AQUAPONICS FOOD SYSTEM

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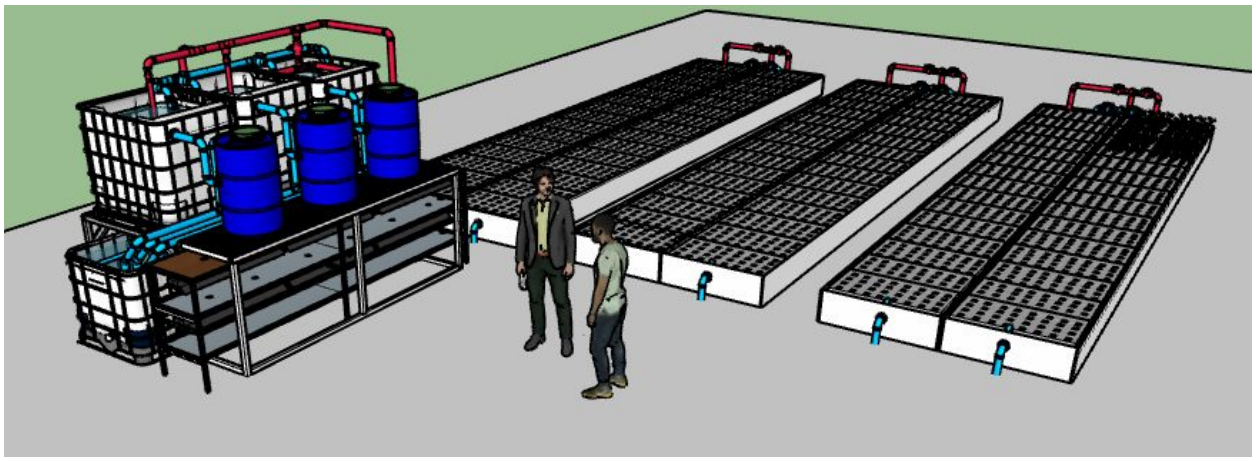


SYSTEM OPERATIONAL MANUAL

Introduction

This manual will enable you to operate a simple aquaponics food system. Before you start you must understand the following

- ✓ The system must be managed & maintained EVERY day.
- ✓ Water circulation, air circulation and aeration of water must happen constantly.
- ✓ Water quality must be maintained at proper levels.
- ✓ There must always be plants and fish present in the system to maintain balance.
- ✓ In order to achieve the desired results, the instructions, checklists and recommendations in this manual must be followed exactly.

If any of the above mentioned items are not happening, the system may not work as designed.

Definitions / Common Acronyms

Acronym	Definition		Acronym	Definition
DO	Dissolved Oxygen		**H3PO4**	Phosphoric Acid
GH	Greenhouse		**HNO3**	Nitric Acid
WQ	Water Quality		**H2SO4**	Sulphuric Acid
EC	Electrical Conductivity		**BSA**	Biological Surface Area
NO3	Nitrate		**FCR**	Feed Conversion Ratio
NO2	Nitrite		**IPM**	Integrated Pest Management
NH3	Ammonia		**BW**	Bi-Weekly
pH	Power of Hydrogen		**BM**	Bi-Monthly
PPM	Parts Per Million		**SLO**	Solid Lifts

Management Tools List

#	Item	Photo	#	Item	Photo
1	Water Testing Equipment		12	Strong Tape	
2	Fish Net		13	Mud Boots/Waders	
3	Temp Gun		14	Work Gloves	
4	Buckets		15	Disposable Gloves	
5	Shears		16	Sponge	
6	Rake		17	Scrub Brush	
7	Shovel.		18	Rags for cleaning	

8	Net Cups.		19	Pump Spray Can	
9	Fish food		20	Broom & Dustpan	
10	Scissors		21	Scale	
11	Knife		22	Ladder	

Task Lists

1. Daily

1.1. Greenhouse

1.1.1. Cursory Exterior / Interior & Leaks

- ❏ Visually check the exterior for loose panels or damage.
- ❏ Remove any snow buildup on the GH roof.
- ❏ Check the door and handle for signs of tampering.
- ❏ Visually check the ground for puddles or damp soil. If a puddle is found, check nearby pipes or beds for leaks.
- ❏ Check that all fans & vents are operating.
- ❏ Visually ensure water is running into fish tanks and grow beds.
- ❏ Check that all grow lights are operating. Replace burnt bulbs.

