Dr. Markus Lenger - EWTS 2022 – May 10th - 11th – San Antonio, TX

DIRECT POTABLE REUSE

CAN IT BE A CONSUMER PRODUCT?

CleanBlu®

We lose thousands of children every day to diseases due to lack of safe water

Get Involved and Save Innocent Lives

ALMOST 100 CHILDREN WILL DIE DURING THIS PRESENTATION FROM POLLUTED WATER

REGULATIONS

IT'S BETTER TO BEG FOR FORGIVENESS THAN TO ASK FOR PERMISSION

…we must collect the data to prove it's safe for all

TECHNOLOGICAL CHALLENGES

- Must be compact and portable (air-liftable)
- Safe and easy to use – little training or skill required
- Common parts and control – open software
- Flexible power option such as wind or solar with backup battery
- Always connected to assist setup and operations
- Automated provisioning, monitoring and remote management
- Easy to implement Preventive Maintenance Program
- Built-in emergency communications
- Inexpensive (less than US$ 10k)

IRP and DRP – CURRENT STATUS

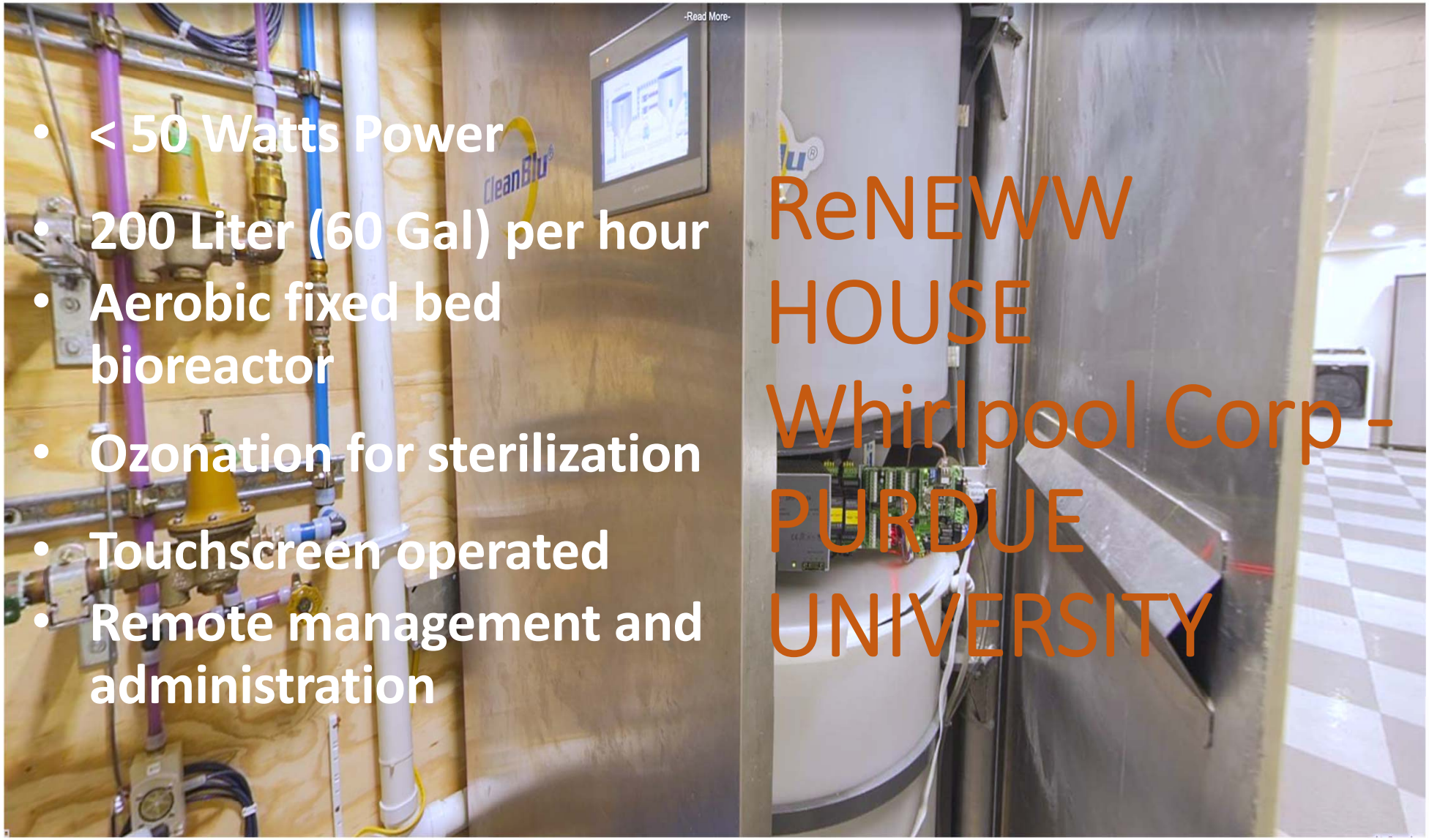
- Utilities already reuse water
- Fountain Valley Groundwater Replenishment System is the largest in the world
- Peter Fox's (Arizona State University) pioneering work
- Least expensive solution for new water
- More precise source-water quality control
- Must detect faulty operation to be safe
- Safe level pathogen removal remains the main concern

