

Instruction & Community Outreach Utilizing Recirculating Aquaponics Systems

Kevin. M. Savage and Gary A. Delanoy, with Christina Del Greco, David Humphrey, Nathaniel Hipsley
SARE Grant YENC13-067



Cincinnati Hills Christian Academy

- Private, non-denominational Christian college preparatory academy
- Total enrollment (K-12) 1455; high school enrollment 475
- 21% of high school students are racially diverse, including 31 international students representing 9 countries
- 99% of graduates attend 4-year colleges/universities
- 18 Advanced Placement (AP) courses offered
- 4 AP courses in Science Department
 - Biology, Chemistry, Physics, Environmental Science

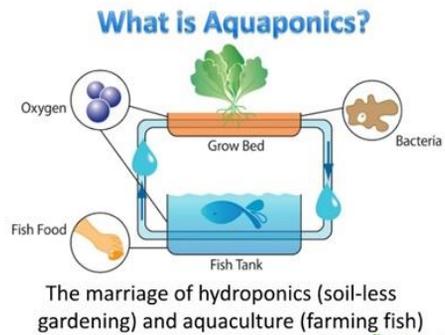


What is Aquaponics?

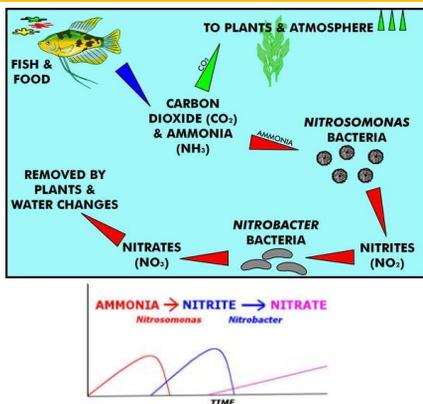
"Aquaponics is the cultivation of fish and plants together in a constructed, recirculating ecosystem utilizing natural bacterial cycles to convert fish waste to plant nutrients.

This is an environmentally-friendly, natural food-growing method that harnesses the best attributes of aquaculture and hydroponics without the need to discard any water or filtrate, or add chemical fertilizers."

(Aquaponic Gardening Community, November, 2010)



The marriage of hydroponics (soil-less gardening) and aquaculture (farming fish)

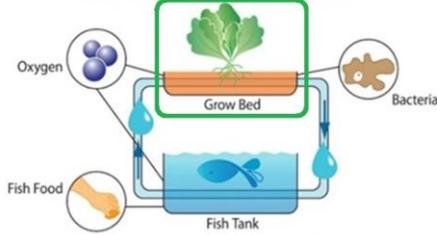


Key Parameters Monitored

Parameter	Range
Dissolved Oxygen	> 4 ppm
Ammonia (NH ₃)	< 1 ppm
Nitrite (NO ₂)	< 6 ppm
Nitrate (NO ₃)	10 – 20 ppm
pH	6 - 8
Temperature	77 – 86 F



What is Aquaponics?



The marriage of hydroponics (soil-less gardening) and aquaculture (farming fish)



NFT (Nutrient Film Technique)



Deep Water Culture (Raft)



Media-Filled Bed



Vertical Towers



(ZipGrow® Photos courtesy of Bright Agrotech, LLC;
<http://www.brightagrotech.com>)



Curriculum Under Development

- An aquaponics-based, sustainable agriculture curriculum for secondary application (modifiable for pre-secondary use)
- Modules with lesson plans to explore core science concepts
 - Biology
 - Microbiology
 - Chemistry
 - Physics
 - Environmental Science
 - Agriculture



Integrating Aquaponics into a Biology Curriculum

- A shift from using aquaponics as a resource to a model in my curriculum for the SY2013 - 2014
- Aquaponics provides a model to understand and apply biology concepts
- Modify past lessons to meet NGSS and school benchmarks
- Develop new NGSS compatible hands-on activities



Next Generation Science Standards (NGSS)

- Positives: Less emphasis on memorization and more emphasis on connecting concepts with applications (models)
- Challenges: Rigid to scope and sequence along with time constraint
- High School Life Science
<http://www.nextgenscience.org/search-standards>
 - HS-LS1: From Molecules to Organisms: Structures and Processes
 - HS-LS2: Ecosystems: Interactions, Energy, and Dynamics
 - HS-LS3: Heredity: Inheritance and Variation of Traits
 - HS-LS4: Biological Evolution: Unity and Diversity



Integrating Aquaponics into a Biology Curriculum

- A year long Biology curriculum at CHCA
 - Unit 1: Introduction and Characteristics of Life
 - Unit 2: Chemistry in Biology and Properties of Water
 - Unit 3: Biological Molecules
 - Unit 4: Cells
 - Unit 5: Transport of Molecules Across Membranes
 - Unit 6: Cellular Energetics—Photosynthesis & Cell Respiration



Integrating Aquaponics into a Biology Curriculum

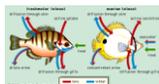
- A year long Biology curriculum at CHCA
 - Unit 7: Cell Division
 - Unit 8: DNA and DNA Technology
 - Unit 9: Heredity & Genetics – Mendelian & Non-Mendelian
 - Unit 10: Change over Time (Evolution)
 - Unit 11: Biological Diversity and Classification
 - Unit 12: Animal Kingdom and Introduction to Anatomy