1.1.2. Water Levels (Tanks, Sump, Beds)

- ❏ Fish Tank level at 900 liters
- ❏ Matala Tank level at 750 liters
- ❏ Bio Tank level at 700 liters
- ❏ Sump Tank level at 500 liters
- ❏ Grow bed level at Standpipe Level

1.1.3. Greenhouse Temperatures & Humidity

- ❏ Record Greenhouse temperature into the Environment Log.
- ❏ Record Humidity level into the Environment Log.

1.1.4. Pest Traps

- ❏ Check all pest traps. If a trapped pest is found, remove, and place the pest in a plastic bag. Tie and seal the bag and throw it away.
- ❏ Re-bait and reset any sprung traps.

1.2. Fish Tanks

1.2.1. Remove Dead Fish

- ❏ Use net to remove dead fish floating on the surface of the tank.
- ❏ Remove dead fish from the greenhouse and cover with soil.
- ❏ Record the number of dead fish in your Fish Log.

1.2.2. Skim Poo & Debris

- ❏ Use a skimmer to remove anything floating on the surface of the water in the fish tanks.

1.2.3. Tank Temperature & DO

- ❏ Measure the water temperature in each fish tank.

- ❏ Record your temperature measurements in your data log.
- ❏ Measure Dissolved Oxygen (DO) in each fish tank.
- ❏ Record your DO measurements in your data log.

1.2.4. Flush Radial Filter

- ❏ Flush the radial filters by opening the flush valve at the base of the filter into a bucket.
- ❏ Dump the bucket, either in a Compost Tea barrel or simply outside.
- ❏ NOTE: Only open the valve long enough to flush out the solids in the filter, then quickly close the valve. Leaving the valve open for too long a period will unnecessarily drain system water.

1.2.5. Feeding Fish

- ❏ Measure out the recommended quantity of fish food (See Section A1) and scatter food across the water's surface of the fish tank.

NOTE: Tilapia are visual feeders, preferring the contrast of dark-colored feed to the surface of the water. For this reason, it's important to feed your fish uncovered, during daylight hours. If your fish are stressed or unhealthy, they may eat less. After feeding your fish, wait 15 minutes and check to see if there is any fish food remaining on the water's surface. If there is, remove excess food with the skimmer.

If your fish aggressively eat all their food before 15 minutes, you MAY consider increasing your feeding rate to the next level. After 15 minutes, your fish should no longer be aggressively eating their fish food.

1.3. Grow Beds

1.3.1. Spot Checking (See Section A2.2)

- ❏ Visually inspect plant leaves for pests and diseases.
- ❏ Remove any dead leaves or other debris from the raft.
- ❏ Record issues with the location in the data log.

1.3.2. Germination Table

- ❏ Ensure all seedlings are watered and constantly moist.
- ❏ Visually inspect grow lights and replace as necessary.

1.3.3. Bed Temperatures & DO

- ❏ Record temperature of bed #3 in the data log.
- ❏ Record DO Level of bed #3 in the data log.

2. Weekly

2.1. Greenhouse

2.1.1. Clean Swamp Cooler Pads

- ❑ Remove pads, rinse with water, remove debris, return to cooler.

2.1.2. Oil Roof Vents & fans

- ❑ Apply oil to each vent hinge and connection.
- ❑ Visually ensure proper operation on all vents & fans.

2.1.3. Maintenance and Repairs

- ❑ Review the Maintenance/Repair Required log.

2.1.4. Create a Supply Order

- ❑ Review inventory and make a supply order.

2.2. Fish Tanks

2.2.1. Water Quality (pH, NH3, NO2, NO3)

- ❑ Perform water tests on all measurements.
- ❑ Verify that all tested values are within normal limits (See Section A1). If not, follow recommended procedures in the additives protocol in Section A4.

2.2.2. Additives (Salt, Nutrients, etc.)

- ❑ Follow Additive Protocol in Appendix

2.2.3. Inspect Air Stones and Matala Filters

- ❑ Inspect all air stones in the fish tanks. Ensure the hose connections are secure and air is bubbling from the stone.
- ❑ Scrub the stones clean of build up as needed.
- ❑ Inspect the Matala filters for build-up and debris.
- ❑ Remove the Matala filter and clean with a hose as needed.

2.3. Grow Beds

2.3.1. Water Quality (pH, NH3, NO2, NO3)

- ❑ Perform water test on all measurements

Note: If the results are outside optimal ranges, make slow incremental changes to temperature and pH over several days. DO can be remedied immediately by checking / cleaning the aeration system or supplementing aeration. Low NO3 levels may indicate a need for more fish in the system or poor bacterial growth in the biofilters.

- ❏ As testing kits are available, test for P, Ca, K, Mg and Fe in Bed #3. Add nutrients according to the test results. (See Section A1)

2.3.2. Integrated Pest Management (IPM) & Foliar Spray (BW)

- ❏ Spray all plants according to the spray protocol, but only in the evening as the day cools (See Section A4).