HOW DO WE GET THERE?

AVAILABLE TECHNOLOGIES AND TREATMENT STAGES

WPC Melbourne

WASTEWATER MANAGEMENT – INSPIRING AN ENVIRONMENTAL REVOLUTION



- < 50 Watts Power
- 200 Liter (60 Gal) per hour
- Aerobic fixed bed bioreactor
- Ozonation for sterilization
- Touchscreen operated
- Remote management and administration

ReNEWW HOUSE

Whirlpool Corp - PURDUE UNIVERSITY

NET ZERO WATER

DESIGN CHARACTERISTICS

- Designed as an appliance
- Must cost less than $ 10k – production less than 1k
- Fit through a standard door
- Zero user input
- Complete remote management
- Network with BMS
- Less than 50 watts power draw
- Less than 1 cent per gallon

Working Flawlessly For Eight Years

HIGHLY PUBLISHED PROJECT

Striving for Net Zero water

Whirlpool Corporation's ReNEWW House

By E. W. Bob Boulware, P.E., MBA; Dr. Markus Lenger; and Eric Bowler

The ReNEWW House is a 2000 square foot, 1920s vintage bungalow-style house, located in West Lafayette, Ind., next to Purdue University's campus. ReNEWW stands for Retrofitted Net Zero Energy, Water & Waste, and reflects the vision of the project – to retrofit an old home to be resource efficient by generating its own renewable energy, capturing and purifying rainwater for it water needs, and sending no waste to the landfill.

The house is a collaborative effort between Whirlpool Corporation and Purdue University to provide a sustainable living public showcase and a live-in laboratory for student engineers who live, study and research the new generation of resource efficient appliances.

Back of ReNEWW House showing Hybrid Photovoltaic/Thermal Solar System and Rainwater Tank Access and Monitoring Risers

The concept of Net Zero energy living has been popularized for residential use due to the recent reduction in costs achieved by solar photovoltaic (PV) technology. To achieve the Net Zero energy status, the ReNEWW House underwent a deep energy retrofit over the summer of 2014. New triple-pane windows and improved doors were installed; spray foam insulation was applied to wall and attic cavities, a geothermal heat pump replaced the natural gas furnace and split AC system; and a solar PVT (photovoltaic & thermal) array was introduced to generate onsite energy.

Net Zero water is a relatively new concept that has been achieved by only a few facilities. The goal for the ReNEWW House is to capture rainwater onsite without requiring supplemental ground water from a well or a water utility.

The first step to achieve the goal of Net Zero water was to minimize the amount of water needed by the occupants, which included replacing the existing fixtures. The fixtures installed in the kitchen include an improved dishwasher by KitchenAid that incorporates a novel filter that removes food particles during the wash cycle and significantly reduces the amount of water required. The old five-plus gallon per flush toilets and four gallon per minute showers were replaced with state-of-the-art fixtures supplied by Kohler, a partner in the ReNEWW House project. The end result of this upgrade was an over 60 percent reduction in fixture water use.

