Mekong Delta Brackish Water Remediation System (BWR)

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Main Issues of the Mekong Delta

* The Mekong Delta ranks amongst the top 5 deltas in the world most likely to be severely affected by climate change. [1]
* On top of the rising seawater level, land subsidence is accelerated 1 to 2 cm/year due to sustained and long-term drainage and groundwater extraction. [2]
* The exploitation of well water must be balanced by the recharging of the aquifers from rainwater. Another source of freshwater must be used to supplement the well water from underground.
* Brackish water from rivers, canals, and low-quality wells can be remediated to provide fresh water to supplement the deep-well water.

[1]. Intergovernmental Panel on Climate Change (IPCC, 2007) Assessment reports 10 Asia Working Group 2, Impacts, Adaptation and Vulnerability.
[2]. MARD Phase 1 Resarch Study: Assessment of land loss Cà Mau, Norwegian Geotechnical Institute, Land loss study for the Cà Mau Province, Vietnam. Presented by Kjell Karlsrud on 17-6-2013 in Cần Tho.

Mekong Delta: The Food Basket under Crisis

* Since 1990, the Mekong Delta (MD) awakening has propelled VN to second rank worldwide in rice export.
* The well water extract increased from about 170,000 m^3/day in 1990 to 16 million m^3/day currently in the coastal areas of the MD since the privatization of well digging. [1]
* The competitiveness and prosperity of the delta depend very much on the efficiency and effectiveness of investments for salinity control, water quality and fresh water supply.
* For the last 20 years, the shoreline of Ca Mau province in the MD retracted from 100m to 1.4km thanks to the subsidence of the land level. 2
* If the uncontrolled exploitation of the underground water is not limited, half of the MD province may disappear within several decades.

1. Long K. Pham, Dean of Agri-/Aquaculture Dept, TVU, 2015)
2. Erban L. E. et al, Proceedings of the National Academy of Sciences of the USA, vol. 110 no. 34

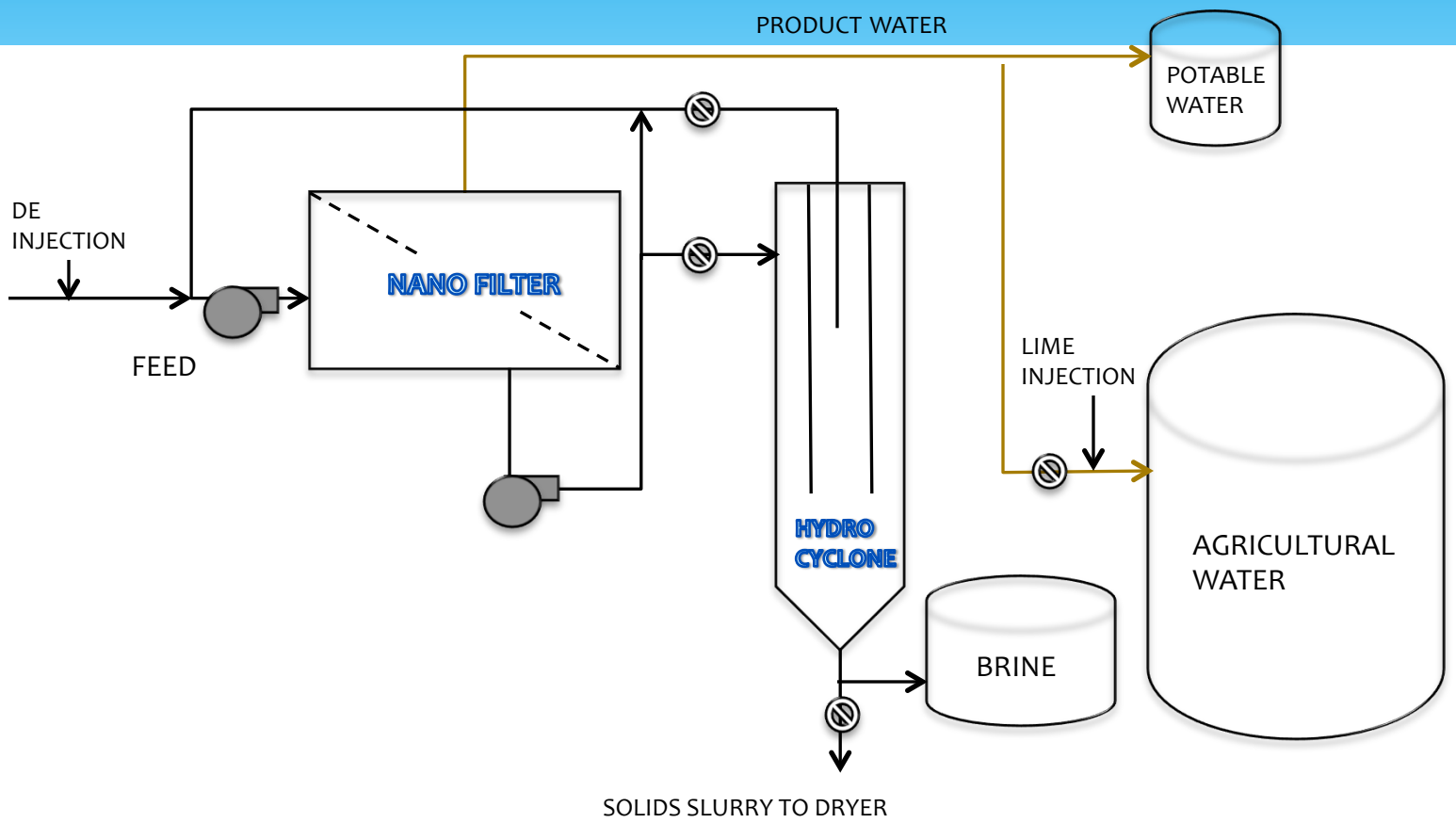
The BRACKISH WATER REMEDIATION System Features