2.4. Planting and Harvest

2.4.1. Seeding, Germination Techniques

- ❏ Prepare planting material
- ❏ Loosely pack material into planting cups or pods
- ❏ Plant seed according to supplier's recommendations
- ❏ Cover freshly planted seeds for three days to increase humidity and warm
- ❏ Uncover and ensure soil is kept moist until ready to transplant

2.4.2. Transplanting

- ❏ After two weeks, transplant the seedling from germination trays into your high density planting area.
- ❏ Once the plant has been in high density for an additional two weeks, carefully move the plant and it's fresh root system from high density to low density rafts
- ❏ Rinse high density rafts with water prior to reusing

2.4.3. Harvest

- ❏ Once the plants are mature, remove the low density raft from the system being careful to not dip plants into water, drip water from roots onto other plants, or snap the raft in half due to the weight.
- ❏ Place the raft on a table and either clip the product from the root or remove the entire cup and root as one unit.
- ❏ Remove dead leaves, wrap roots around base if keeping, and ensure the product is dry from excess moisture.
- ❏ Once the raft is harvested, rinse with clean water prior to reusing

2.4.4. Packaging, storage and shipping

- ❏ Place harvested plants into a proper food safe container or bag
- ❏ Ensure no extra moisture is present
- ❏ Label, store in cool place or refrigerator until ready to deliver
- ❏ Make delivery within the day of harvest to ensure freshness

3. Monthly

3.1. Greenhouse

3.1.1. Oil Swamp Cooler Fan bearings (BM)

- ❑ Oil swamp cooler fan bearings with zoom oil.

3.1.2. Check Propane Levels

- ❑ Replace and refill empty propane tanks.

3.2. Fish Tanks

3.2.1. Inspect Pumps

- ❑ Inspect pumps for proper flow.
- ❑ Clear pump inlets of any buildup or debris.

3.2.2. Inspect Tank Heaters

- ❑ Replace any faulty or failed tank heaters.
- ❑ Ensure the heater isn't charging the tank water.

3.2.3. Clean Fish Tanks

- ❑ Turn off the water inlet and cross-connections.
- ❑ Partially drain the tank water.
- ❑ Scrub build up on the inside of the tank, particularly around the waterline. DO NOT use chlorine bleach as chlorine will ruin the biofilter.

3.2.4. Clean Air Pump Filter

3.3. Grow Beds

3.3.1. Submit Sample for Water Quality Testing

- ❑ Ensure hands are clean of dirt and soap residue.
- ❑ Use a lab-supplied container to collect a sample in Bed 3
- ❑ Submit the sample to a WQ lab.
- ❑ Review the results and compare to the recommended parameters in Section A1.
- ❑ Make WQ adjustments as needed.

NOTE: Your produce will receive more hours of sunlight in the summer months than in winter months, resulting in faster growth rates in the summer, and slower growth rates in the winter. Consider shortening your growth cycle in the summer beginning around the Spring Equinox (March 20th) and extending your growth cycle beginning around the Autumn equinox (September 22nd). How long you extend or shorten your growth cycle will depend on several factors including the variety of produce and observed growth rate. If your produce begins to bolt (that is flower and produce seeds), it has been in your system for too long a period.

Appendices

A1: General System Parameters

Item	Range	Ideal
Water Temperature	17-34 ºC	21 ºC
Air Temperature	18-26 ºC	20 ºC
Fish Stocking (kg/sqm grow space)	1-3 kg	2.5 kg
Fish Stocking (liters/kg)	14-18 l	16.6 l
Dissolved Oxygen Levels	3-10ppm	7ppm++
Feeding Rates (% of body weight)	1-4%	2%
pH Levels	6.5-7.5ppm	7ppm
Ammonia Levels	0-1ppm	0ppm
Nitrite Levels	0-1ppm	0ppm
Nitrate Levels	40-160ppm	100ppm
Iron Levels	1-3ppm	2ppm
Phosphorus Levels	20-40ppm	40ppm
Greenhouse Air Dwell Time	3-10 min	5 min
Water Dwell Time - Fish Tanks	60-120 min	90 min
Water Dwell Time - Grow Beds	1-6 hrs	3 hrs
Water Dwell Time - Radial Filter	2-20 min	7 min

