Setting Up An Aquaponics System and Teaching Aquaponics to Sixth Graders at Keaukaha Elementary

DURATION

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Background

Aquaponics is an integrated farming system that involves the cultivation of fish, plants, and microbes. Aquaponics is believed to have originated in China over 1,500 years ago. The Chinese raised ducks in cages over ponds that housed finfish and catfish. Excess feed and excretion from the ducks fell into the ponds and fertilized them for phytoplankton growth which the fish ate. Water from these ponds was then diverted to the rice fields (Jones, 2002).

There can be many problems associated with growing food including limited space, poor soil, scarcity of water, and high input costs. Fortunately, aquaponics can alleviate these problems. Three-quarters of the freshwater on Earth is used to water crops (Jones, 2002). Unfortunately, plants are unable to retain all the water that they are given and lots of water seeps into our groundwater and rivers.

The principles that make an aquaponics system work are simple. Fish excrete waste which is then converted by bacteria to fertilizer. Next, the nutrient-rich water and dissolved wastes are filtered by plants, finally returning clean water to the fish (Figure 1). Although there are a variety of ways to design an aquaponics system, all aquaponics systems follow the same principles (Tidwell, 2012, p. 343).

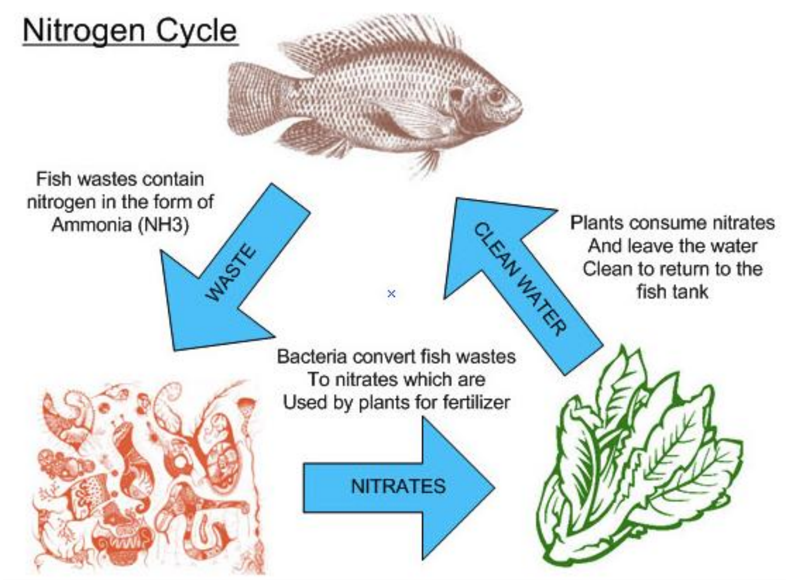

Figure 1. Nitrogen Cycle (Photo Credit: New Streams Aquaponics)

An aquaponics system is divided into three main components: rearing tank, biofilter, and grow bed. Water is recirculated through the system so that water and effluent are recycled. The rearing tank or fish tank contains the fish. The fish excrete waste through their gills, which releases ammonia (NH_3); high levels of ammonia are toxic to fish (Rakocy et al. 2006).

In an aquaponics system, the water and fish effluent are pumped from the rearing tank to the biofilter. The biofilter holds plastic media called bioballs which provide surface area for beneficial bacteria. These beneficial bacteria are responsible for converting toxic ammonia to usable forms for plants and they live throughout the system and form a biofilm on all surfaces submerged by water. The amount of surface area in a system determines the amount of bacteria able to survive in the system. The surface area that the bioballs provides allows for large numbers of bacteria. As the biofilter fills with water, the bacteria convert toxic ammonia to usable forms of nutrients, which plants use as fertilizer (Rakocy et al. 2006).

There are two types of nitrifying bacteria in a freshwater system: *Nitrosomonas* and *Nitrobacter*. *Nitrosomonas* converts ammonia to nitrite ($NO2^{-}$). *Nitrobacter* converts nitrite to nitrate ($NO3^{-}$). This aerobic process of converting ammonia to nitrite and nitrite to nitrate is called nitrification (Tidwell, 2012, p. 357).

As soon as the water level in the biofilter reaches an overflow pipe, the water is pumped into the grow bed where a variety of plants can be grown. Plants that do well in an aquaponics system include: lettuce, spinach, kale, and other leafy greens (Jones, 2002). The plants absorb nutrient-rich water through their roots. The plants also filter the water and dissolved fish waste, which reduces the amount of toxic compounds in the system. The clean water from the grow bed flows via gravity back into the rearing tank (Rakocy et al. 2006).

