An Aquaponics Experience:

Farmer to Farmer
From Arizona to Trinidad

Eric Highfield
Aquaculture without Frontiers / Farmer to Farmer Volunteer
Tucson, Arizona

March 12th-19th, 2011

BACKYARD AQUAPONICS

SUNDAY 3/19/2011

I met with Capildeo Barath, the secretary of the Aquaculture Association and he took me to observe a small-scale aquaponics operation at the house of Sherma Wong-Kang. She took Dr James Rakocy's short course offered through the UVI, and her system appears quite functional, especially concerning plant production. The system has been going since November 2010 and contained cabbage, lettuce, Bok Choy, Chinese spinach, and several herbs all of which appears very healthy. The plants had been started in soil in small pots, which were then placed in floating closed cell Styrofoam rafts. There were two beds approximately 5ft x 10ft and one large fish tank containing tilapia. The water quality was impressive, and there was an elaborate filtration/ clarification system in place. I made a few suggestions, including the dilution of the sludge waste before using it to water other plants in soil. I also recommended not using the sludge waste directly on plants for consumption, and instead using it to water ornamentals and trees. Overall the system was impressive and successful, as Dr. Rakocy referred to her setup as "the Cadillac of backyard aquaponics".

SEAFOOD DEVELOPMENT

MONDAY 3/14/2011

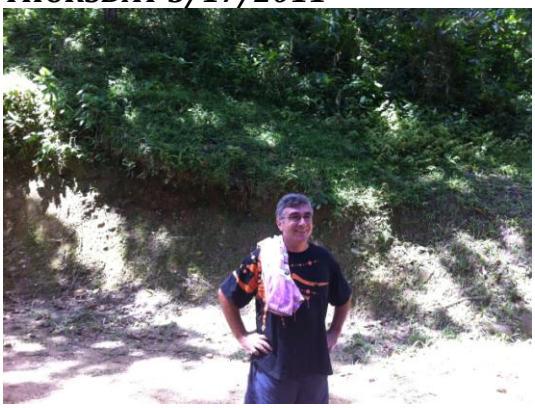
The Seafood Development Company Limited in an organization affiliated/ operated in conjunction with the Trinidad government. There is a government appointed board that

makes decisions regarding the development of various seafood applications for the country of Trinidad. There I met with a supervisor by the name of Nigel, who gave us a tour of the research facility involved with Tilapia. They had several outdoor tanks with individual filtration systems, and the basic premise of their current research project was reducing the cost of pelletized Tilapia feed by supplementing with algae bioflocs, which were being grown in both the fish tanks and clarifiers. The operation was somewhat similar to the aquaculture greenhouse located at the Environmental Research Labs at the University of Arizona, just larger tanks and placed outdoors. We discussed the energy equation involved in the process, and how chemical photo energy are the system inputs in the form of pelletized feed (chemical energy) and solar radiation (energy transformed by algae). I suggested the possibility of eliminating duckweed from the clarifiers so that more nutrients would be available for algal growth. We also discussed polyculture of shrimp and Tilapia together, and some of my fellow graduate colleagues at University of Arizona as well as others

have demonstrated that the relationship between the two species can be synergistic in an aquaculture system, and could potentially increase productivity of the system as a whole. Other issues discussed include how some fish develop tendencies to overfeed, and how the resulting effluent is rich in protein and other nutrients from feed that remain undigested in fish that gorge themselves.

COMMERCIAL SCALE AQUAPONICS START-UP

TUESDAY 3/15/2011 & THURSDAY 3/17/2011



Mark Webster is an insurance broker who has always dreamed of self-sufficiency and running a green business from his home as a viable retirement option. He owns 5 acres of land in the Morracas valley where he has constructed a commercial production aquaponics system based on the Rakocy model. His system is made of poured concrete and includes six 100 x 4 ft grow beds for plants, four fish tanks 10 ft in diameter and 4 ft deep, a dual clarifier and a single degasser.