Updated first floor bathroom with Low-Flow Showerhead and Dual Flush Toilet

Once the demand for water was reduced, the resultant water demand was designed to be collected from the 1,600 square feet roof suface with the expectation it will harvest approximately 34,000 gallons per year. To assure good quality, end-use water, the raw rainwater is pre-filtered before going into the storage tanks with a WISY rainwater filter, which diverts roof debris away from the stored rainwater by wasting the initial portion of a rain event.

When the 280-micron screen is thoroughly wetted, capillary action then diverts the rainwater through the screen into two 1,500-gallon underground tanks. Water exiting the tanks is then made potable by filtration through a 1 micron absolute filter and activated carbon block, and disinfection by exposure to ultraviolet light.

The house further reduces potable water demand through the internal reuse of greywater. The use of greywater begins with a water audit to quantify the expected greywater sources and potential greywater uses. In the case of the ReNEWW House, greywater provided from the shower and lavatory was expected to be slightly more than the flushing requirements for the low flush toilets (54 gallons per day versus 42 gallons per day). Any excess water available will be used to supplement the washing machines water needs.

Kohler had previously studied existing greywater processing systems on the market and all were found to be disappointing for various reasons, either providing effluent

NAVAJO MOUNTAIN

CleanBlu®

PROBLEM
Toilet flushing consumed 50% total water usage

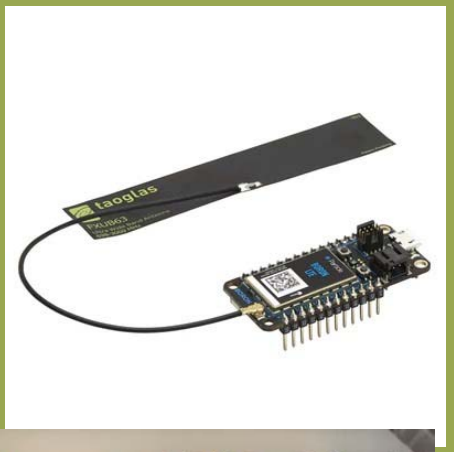
CHALLENGE
Design a system to treat and recycle toilet wastewater inside the septic tank and continuously reuse it

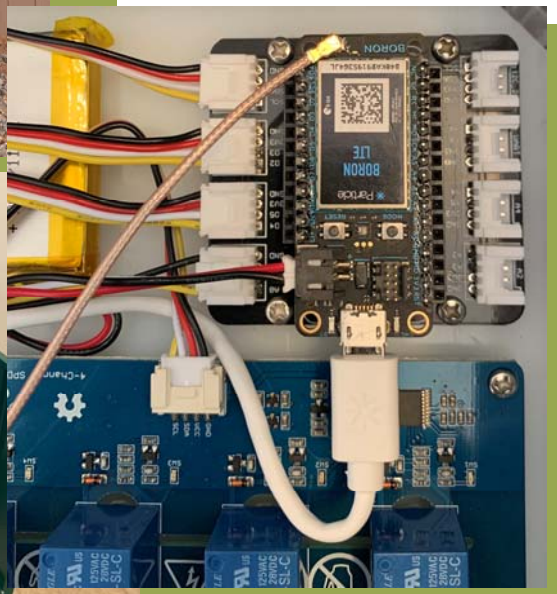
IWSH

NAVAJO INDIAN CHAPTER HOUSE

BLACK WATER REUSE

- 4-stage aerobic biological treatment system
- Low maintenance
- No sterilization
- O2 and microbial management to treat wastewater
- App controlled
- Fully autonomous



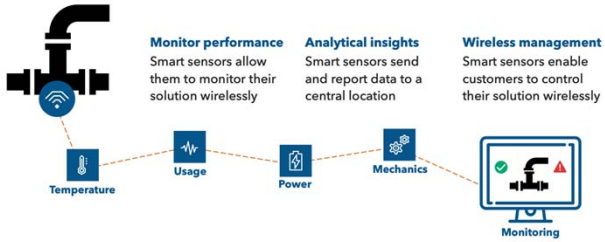


CLEANBLU TRANSFORMS HOW WE REUSE WATER WITH IOT

Particle

Executive summary

CleanBlu is revolutionizing the wastewater treatment industry with Internet-connected water reuse technologies. With the Particle IoT platform, CleanBlu has helped residents and commercial industries connect their water systems to the Internet so they can not only monitor and control them wirelessly but also operate them autonomously. With these new wastewater technologies, CleanBlu has made it so residents and commercial industries have access to water that is safe and clean to use.