Traditional farming practices can have detrimental effects on the environment and those that inhabit it. Excess nutrients from fertilizers seep into groundwater, rivers, lakes, and oceans. Drinking water that is contaminated with excessive nutrients can make people, livestock, and other animals sick. Eutrophication can lead to harmful algal blooms that often have deleterious effects on aquatic organisms and ecosystems. Aquaponics recycles water, eliminates fertilizer inputs, and reduces waste – making it a great alternative to traditional farming practices.

Hawai`i relies almost entirely on imports from other states and countries. With the high cost of shipping due to fuel prices, it is extremely important to become more sustainable. One way to lessen dependency on imported goods is to grow fish, fruits, and vegetables in an aquaponics system. It is important to teach the children of Hawai`i aquaponics so that they have the knowledge to be able to grow food for their friends and family.

Objectives of the project

The completed objectives included:

1. Working with sixth graders to assemble an aquaponics system
2. Teaching sixth graders how to maintain the aquaponics system
3. Adopting a teaching style to teach sixth graders complex topics
4. Constructing an Powerpoint presentation to present to the sixth graders

Methods and Materials

Fish tank
Grow bed
Rafts
Particle swirler
Pump
Biofilter
Bioballs
PVC
Koi
Swordtails
Fish food
Fish net
Lettuce seeds
Spinach seeds
Jiffy Cubes
Cups
Coconut fibers
Cinders

Buckets	Hose
Gloves	Jigsaw
Scrub brushes	
Soap	
Bleach	

I worked with James Moore to teach the 2013 sixth grade class at Keaukaha Elementary how to assemble and care for an aquaponics system. I focused on getting the system in working order and contacting people to get fish and other materials needed for the project. I also contacted teachers to set up meeting times. James helped with all aspects of setup and focused on teaching styles to teach kids complex topics. He also focused on getting funding for the school to have books, feed, ect. James will be continuing the project next semester as I will be graduating.

The Pacific Aquaculture & Coastal Resources Center previously worked with Erika Perry and Noe Puniwai to install an aquaponics system at Keaukaha Elementary. Back in January 2013 when James and I took on the project, the system was not running. James and I were able to work with the sixth graders to clean out the existing system and prepare it for fish and plants. We then transferred koi from the UH Hilo Panaewa Farm to the aquaponics fish tank.

Once the fish settled into their fish tank we showed the kids how to plant lettuce and spinach seeds in Jiffy Cubes which were later transferred to the grow bed. We conducted an oral presentation for the sixth grade class at Keaukaha Elementary to show how an aquaponics system works and how to maintain one. The sixth graders were responsible for setting up the system, feeding the fish, monitoring the water level, and making sure the pump was in working condition. James and I visited the school once a week to teach the students about aquaponics and to check on the system.

Timeline

Visited KES to evaluate system and meet 6th graders	February 12th
Cleaned grow beds and fish tank and pulled weeds around system at KES	February 13th
Calculated amount of feed needed to support grow bed area and calculated how many fish could be fed with this amount of food	February 18th
Went to Panaewa to weigh fish and transported fish to PACRC	February 19th
Showed 6th graders how to siphon bottom of fish tank to remove dirt and filled fish tank with water	February 20th
Transported fish from PACRC to KES and let sixth graders net fish into fish tank and fed the fish gradually	February 21st
Picked up rafts, cups, cinders and coconut fibers from Panaewa and trimmed excess off of rafts	February 26th
Filled cups with cinders and coconut fibers and planted lettuce, kale, and spinach seeds in cups	February 27th

Worked on PowerPoint presentation	March 4th
Trimmed even more excess off rafts and bought Jiffy Cubes and more seeds	March 5th
Planted new seeds in Jiffy Cubes and taught kids how to calculate amount of feed for an aquaponics system	March 6th
Gave PowerPoint presentation on the history of aquaponics, why it's important, how to set up a system, and what goes on in an aquaponics system	March 13th
Cut-out activity with different components of our aquaponics system detailing water flow and location of bacteria, fish, and plants	March 20th
Harvested lettuce and spinach and cleaned dead leaves off of raft and growbed	March 27th
Checked temperature and pH in system and explained optimal ranges for fish and plants	April 3rd
Checked in on kids and saw how aquaponics system was running	April 10th-24th
May Day	May 1st
Transferred responsibilities over to KES, but remain in contact for consultation	May 8th

Results/Discussion

The students at KES now have a fully functioning aquaponics system with fish and vegetables. After having aquaponics classes once a week, they now have the knowledge necessary to maintain the system on their own. It was such a rewarding experience getting to work with sixth graders and teaching them the importance of growing food.