Integrating Aquaponics into a Biology Curriculum

- Unit 5: Transport of Molecules Across Membranes

Selected Topics	Aquaponics correlations	NGSS
<ul style="list-style-type: none"> • Passive transport • Diffusion (ions, dissolved gases) • Concentration gradients • Active transport • Osmosis <ul style="list-style-type: none"> - hypertonic - hypotonic - isotonic • Osmoregulation 	<ul style="list-style-type: none"> • Ammonia excretion fish • Dissolved oxygen movement across fish gills • Movement of ions across plant roots • Activity – plan and conduct investigation to study effect of ion concentration in water on plant cells. • Challenge Questions – effect of salinity on raising freshwater fish and/or plants in brackish water 	<ul style="list-style-type: none"> • HS-LS1-2 • HS-LS1-3 <p>From Molecules to Organisms: Structures and Processes</p>



<http://files.chapterfortyfour.weebnode.com/200/000002-614a66244a6541-004-A98978202.gif>

Integrating Aquaponics into a Biology Curriculum

- Unit 5: Transport of Molecules Across Membranes

<http://files.chapterfortyfour.weebnode.com/200/0002-614a66244a6541-004-A98978202.gif>

<http://www.rainjardens.us/images8.gif>

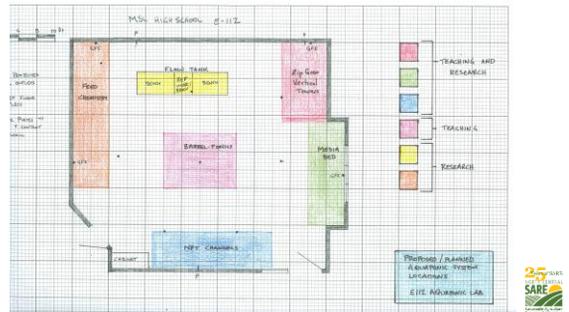


CHCA Aquaponics Systems



CHCA Aquaponics Systems

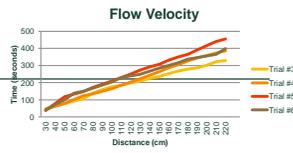
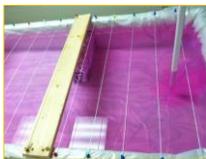
- Plans for aquaponics lab



27

Independent Student Research

The Effect of Baffle Placement in an Aquaponics Grow Bed to Control the Nutrient Flow Path (Kirbabas & Savage, 2012)



- Addition of simple baffles increased flow/residence time by more than 30%
- Temperature difference of 1.5°C between influent water and grow bed water produced flow stratification



28

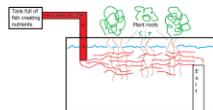
Independent Student Research

Christina Del Greco, Air Bubble Curtains to Control Nutrient Flow Path in Deep Water Culture Grow Beds (in progress)



Independent Student Research

David Humphrey, Effect of Thermal Stratification on Nutrient Flow Path in Deep Water Culture Grow Beds (in progress)

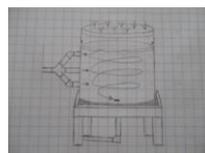


- Current goal: find out how the water will move when the only variable influencing the movement is the temperature of the incoming nutrient-rich water
- Purpose: to later use results of this experiment to determine problems and design a new experiment which attempts to manipulate thermodynamics to solve them.
- Possible problems:
 - If the dyed water moves too quickly or unpredictably, the nutrients will not be deposited consistently enough
 - The water needs to flow through the area where the branches of the roots will be, since the branches on the roots absorb the nutrients (Whiting, Roll, Vickerman)
- Will be referring to my literature review to get an idea for how thermodynamics can be manipulated.



Independent Student Research

Nathaniel Hipsley, Maximizing Grow Bed Efficiency with a Circular Design (in progress)



Community Outreach CHCA Aquaponics and Education

- Classroom aquaponics projects at other schools – CHCA students to lead and/or help with classroom aquaponics projects at other schools in greater Cincinnati area
 - North Avondale Montessori (2 systems)
 - Mt. Healthy Community Schools (2 buildings)
 - West Chester Community Montessori



Community Outreach Cincinnati Zoo & Botanical Gardens

- Two combination media bed / DWC aquaponics systems with catfish and bluegill
- Leaf greens and herbs used in Zoo's sustainable café
- CHCA faculty involved with initial system set-up & water quality testing
- CHCA students to conduct on-going water quality testing



<http://blog.cincinnati-zoo.org/2013/08/28/fishy-business-at-the-base-camp-cafe/>

Community Outreach



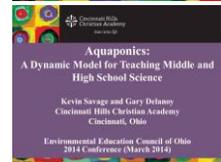
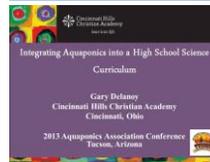
Krohn Conservatory – Cincinnati Park Board

- Special exhibit on sustainable agriculture in an aesthetic setting
- Featured aquaponics, hydroponics, aeroponics, and vertical gardening
- CHCA faculty assisted with exhibit installation & water quality testing



Community Outreach

Presentation at Professional Conferences



Summary and Conclusions

- Aquaponics provides a dynamic, hands-on environment which can be utilized for:
 - Classroom instruction and modeling of natural and agricultural systems
 - The platform for independent student research
 - Outreach:
 - Pre-secondary and secondary education
 - Community exposure and service
 - Sharing of information in the professional community



Acknowledgements

- North Central Region SARE
- Dr. Laura Tiu, OARDC
- CHCA Colleagues & Administration
- Pete West (SSE)
- Dan Divelbiss (WaterFields, LLC)



Questions?

Kevin Savage

kevin.savage@chca-oh.org

Gary Delanoy

gary.delanoy@chca-oh.org

Cincinnati Hills Christian Academy

11525 Snider Road

Cincinnati, OH 45249

(513) 247-0900

<http://www.chca-oh.org>