* Brackish Water Remediation system (BWR) already advances through the pilot stage to provide selective commercial systems in the US, India, and Vietnam.
* BWR is particularly suitable for operations in remote areas of developing world. BWR membrane is designed to operate for years without chemical cleaning, an essential tasks required by other membrane systems.
* BWR concentrated brine is evaporated to a sludge/solids to minimized disposal issues. The dryer is designed to evaporate water using only ambient air to minimize energy consumption.
* BWR excels in maintaining constant flux rate and to minimize the maintenance costs through several patented technologies.

Features: Brackish Water Remediation

* The BWR Membrane Filtration Module (MFM) is protected by with several powerful anti-fouling mechanism to keep long-term operability and low service requirements: 1) Using a sacrificial layer of Diatomaceous Earth(DE), 2) Periodic self-cleaning cycle, and 3) Hydro-cyclone for removing solids from brine to minimize membrane fouling.
* Zero Liquid Discharge (ZLD) through brine evaporation using using ambient air.
* System can operate solely on solar and/or wind energy.

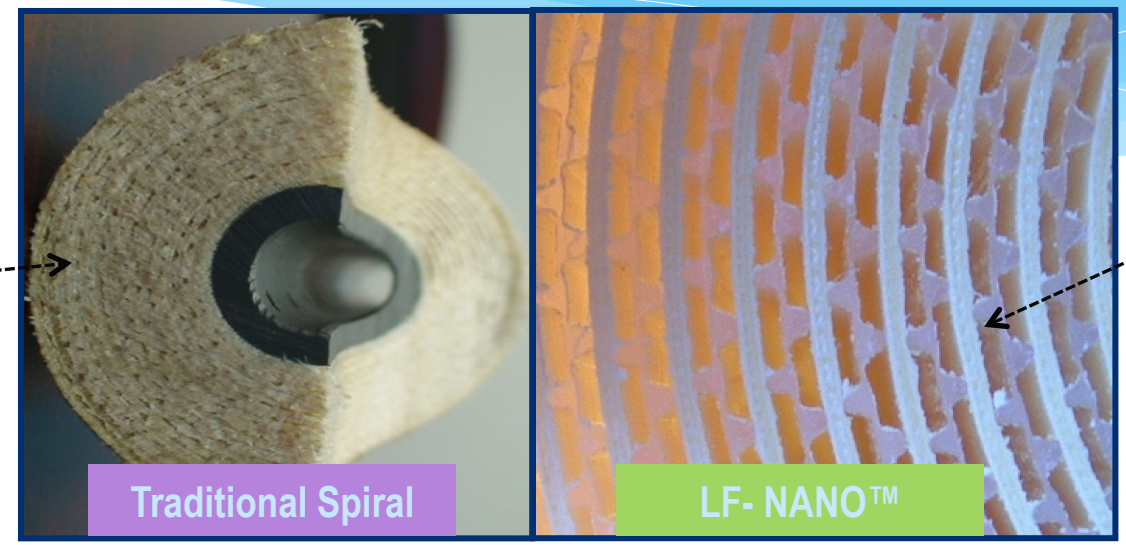
BWR Desalination Technology



Low Fouling LF-Nano™

Cross Flow Membrane Elements

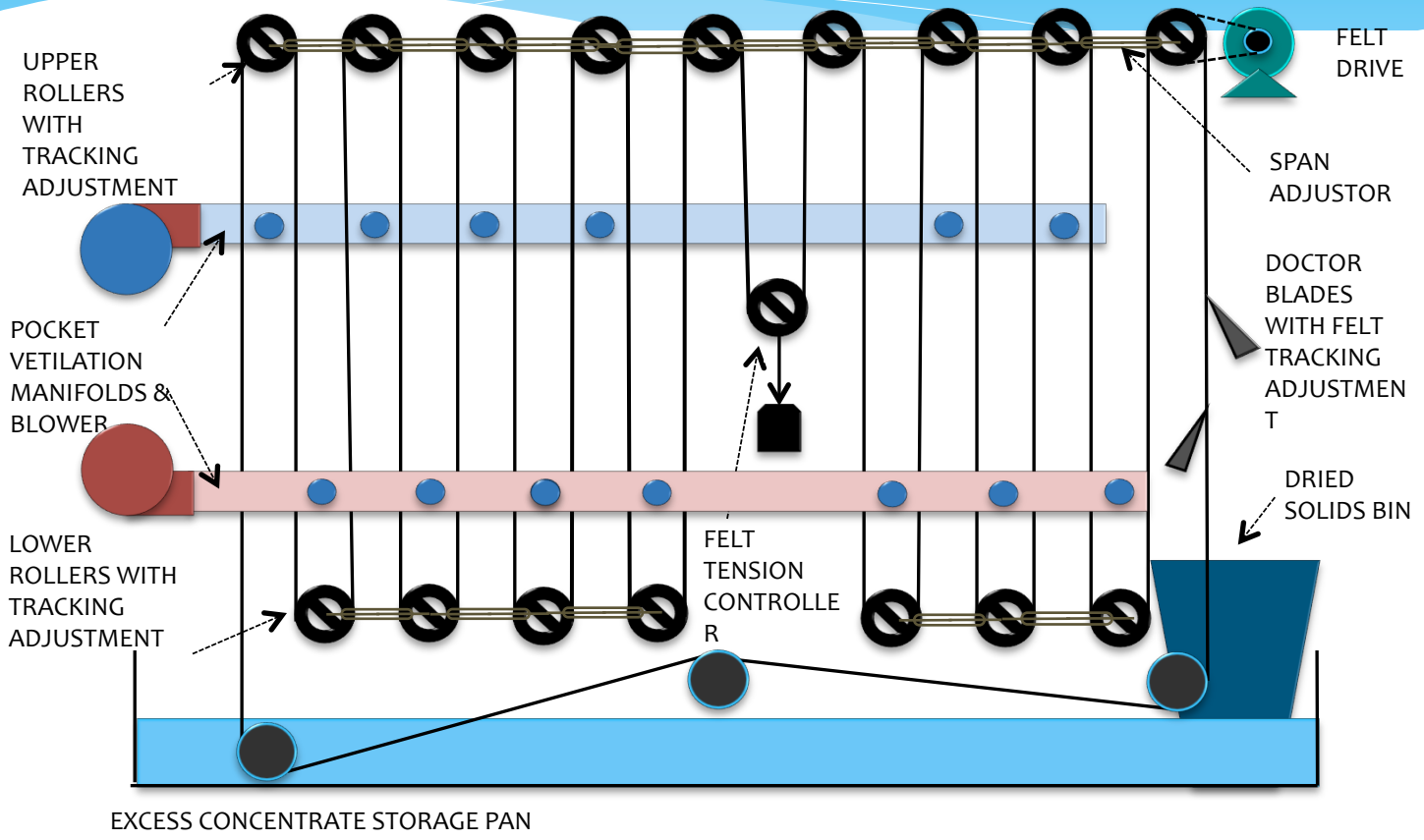
Tight spiral RO elements clog and foul easily