When the group of sixth graders we taught graduate their teachers will have to pass on the information to next group. To make this task easier, James will be creating a daily, weekly, and monthly checklist to make sure the system is up and running. In addition, we will both be available as a resource and to help the teachers in the coming semesters if they need help.

Conclusion

Our deliverables included a fully functioning aquaponics system that sixth graders have the knowledge to run and a PowerPoint presentation for the teachers to present to future classes. Teaching the students went really well. They were able to understand complex subjects and explain what we taught them to others. The teachers and staff were also really helpful at accommodating our schedules so we could be the ones to actually teach the kids. They worked around our schedule so that we could have weekly aquaponics classes. Matt Barton from the aquaculture section of the University of Hawaii at Hilo Panaewa Farm provided us with fish, rafts, media, and extensive support regarding operation of the system. Once we transferred the responsibilities over to Keaukaha Elementary School, we stopped contacting them weekly. When this happened, there was a lag period in which the system did not have plants to utilize the nitrates from the fish and a few fish died. This could have been avoided by being in better contact with the school, perhaps on a weekly basis. It would also have benefited them to have a checklist of things that needed to happen on a daily, weekly, and monthly basis including planting seedling for the next batch a week before harvest. This experience has taught me a lot about teaching and working with different age groups. I found out that I really enjoyed teaching and now I am considering it as a career option. This project provided me with many learning experiences and I am grateful to have been able to work with KES to setup and maintain an aquaponics system for future students to enjoy.

References

Jones, S (2002) Evolution of aquaponics. *Aquaponics Journal* VI.1 14-17

Rakocy JE, Masser MP, Losordo TM (2006) Recirculating Aquaculture Tank Production Systems: Aquaponics—Integrating Fish and Plant Culture. Southern Regional Aquaculture Center.

Tidwell, JH (2012) Aquaculture Production Systems. Ames: Wiley-Blackwell 343-83

SYDNEY K. GAMIAO

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Education

University of Hawaii at Hilo *Hilo, Hawaii*
B.S. in Agriculture, Specialization in Aquaculture *Expected December 2013*

GPA: 3.7

Work/Research Experience

Hatchery Technician, Pacific Aquaculture and Coastal Resources Center *Hilo,Hawaii*
University of Hawaii at Hilo *April 2010-Present*

- Responsible for caring and handling of several aquatic species, which include but are not limited to the Pacific oyster (*Crassostrea gigas*), Hawaiian oyster (*Dendostrea sandvicensis*), and the black lip pearl oyster (*Pinctada margitifera*)
- Knowledgable of the different life cycles of these species as well as feeding requirements and issues with water quality
- Proficient in inoculating and farming several species of algae including *Chaetocerus muelleri*, *Isochrysis galbana*, and *Nannochloropsis oculata*

Research Experience for Undergraduates *Hilo, Hawaii*
Pacific Internship Programs for Exploring Science *Summer 2011-December 2012*

- Collected data from Kaloko Fishpond and processed phytoplankton samples using standard protocols for Scanning Electron Microscopy
- Operated Hitachi Scanning Electron Microscope
- Analyzed phytoplankton characteristics using fluorometry, epifluorescent microscopy, and flow cytometry

Presentations

Pacific Internship Program for Exploring Science Symposium *Hilo, HI*
Gamiao, S. Effects of groundwater discharge on the coastal environment *August 2010*

Conferences & Workshops

- HAAA International Workshop on Aquaponics and Tilapia, *Hilo, HI* *August 2010*
- Hawaii Conservation Conference, *Honolulu, HI* *August 2011*

Certifications

- SCUBA Open Water Certification, PADI *Spring 2010*

References

- DR. MARIA HAWS, Director of Pacific Aquaculture and Coastal Resources Center, haws@aol.com
- DR. KEVIN HOPKINS, Professor of Aquaculture at University of Hawaii at Hilo, hopkins@hawaii.edu
- DR. ARMANDO GARCIA-OTEGA, Assistant Professor of Fisheries and Aquaculture at University of Hawaii at Hilo, agarciao@hawaii.edu