicals. It must be mentioned at this stage that at higher pH, the proportion of molecular ozone and OH free radicals changes with OH free radical increasing at the expense of molecular ozone. Hence it should be an important aspect to keep a check on the pH of the water and ensures that it does not go beyond pH 8.0.

Ozone provides the required insurance for safe water for the disinfection of the process. 10 out of 10 times, water tested for pseudomonas and other gram negative pathogens would be negative. Apart from this ozone takes care of other contaminants including color, odor and heavy metals contamination.

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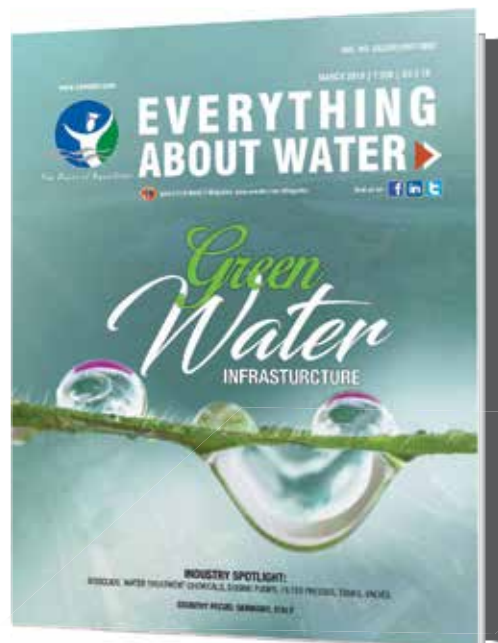
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T E N D E R S

1. Design, Construction Supply, Installation, Testing, Commissioning And Operation And Maintenance Of Effluent Treatment Plant Of Capacity 425 Kld At C And D Waste Processing Plant In Indl. Area Phase-1, Chandigarh. Authority Municipal Corporation Name: Executive Engineer Roads Division No 3 Mc Chd Address: Executive Engineer Roads Division No. 3 Mc Chd Location: Chandigarh Chandigarh India Bid Open Date: 29 Apr 2022 Tender Value: 96.00 Lac Doc Collection Date: 29 Apr 2022 Competition: Domestic Competitive Bidding FTID: 220419247410	Competitive Bidding FTID: 22041947270 3. Up-Gradation Of Water Treatment Plant Infront Of Iclds School No. 100, Sansadxi, J.L No-64, Mouzasonadanga. Under-Amdanga-Gp Authority Zilla Parishad Name: Prophan Address: Pradhan-Amdanga Gram Panchayat, Vill-Amdanga And Po-Amdanga, Ps- Amdanga, Pin-743221, North 24 Parganas. Location: North 24 Parganas West Bengal India Bid Open Date: 27 Apr 2022 Tender Value: 7.47 Lac Doc Collection Date: 27 Apr 2022 Competition: Domestic Competitive Bidding FTID: 22041926550	Competitive Bidding FTID: 22041926570 5. Setting Up Of Sewage Treatment Plant S In 2 Clusters Inside Plant Atntpc, Farakka Authority Ntpc Limited Name: Nitin Patelsr. Manager Cnm Address: Sipat Super Thermal Power Proj Po Ujwal Nagar District Bilaspur 495555 Location: Murshidabad West Bengal India Bid Open Date: 25 Apr 2022 Doc Collection Date: 25 Apr 2022 Competition: Domestic Competitive Bidding FTID: 220419236710	7. Annual Maintenance, Repairs, And Other Emergent Works Of Water Treatment Plant Tangnar With Trunk Main For The Year 2022-23 (Stage Contract). Authority Public Health Engineering Name: Executive Engineer Wsmp Div Sgr Address: Soura Srinagar Location: Srinagar Jammu & Kashmir India Bid Open Date: 26 Apr 2022 Tender Value: 11.00 Lac Doc Collection Date: 26 Apr 2022 Competition: Domestic Competitive Bidding FTID: 22041927590
2. Operation And Maintenance Of Sewage Treatment Plant Inside Nctps-Ii From 01.05.2022 Or From The Date Of Commencement Upto 31.03.2023 Authority Tamil Nadu Generation And Distribution Corporation Limited Address: Office Of Se Cm Nctps Ii Chennai 120, Pincode 600120 Location: Ambattur Tamil Nadu India Bid Open Date: 05 May 2022 Doc Collection Date: 04 May 2022 Competition: Domestic	4. Installation Of Water Treatment Plant At Karnasubarna Bphc Under Rangamati Chandpara G.P. Within Berhampore Panchayat Samity. Activity Code 62236104. Fund 15th. F.C. Authority Municipal Corporation Name: Executive Officer Address: Panchanantala, Berhampore, Murshidabad Location: Baharampur West Bengal India Bid Open Date: 25 Apr 2022 Tender Value: 2.42 Lac Doc Collection Date: 25 Apr 2022 Competition: Domestic	6. Routine Civil Maintenance Works For Ph-1 Area, Thermal Plant , Water Treatment Plant , Silo, Main Canteen Building, Administrative Building And Other Non- Plant Buildings Etc. Of Fact (Cochin Division). Authority The Fertilisers And Chemicals Travancore Ltd. Name: Varghese P O Address: Senior Manager (Projects And Planning), Fact (Cochin Division), Ambalamedu Ernakulam Location: Ernakulam Kerala India Bid Open Date: 04 May 2022 Tender Value: 9.00 Lac Doc Collection Date: 04 May 2022 Competition: Domestic Competitive Bidding FTID: 22041929010	8. Construction Testing And Commissioning Of Rapid Sand Filtration Treatment Plant S Rsfp Including Pre Settling Tank Flash Mixer Clari Flocculator Filter House Clear Water Chamber Electro-Mechanical Works Etc Under Jjm For District Kathua Authority Public Health Engineering Name: Office Of The Chief Engineer Jal Shakti Jammu Address: Office Of The Chief Engineer Jal Shakti Jammu Location: Kathua Jammu & Kashmir India Bid Open Date: 09 May 2022 Doc Collection Date: 09 May 2022 Competition: Domestic Competitive Bidding FTID: 220419226660

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