Open configuration avoids fouling (wider channels)

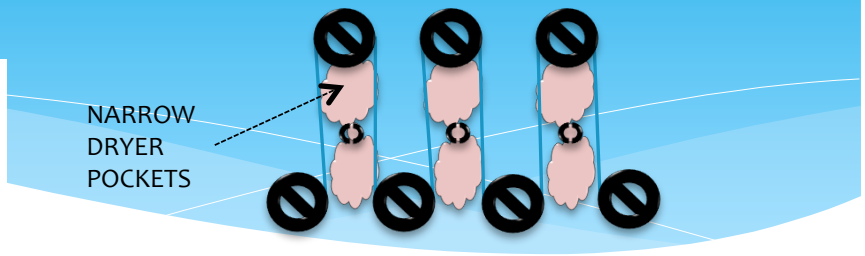
* Open configuration (illustrated above) allows for coating a sacrificial particulate coating of DE, which absorbs solid contaminants and precipitates.
* Periodic raising permeate pressure or "self-cleaning cycle" by equalize trans-membrane pressure, allowing the high cross flow to shred the DE layer laden with fouling contaminants on the membrane surface.

Dryer Prototype

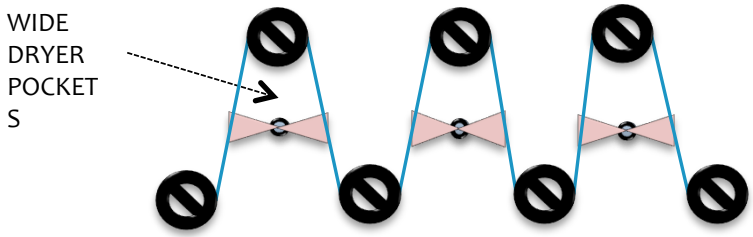


Brine Dryer Operation

* Dryer is constructed with with flexible frame like an accordion. The moveable rollers allows the dryer pocket to be optimized for ambient air in different climate zones.
* Ambient air can evaporates water on both sides of vertical felt.
* Pocket ventilation reduces Relative Humidity on both felt surfaces, raising drying rates close to theoretical limits. Air flow can be impinging or tangential, depending on pocket. Pocket air is exchanged 1-2 times/minutes.