The challenge

The wastewater treatment industry is full of laws and regulations that businesses must adhere to in order to maintain operations and not create a negative health impact. This makes it challenging to build new and affordable solutions for the industry.

CleanBlu needed to build an intelligent wastewater treatment solution that could be controlled wirelessly and follow regulations within that industry. Initially, CleanBlu used the Particle Electron 2G/3G only as a modem. However, after some research, CleanBlu realized that the Particle product and its Cloud Services can run an entire system, becoming its main controller, not just a simple modem.

Particle enables the path to scale

With the help of Particle, Cleanblu built a fully automated BioController that can be used to manage every aspect of the treatment process.

Cleanblu BioController

The controller uses a Particle Boron, which allowed them to easily connect their solution to the Internet via a cellular network. They chose the Particle Boron because it came with the right processing power for their solution and was fully-certified, which helped convince partners that their solution was safe.

With the Particle IoT platform, CleanBlu could easily reconfigure the Particle Boron, meaning they could wirelessly send all-new features and change the way their solution reports data. And with the Particle For Good program, they got a discount on all Particle hardware and were able to receive technical support to help them build their solution.

Navajo Mountain water reuse project

CleanBlu has also used the Particle Boron for other projects. In 2019, CleanBlu was chosen by The International Water, Sanitation and Hygiene Foundation to design a low cost, fully autonomous water reuse system for the new Navajo Mountain Chapter House in Piute Mesa, Arizona.

There are over 175,000 people living In the Navajo Nation without any form of access to clean running water. Being situated in the desert, water is typically brought to them in

Navajo Mountain water reuse project

barrels. However, things like toilet flushing consumed ~50% of their total water usage, making it so they have to use their water diligently. CleanBlu started to think about how they could build a smart solution that allowed people to get the most of their water so it wasn't a scarce resource.

With the assistance of the Particle IoT platform, they developed a low maintenance 4-stage aerobic biological treatment system that could be used to treat wastewater for reuse. The system is fully autonomous and can communicate to the Internet thanks to the Particle Boron. This means the solution can be fully managed via the CleanBlu Connect app, giving them more control over their solution.

Cleanblu and Particle exceed expectations

Cleanblu chose the Particle IoT platform because it provided all the tools they needed to build a reliable Internet-connected solution. Particle handled the complex infrastructure of IoT for Cleanblu, meaning they could focus on making water accessible, safe, and clean.

The Particle for Good program also helped them achieve their vision of making clean water accessible, and reusable by providing technical support and discounts on hardware. In the future, they hope to see smart cities with a decentralized water treatment system.

Contact Particle

If you are looking to build profitable IoT solutions, consult our team of experts at Particle.io/sales.

Particle Store

Start your IoT journey by checking out our industrial hardware on the Particle Store.

FOG WATER REUSE

PROBLEM
Food plant violating wastewater disposal permit limits – paying $$$$$ in penalties

SOLUTION
Design in-situ FOG remediation system to process 15,000 gallons/day wastewater from commercial kitchen to <20ppm FOG waste

