Water Recovery Systems Technology Development Overview and Capabilities

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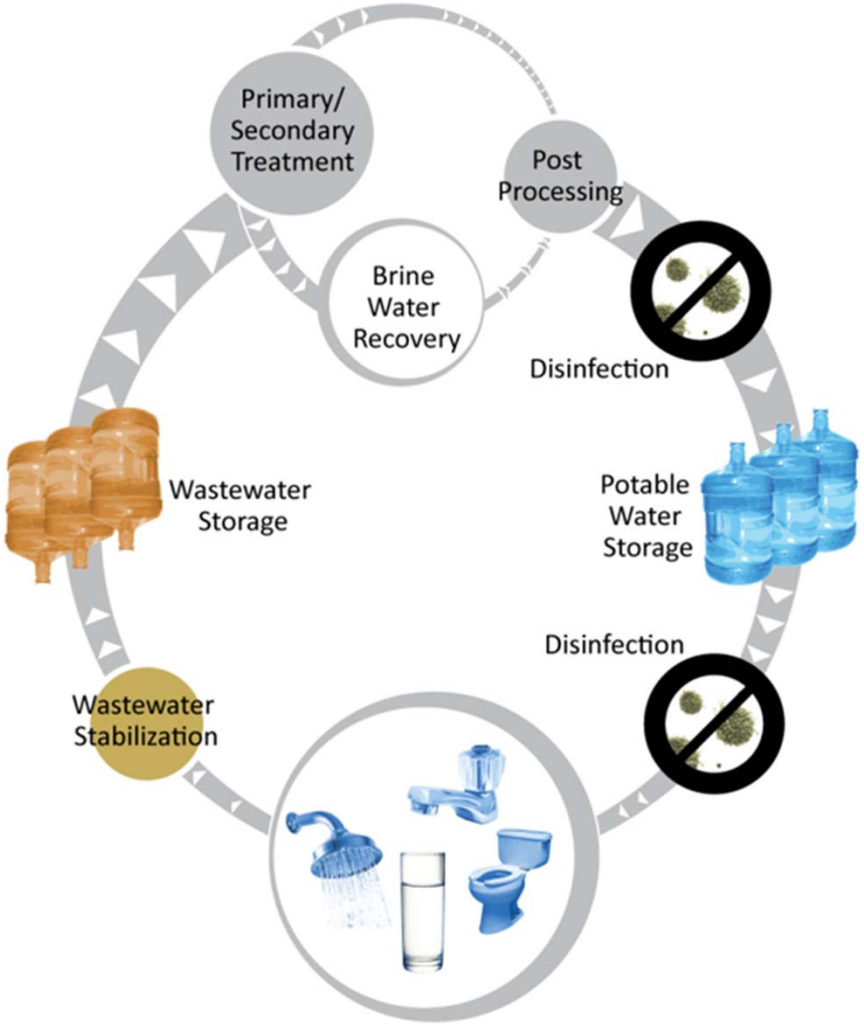
The Spacecraft Water Cycle



- **Stages of the water recovery process:**
  - Stabilization
  - Wastewater Storage
  - Primary Processing
  - Brine Water Recovery
  - Post-processing
  - Disinfection
  - Potable Water Storage

Spacecraft wastewater

- Characteristics of spacecraft wastewater
  - Low volume
  - Highly concentrated compared to most municipal wastewater
    - High concentration of surfactants
    - High total dissolved solids
  - Composition (and dilution!) depend upon mission
    - Space Station has limited wastewater sources
    - Exploration missions are expected to have greater wastewater volume

Current areas of development

- Wastewater stabilization
- Energy efficient, scalable distillation systems
- Biological systems
- Membrane systems
- Integration of treatment systems
- Brine recovery systems

Development process

- Early stages of technology development may be through internally funded projects or academic studies
  - Partnering with academic institutions, industry, and other federal laboratories is efficient way to transfer technology
- Common technologies are “downselected” to determine most effective system for continued investment
- Analysis and modeling are key components of development
- Downselected systems are tested in integrated systems
  - Integrated system design driven by mission architecture
  - Integrated test demonstrates overall system efficiency and higher fidelity performance metrics

Wastewater Storage & Stabilization

- Some water recovery systems rely on minimal microbial growth and prevention of urea breakdown to ammonia
- Stabilization typically involves the addition of strong acids/oxidizers
- The goal of current stabilization studies is to find alternatives to hazardous acids/oxidizers (alternate chemicals or biological stabilization).