Mr. Webster is not a biologist and his only experience with aquaponics consists of a small-scale system he constructed out of several 55 gal plastic drums. The problem with his system when I arrived was an alkaline pH (around 9) and a significant accumulation of foam that would form when he turned on the aeration. I attributed these problems to residues from the concrete, and I determined that the concrete had not been washed or rinsed after it had been poured. Concrete contains alkaline compounds that will raise the pH if not properly leached as well as

several other chemical compounds such as cement binders that were likely to be responsible for the strange foam that we observed. Between both of these problems we decided to drain the system completely, wash it out and refill it with clean water. This process was begun immediately and after refilling the system the pH values were tested and the system was once again aerated. The changes proved effective, as the pH was found to be in a desirable range (7.2) and the strange foam had disappeared.

Mr. Weber was pleased with the results and he asked me what steps he needed to take before stocking fish. I presented him with a brief report presenting two options for cycling the system and initializing bacterial nitrification. The first option was to stock fish gradually so that ammonia levels would build with a decreased risk of mortality, the second option was cycling the system by adding pure ammonia and seeding a culture of nitrifying bacteria from his existing small scale system so that he could stock fish to full capacity without risking fish mortality from an ammonia spike. This was the option that he chose, as he was anxious to begin production so that he could begin full production sooner and start obtaining income. Next I was asked to create a written timeline for the first crop cycle of both fish and plants, so that he has a reference on when to plant seeds, transfer seedlings into the aquaponic system, harvest both fish and plants, and when to begin the entire process over again so that he has a consistent production of both Tilapia and lettuce. Mr. Weber was grateful for my input and assured me that he would update me on his progress.

Time Table of Events

Saturday 3/12/2011: Arrived at Tucson airport

Saturday 3/12/2011	Arrived at Tucson airport at 4:00 am. Flew to Dallas airport, transferred planes and traveled to Ft. Meyers. Transferred planes and flew to Miami international airport. Transferred planes and traveled to Port of Spain, Trinidad, where I arrived after midnight. Went through customs, and took a taxi to Shalom house 42 Windsor Rd., North Valsayn where I arrived around 1:30 am.
Sunday 3/13/2011	Met with Capildeo Barrath, head of the Trinidad Aquaculture Association at my residence and he took me to observe Sherma's backyard aquaponic setup.
Monday 3/14/2011	Capildeo took me to The Seafood Development Company Limited where I was able to observe their research. Toured the Caroni swamp.
Tuesday 3/15/2011	Met with Mark Webster, and we traveled to the Maracas valley where his aquaponics system is located.
Wednesday 3/16/2011	Took a taxi to Maracas bay for a field trip to observe a small fishing village and try Richard's Bake and Shark.
Thursday 3/17/2011	Traveled back to Maracas valley to help Mark Webster cycle and set up his aquaponics system.
Friday 3/18/2011	Met with Indar Ramnarine, and we discussed his aquaponic system, and Dr. James Rakocy.
Saturday 3/19/2011	Took a taxi to the Port of Spain airport at 4:00 am, traveled to Miami, went through customs, transferred planes and traveled to Washington D.C. Transferred planes and travelled to Chicago, transferred planes again and travelled to Tucson, arriving around 9:00pm.

People trained/ interacted with:
Men: 11
Women: 3

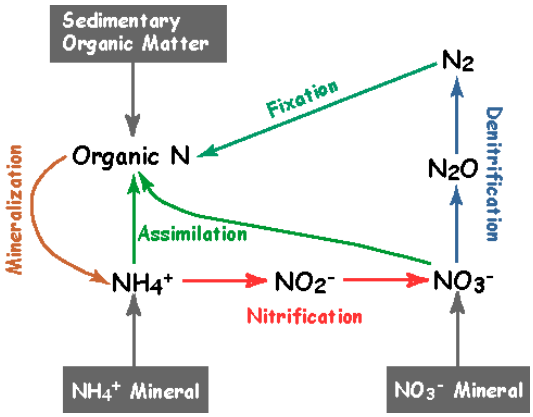
Number of people affected:
3 families, 27 individuals + consumers of products