Disinfection

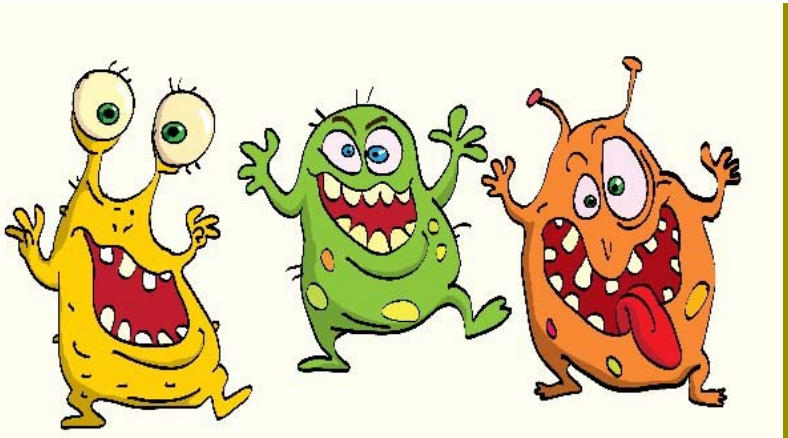
STERILIZATION

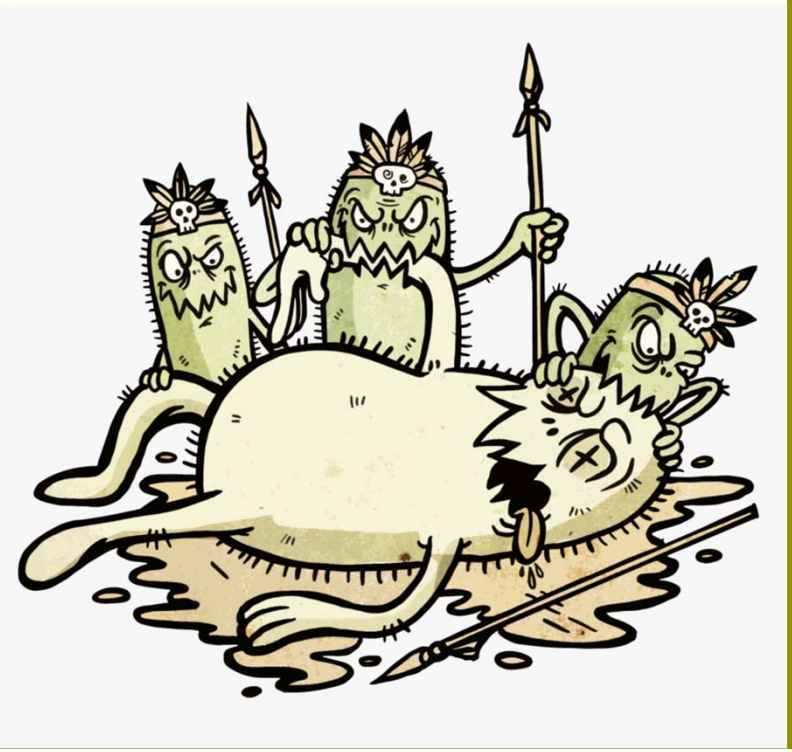
PATHOGEN REDUCTION

Pathogen Elimination

IT'S TRICKY

- 100% kill rate impossible
- Incomplete disinfection leaves behind strongest pathogens
- With no competition they will radically multiply
- Killing all pathogens damages the environment





IS PATHOGEN REDUCTION AN OPTION?

- Physicists know nature works in logarithms
- Pathogen reduction targets are LOG targets
- Feed the good guys - make them thrive
- The bad guys can’t compete and so die out
- I call it Communal Microbiology (Metagenomics)

WE ARE GETTING VERY CLOSE

- Cost and reliability are the biggest issue
- Can now be run safely
- Well established science
- Multiple disinfection methods
- Power issue has been solved
- Reliable communications are becoming affordable and robust enough for integration