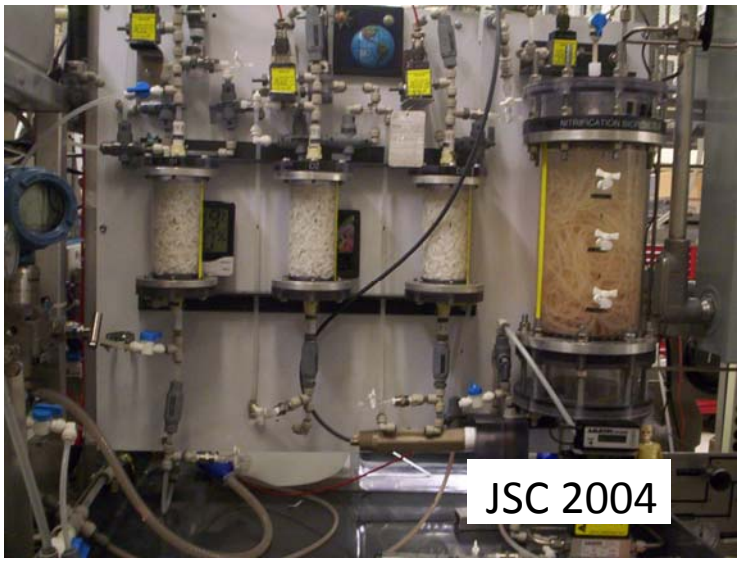
Improved distillation systems

- Rotary, vacuum driven distillation process
- New technology is scalable, energy efficient
- Key questions are to quantify energy savings, demonstrate reliability through increased recovery and long-lived bearing

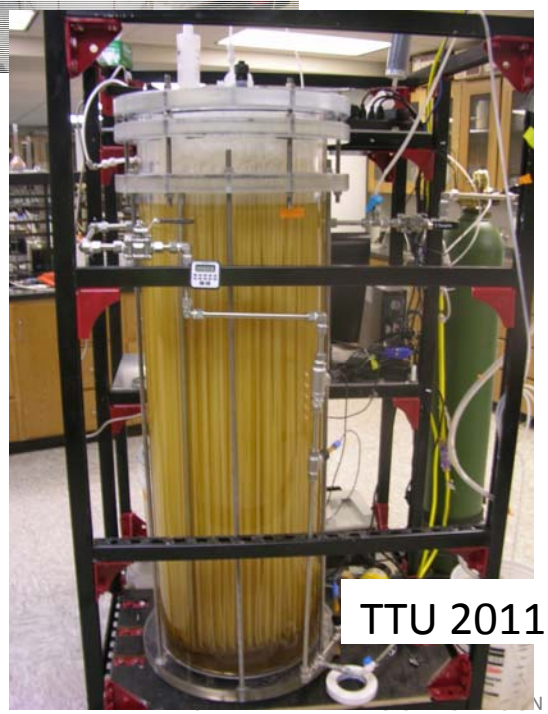
Biological Water Processors

- Low energy, regenerable treatment process
- Key questions include reliability, rapid startup, and scalability