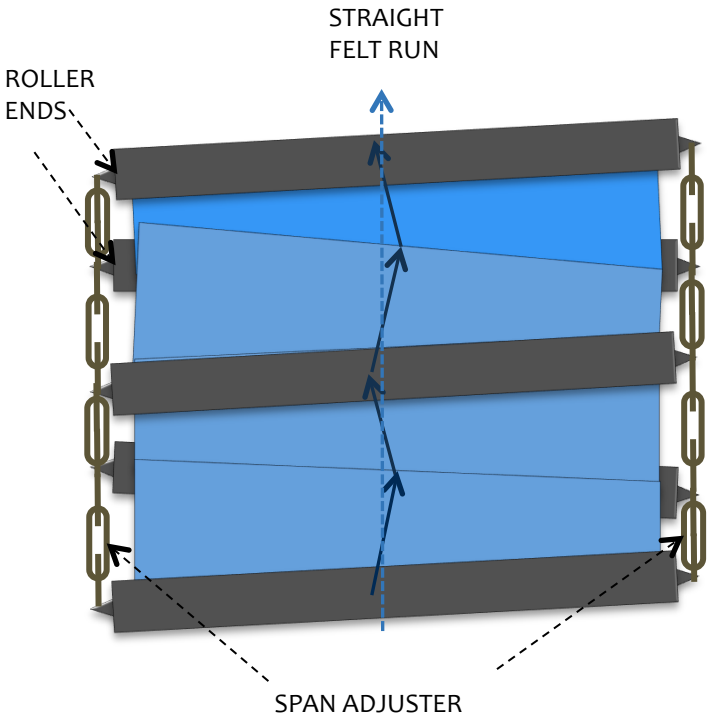


TANGENTIAL AIR VENTILATION IN LOW HUMIDITY AMBIENT AIR



IMPINGING AIR VENTILATION HIGH HUMIDITY AMBIENT AIR

Simple and Effective Dryer



* Lateral distance between the roller ends can be adjusted precisely using Span Adjusters.
* Span Adjusters regulate roller angles to the straight path, guiding felt from veering off track.
* Doctor blades are mounted at opposite angles to scrape and conveyed dried sludge off felt surfaces from both sides. Blades angles can be adjusted to keep felt on straight run.
* Rollers rotates at .5 to 1 rpm depending on drying rate.

Ambient Air Dryer

* Water evaporates 4-5 times faster from a Dryer felt than the same area of an evaporation pond in similar drying conditions.
* The Dryer packs 9-10 times larger drying felt surface than an evaporation pond thanks to the vertical construction.
* Together, the land use can be reduced 40-50 times.
* The size of the Dryer is 1.5m W x 10m L x 2m H

BWR Operation

* Feed water is filtered by MFM at 80 psi to produce water and brine at 9/1 ratio.
* Produce water is of potable quality but low in Calcium.
* Lime is added to 97% of produce water to make agricultural water.
* Brine is evaporated in the dryer to a paste, which can be further air dried before disposal.

Renewable Energy Options

* BWR can operate on solar or wind energy or both.
* The total energy consumption of BWR, including energy to evaporate the concentrate is about 3kwh/m^3 - 4 kwh/m3, among the lowest energy consumption worldwide.
* 10 years Life Cycle Cost estimate of product water for a 20m^3/day capacity BWR is about 1-2/m^3

Maintenance and Repair, 10-yr Life

* Yearly scheduled maintenance:
  1. Dryer cleaning (3 times)
  2. Filter elements inspected and clean element vessel if necessary (3 times)
  3. Miscellaneous mechanical repairs
* Five-year interval system overhaul:
  1. Replace filter elements, about 50% of dryer rollers and dryer felt.
* Operating Costs:
  1. Lime: about 1kg/day at $200/ton or $.20/kg
  2. DE: 1kg/week at $1/kg
  3. Waste solids can be landfilled locally or disposal assuming $200/ton in the US or $50/ton in many developing countries

EBWR: Durable, Reliable, Innovative, Practical, and Economical

* BWR LFNano™ membrane requires no costly pre-treatments (sand filter, coagulation or ultra filtration) and harsh chemical chemical cleaning.
* BWR technology is not only competitive in the first world but also practical in the developing world.
* Except the LFNano™ elements, all parts and chemicals required for the operation of the BWR can be procured or manufactured in VN.
* The cost of $1-$2/m^3, including brine processing and disposal, is ranked as one of the most economical industry-wide for Brackish Water remediation.

Why can BWR be a Disruptive Technology?

* BWR takes the conventional & proven technologies of NF-filtration and air drying to a game-changing level using innovative measures.
* BWR introduces for the first time the option of zero-liquid discharge (ZLD) to small-scale farming and rural areas. The dryer is amazingly effective, requires minimum foot print, yet easy to operate and maintain.
* BWR can be manufactured with capacity in hundreds of m^3/day to bring down the costs to below \$1/m^3 thanks to the economy of scale.