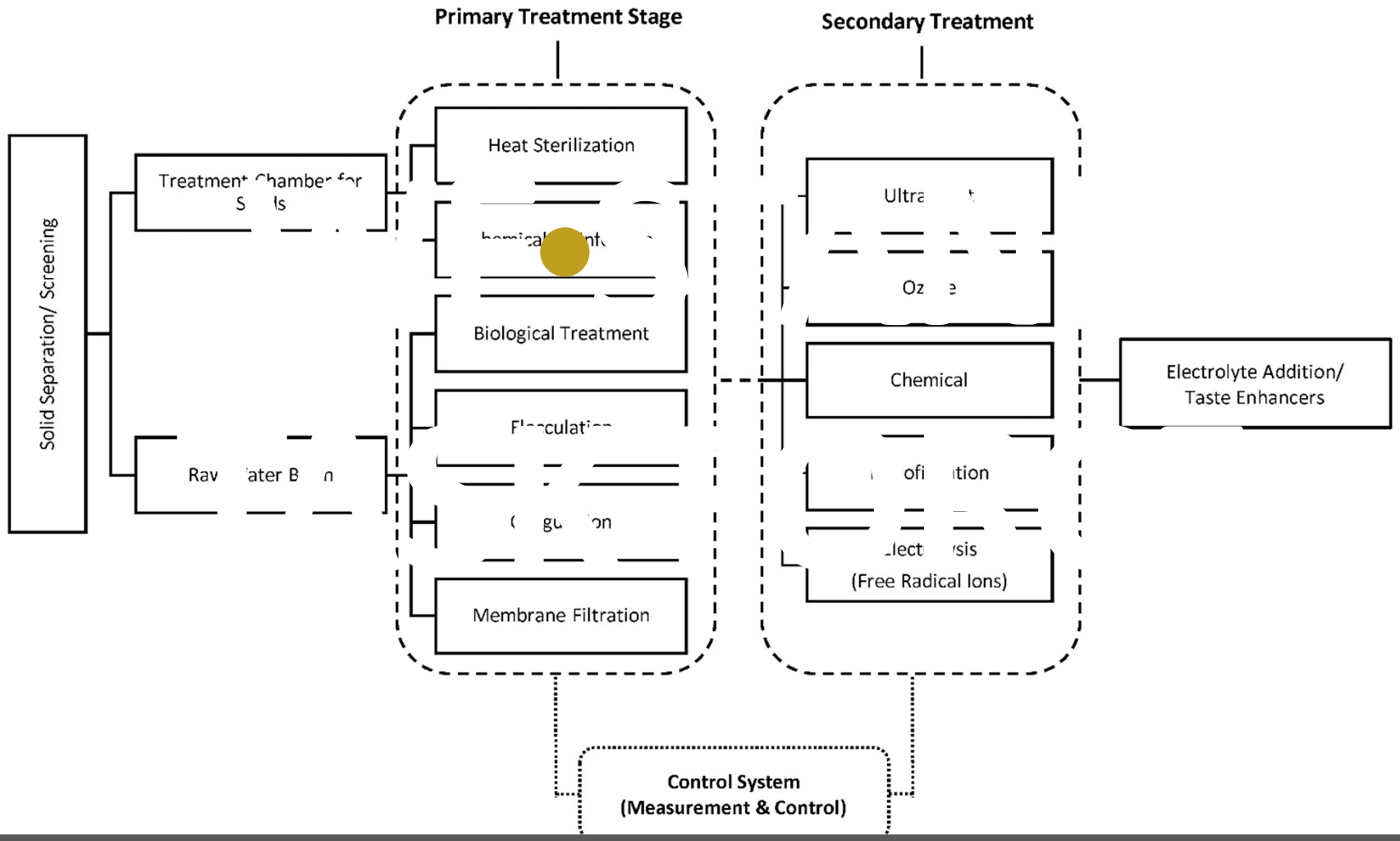
CURRENT TECHNOLOGICAL LIMITATIONS

- Biological testing in a lab takes too long – meanwhile water safety unconfirmed
- Online (instant) sensors only – no pathogen sensors yet
- Strive for pathogen reduction vs elimination
- Pitfalls of sterilization - the very bad actors survive
- No resource competition - pathogens radically multiply causing upsets and even outbreaks