JSC 2001



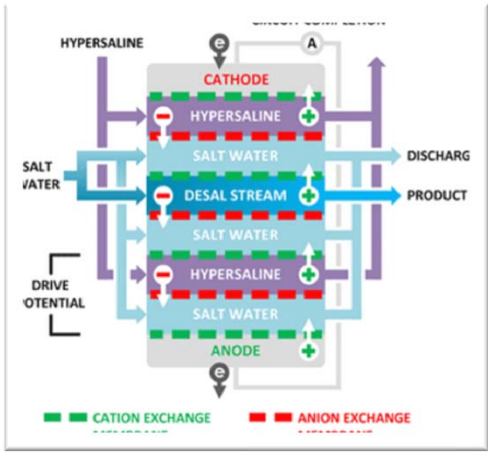
JSC 2004

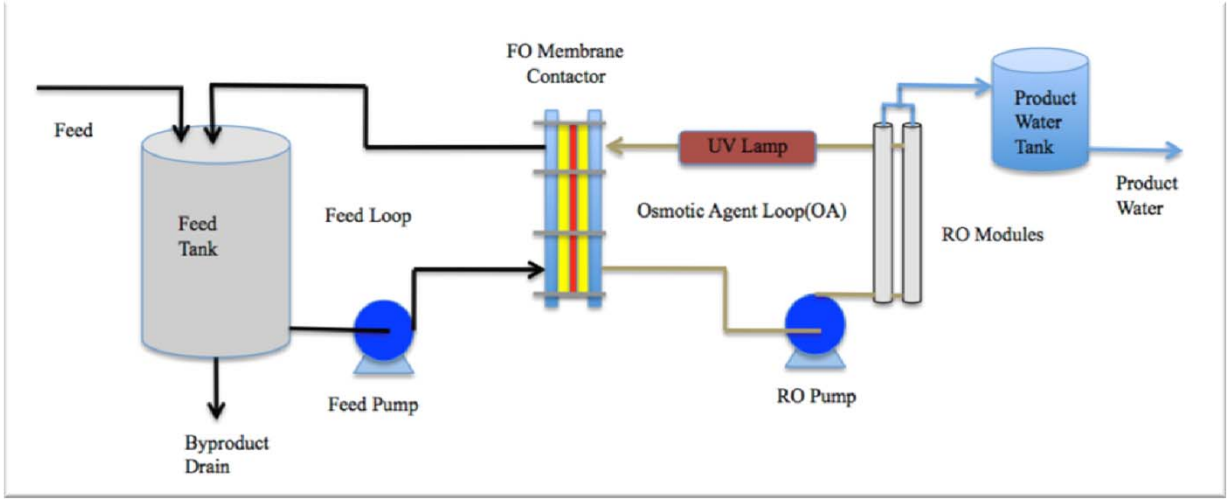


TTU 2011

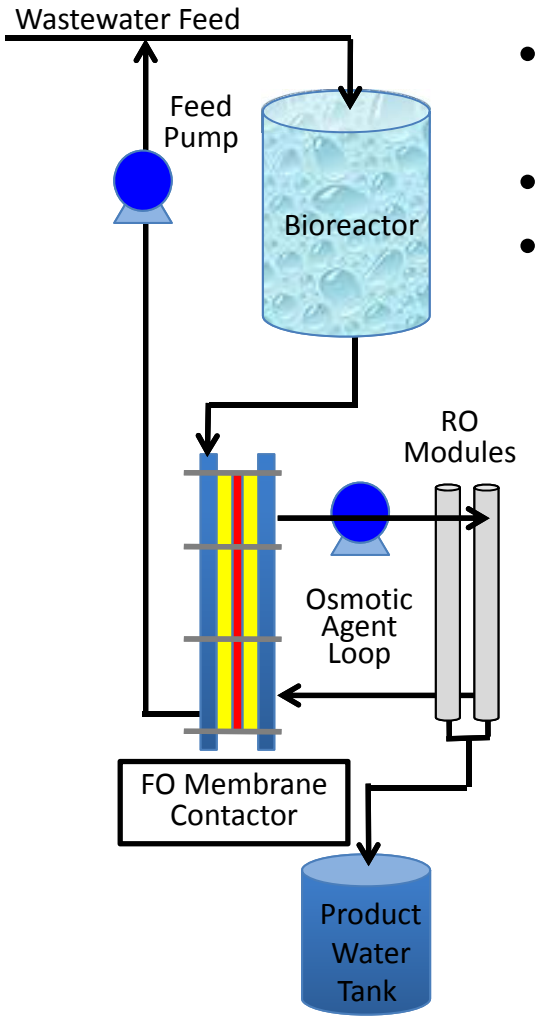
Membrane systems

- Membrane systems are ideal for removal of inorganic solids downstream of a biological water process
  - Forward osmosis has low fouling potential and high rejection of contaminants
  - Reverse osmosis systems produce near potable quality water
- Electrodialysis has potential for calcium scale prevention
- Key questions include fouling and energy requirements

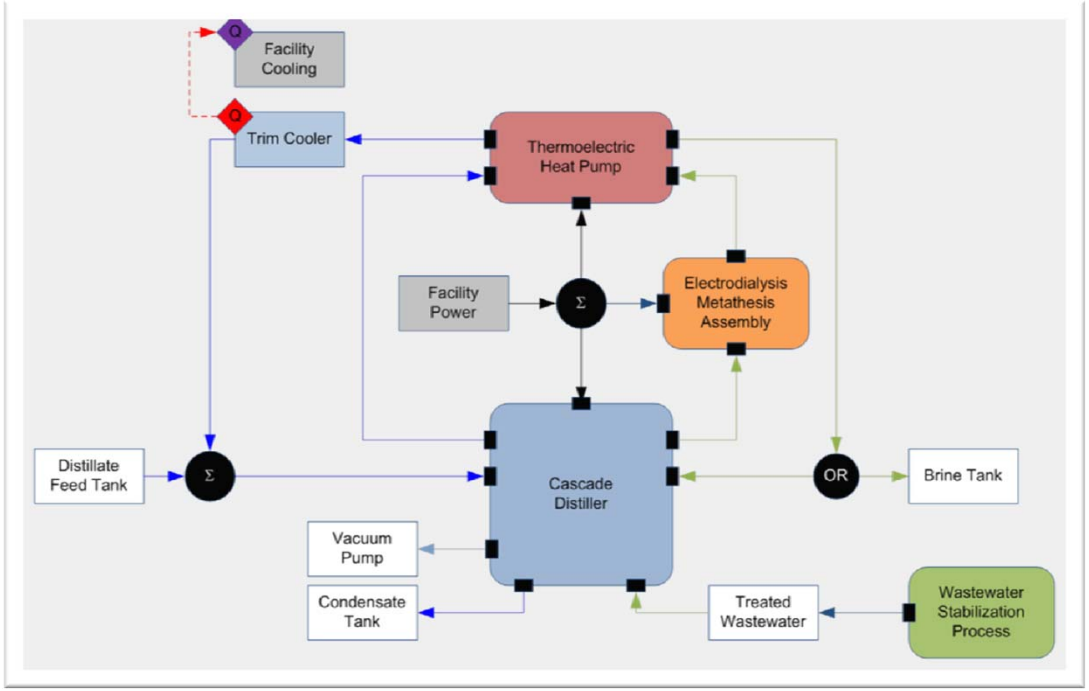




Integrated treatment systems



- Quantify consumables, power requirements
- Demonstrate water quality of produced water
- Define integration issues for future system development fc exploration habitats



Brine Water Recovery

- Brine water recovery is our major technology gap.
- Membrane and distillation technologies all produce brines
- Approximately 15% of daily wastewater is lost as brine
- Solids handling is greatest challenge to development
- There is currently no brine recovery system in flight.

WRS Technology Team Capabilities

- Advanced Water Recovery Systems Development Facility
  - System development
  - Integrated testing
  - Water quality analysis
  - Microbial analysis

Contact information

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