Number of suggestions provided
8 suggestions: 1 to Sherma (backyard aquaponics), 2 to Nigel (seafood company), 4 to Mark (large scale aquaponics)

Appendix: reports for Mark Webster

Aquaponics setup

cycling



Option # 1: Cycling with fish

The premise of cycling is to establish a population of nitrifying bacteria to convert ammonia into nitrates that are available for plant uptake. The problem is that ammonia and nitrites are toxic to fish, so it can be tricky and often fish may be lost while ammonia (NH_3) builds up to provide an adequate supply for the bacteria that convert it into nitrites (*Nitrosomonas)*. The second part of nitrification converts nitrites into nitrates. *Nitrobacter* is the species responsible for this step, and nitrites are also toxic to fish and can result in what is known as brown blood syndrome. Both of these species occur naturally and will just show up in a system if it is left long enough, but to speed up the process we can seed the

system with either a commercial aquarium starter, or we can transfer from an established system. Now we need to provide an initial source of ammonia to begin the cycle.

Option # 1: Cycling with fish
Fish will provide ammonia and can be used to stat the nitrogen cycle, however it is not wise to fully stock a system as ammonia will quickly build up to toxic levels and will likely kill fish. The initial fish added to a new system should be considered expendable as they could succumb to toxicity from either ammonia or nitrites. If a small number of fish are stocked into a system this is unlikely, however the resulting bacteria are not going to be capable of processing waste from a fully stocked system and should be stocked gradually to prevent losses. This is a viable option, but it will take longer if performed correctly and if the process is rushed it can result in fish mortality.

Option #2 cycling without fish
In this scenario ammonia will be added to the system that has been seeded daily, levels of ammonia and nitrite will be monitored and a nitrifying population can be established without any potential losses and the system will be capable of handing large amounts of ammonia so that all tanks could be fully stocked so that plant production can begin as soon as possible. This would be my recommendation; the only potential difficulty is the availability of ammonia. 100% Ammonia, pure Ammonium Hydroxide or ammonium chloride would be ideal if available just so long as there are no perfumes or other additives. Human urine could be used however there are few other issues with this source as urine contains urea which must first be converted to ammonia. Letting it sit in a bottle for a few days can perform this, but there is a slight "yuck factor" involved.

Instructions for Fishless Cycling

Once you have identified your source of ammonia, you will be ready to start the cycling process. Just follow these simple instructions.

1. Add the ammonia to the system a little at a time until you obtain a reading from your ammonia kit of ~5 ppm.
2. Record the amount of ammonia that this took, and then add that amount daily until nitrites appear. By appear, I mean a reading of ~ 0.5 ppm.

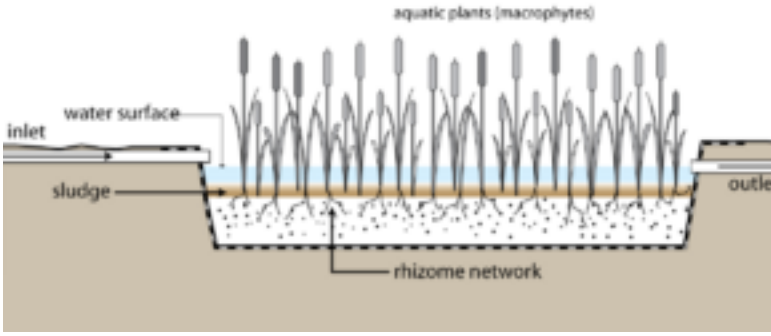
3. Once nitrites appear, cut back the daily dose of ammonia to half the original volume.
4. Once nitrates appear (5 – 10 ppm), and the nitrites have dropped to zero, you can add your fish.