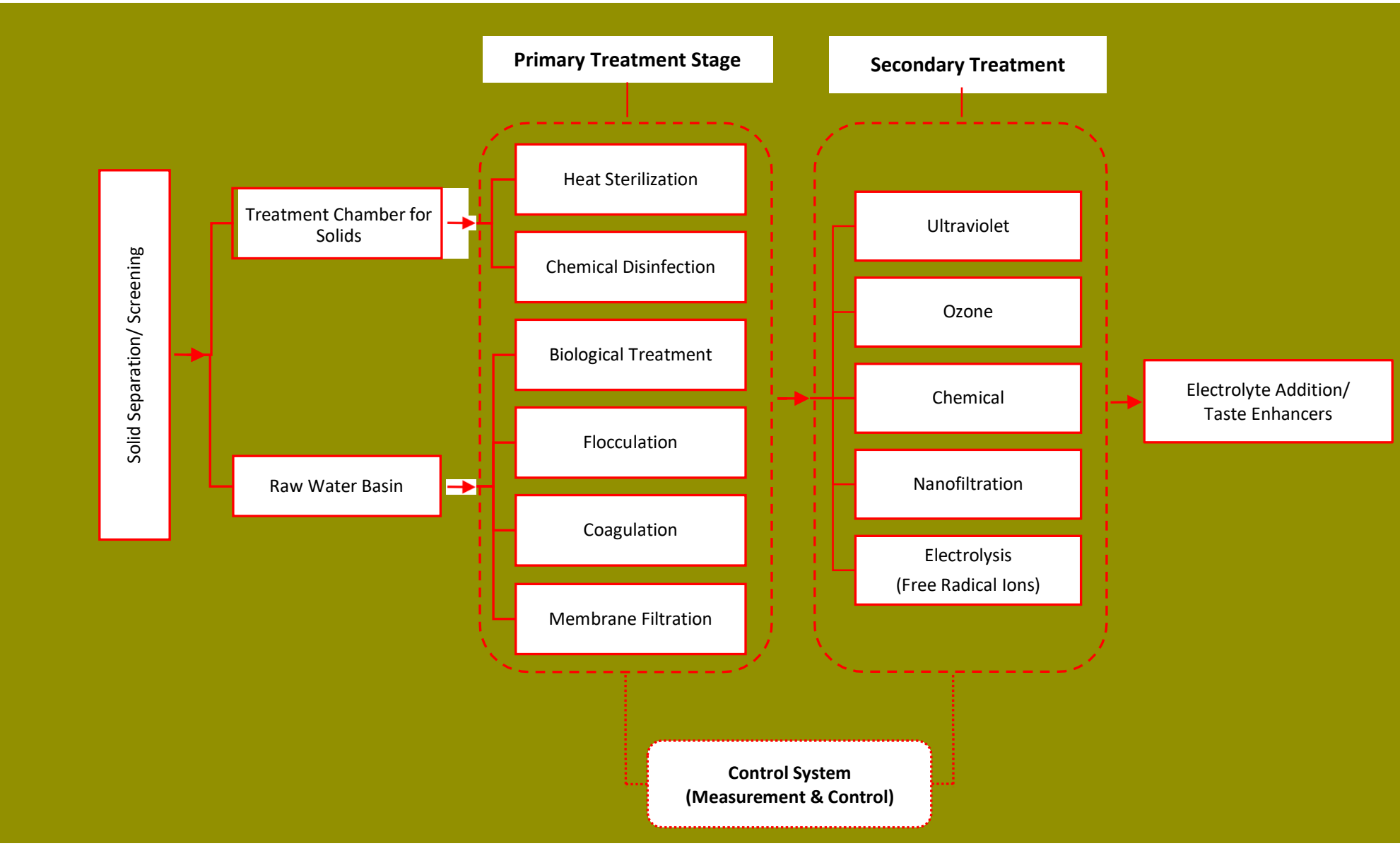
…BUT CAN WE PROVE IT'S SAFE?

THE TECHNOLOGY IS READY
LET'S GET THE DATA AND IMPLEMENT

WHAT'S NEXT?



DIRECT POTABLE WATER REUSE

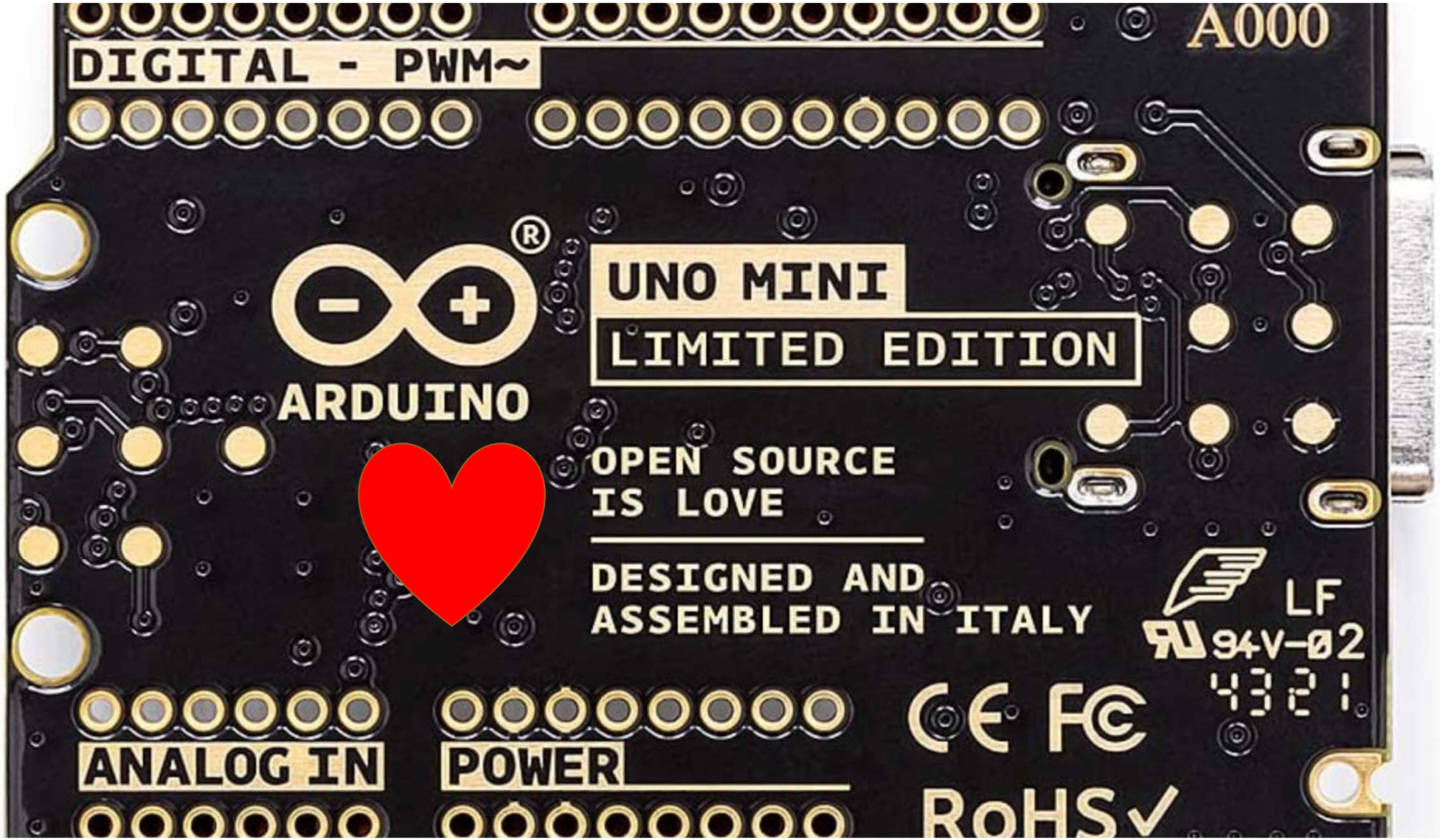

Primary Treatment Stage
Secondary Treatment
Solid Separation/ Screening
Treatment Chamber for Solids
Raw Water Basin
Heat Sterilization
Chemical Disinfection
Biological Treatment
Flocculation
Coagulation
Membrane Filtration
Ultraviolet
Ozone
Chemical
Nanofiltration
Electrolysis
(Free Radical Ions)
Electrolyte Addition/
Taste Enhancers
Control System
(Measurement & Control)


INTERNATIONAL COLLABORATION
PROJECT
BERGBACH
Safe drinking water from (almost) any source
bergbach.org

HARDWARE AND SOFTWARE

OPEN SOURCE

No License Fees For Any Non-commercial Use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ARDUINO
UNO MINI
LIMITED EDITION
OPEN SOURCE
IS LOVE
DESIGNED AND
ASSEMBLED IN ITALY
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ANALOG IN
POWER
RoHS

Thank you

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