I have pasted links to a helpful site that gives more detail on both of these options.
Without fish:
http://www.aquaponicgardeningblog.com/2010/11/01/starting-your-aquaponics-system-using-fishless-cycling/

With fish:
http://www.aquaponicgardeningblog.com/2010/11/01/starting-your-aquaponics-system-using-fishless-cycling/

wetlands

Here is a simple diagram of how a constructed subsurface flow wetland works. I would recommend using a local macrophyte (aquatic plant). I am not familiar with specific macrophytes found in Trinidad, however I am sure the Indar could provide a contact with a wetland specialist at the university that could give you more ideas about what to grow here. In the mean time bamboo seems to be readily available on site and could be planted initially.



Automated and remote continuous monitoring

Basic computerized monitoring costs about $2000 for basic Campbell unit with temperature [$50 each], plus PAR [$400 ea], but then add the costs for the special sensors like TDS [$500 ea], pH [$500 ea], and EC [$500 ea]. This would get you the onsite system.

There are several other brands available and some would be cheaper, however this system is proven and should be reliable for the long run.
http://www.campbellsci.ca/Products.html

AQUAPONICS INITIAL OPERATIONS

DAY 1

-Add ammonia to 5-10 ppm and record volume required and add filter mesh from small trial system
-Purchase all necessary supplies (test kits, seeds, seed starters or coco coir, pH up & down, fish feed, mild all purpose water soluble fertilizer)

DAY 2 UNTIL APPERANCE OF NITRITES

-Continue to add same amount of ammonia daily, test ammonia & nitrite daily until nitrites appear (0.5-1 ppm).
-When nitrites appear reduce amount of ammonia added by one half.

ONCE NITRITES APPEAR

- Begin testing daily for all (ammonia, nitrites, nitrates) until nitrates appear.
- Continue adding ammonia and testing daily until nitrates reach 10 ppm and nitrites drop to zero. Discontinue addition of ammonia.
- Test pH in duplicate to ensure you are within a safe range & adjust as necessary
- When this occurs you are ready to stock fish in all four tanks (20 g fingerlings @ 500 per tank + 5-10 fish in each clarifier)

WHEN TANKS ARE READY TO STOCK

- You are ready to start seeds for ¼ of system. If 1000 plants are desired seed 1200 (so that only the strongest seedlings are added to system) seedlings should be checked daily for moisture.
- Test parameters daily

ABOUT ONE WEEK AFTER STOCKING & PLANTING 1ST SEEDS

- Start adding a dilute fertilizer solution once seedlings are showing second or third set of leaves
- Test parameters daily
-

TWO WEEKS AFTER STOCKING & PLANTING 1ST SEEDS

- Repeat the planting of seedlings every 2 weeks, so that eventually every two weeks seeds are started, seedlings are transferred to system and after 1st batch reach maturity, harvest. This process can be changed to weekly after fish become larger so that adequate nutrients are available.
-

THREE WEEKS AFTER STOCKING & PLANTING 1ST SEEDS

- Seedlings should be transferred to system about 3 weeks after planting.
- Add chelated iron.
- Continue testing all parameters daily (pH, ammonia, nitrite, nitrate)

FOUR WEEKS

- Examine plants for signs of nutrient deficiency, as other micronutrients might be needed (manganese, etc.)
- Begin construction or purchase purging tank and fry grow out tank. Grow out tank can be smaller (one third to one half volume) than other fish tanks.

- Remember to cycle purge tank & grow out tank before adding fish
-

SIX <u>MONTHS</u>

- Add new fry to grow out tank about six weeks before 1st fish harvest. (Since smaller 20 gram fish were added this will take about 7 ½ months)

FOR FUTURE CONCIDERATION

- Once you are comfortable with the entire process consider adding a breeding tank, so that you can begin producing your own fry instead of purchasing
- Consider adding bug screens around grow beds and using biological controls such as ladybugs or praying mantis
- Build wetland for disposal of sludge waste
- Purchase computerized monitoring equipment (I'm sure you will be sick of testing with kits)
- Think about adding a few catfish, grass carp or fresh water prawns under grow beds to keep troughs clean
- Think about using soaker hoses to replace air stones
- Replace Styrofoam boards with appropriate closed cell dense boards.
- Think about using seed starters and doing away with gravel pots.