A2: Sample Weekly Schedule

	MON	TUE	WED	THU	FRI	SAT	SUN
9:00-9:15	Inspection						
9:15-10:00	Daily Tasks						
10:00-10:30	Tea Break						
10:30-11:00	Harvesting Planting Transplanting	Spray Protocol	Harvesting Planting Transplanting	Spray Protocol	Harvesting Planting Transplanting	Spray Protocol	
11:00-12:30		Water Test		Fish Care		Data Recording Adjust Protocols	
12:30-13:00		Team Meeting		Team Meeting			
13:00-14:00	Lunch						
14:00-14:30	Feed Fish						
14:30-15:30	Customer Delivery	Clean Filters	Customer Delivery	Maint.	Customer Delivery	Weekly Tasks	
15:30-16:00		Tea		Tea			
16:00-16:30		Clean Beds		Monthly Tasks			
16:30-16:45	Extra Tasks - i.e. Bug Bomb, Mist Floors						
16:45-17:00	Inspection						

A3: Plant and Fish Health

Plant Nutrient Deficiencies

Deficiency	Image	Description	Solution
Calcium (Ca)		Yellow / Brown spots surrounded by brown outlined edges, especially on the bottom most older leaves. Growth can be stunted	Check for excessively high ammonium, EC and humidity levels. Add calcium nitrate solution or a buffering agent like oyster shells.
Phosphorus (P)		Darkened or Blackened spots of dying tissue on the leaves. Leaves may deform or shrivel	Check that the pH is not too high (> 7) to prohibit P absorption. Add an inorganic phosphate solution
Magnesium (Mg)		Undefined yellowing / rusty spots between the leaf veins in older leaves.	Water temperature may be too cold (Below 20°C). Spray 2% Epsom salt solution topically once a week in the evening (to prevent tip burn) Add a magnesium sulphate solution or dilute system water if calcium carbonate levels are too high

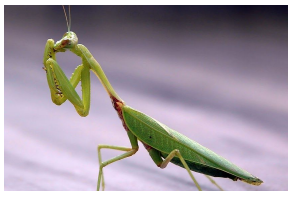
Iron (Fe)		Overall yellowing of the leaf from the base while veins remain green, especially in young leaves	pH may be too high or too much zinc / manganese in the water. It's also possible aeration is insufficient. Add iron chelates
Nitrogen (N)		Leaf stalks turn purple. Leaves will uniformly pale to yellow-brown before falling off.	Ensure a sufficient fish stocking density in the fish tanks and that fish are feeding well. Check that bacteria cultures are sufficiently converting ammonia to nitrite and nitrate. Presence of Chlorine in the water may be killing vital bacteria.
Potassium (K)		Most common deficiency in an aquaponics system. Edges of the leaves are dead or browned (tip burn) due to lack of evaporation	Add an inorganic potassium solution (potassium carbonate, potassium sulfate or potassium hydroxide) or a seaweed / kelp meal fertilizer to the grow bed water.

Common Pests and Interventions

Pest	Image	Description	Solution
Spider Mite		Small yellowish or white specks along the midrib and veins of the leaf. Some leave a silk webbing	Keep the GH temperature below 25°C and humidity above 60%. Spray with alcohol and soap or use beneficials.
Whitefly		Whitish as their name suggests, Whitefly leave behind a waxy powder. Damage and mold may be visible on the leaf where the whitefly feeds.	Whiteflies reside in dead leaves and debris. Be sure to clear the rafts of debris. Barriers, such a netting, and beneficials, specifically parasitic wasps (*Aphelinae*), can be effective.
Thrips		Small, long and flat, Thrips can vary between shades of yellow and grey. Toxins in thrip saliva can deform the shoot or flowers of infected plants, leaving behind almost transparent discoloration with black dots.	Thrips are strongly attracted to blue adhesive tape. Spray well with potassium soap or pyrethrum as thrips can find refuge under leaf veins.

Aphids		Often green but vary in color, aphids have bulbous abdomens no larger than 4mm. As they feed on the plant's sap, they often weaken and stunt plant growth. Their secretions also tend to mold in small black spots.	Beneficials, particularly green lacewings, are effective against aphids. Spray with Botanigard or a similar mix. Take care as many aphid sprays are harmful to fish health.
Mildew		A fungi that typically grows on the upper surface of the leaf, mildew will appear as a if the leaf were dusted with a grey powder.	Prevention is more effective than containment. Keep the growing area and utensils washed and clean. Remove any affected leaves,being sure to not transmit the fungus by contact, and wash your hands.
Botrytis Cinerea		A fungi that begins as bruise or soft dark spot, which in time, a layer of fuzzy grey mold will form over.	Remove the infected plant, and do not allow it to come in contact with another plant or transmit the mold on your hands. Nematodes and certain plant extracts (thyme, citrus seed, oregano, mint, pepper and garlic) can be effective.

Fungal Gnat		A small black fly about 3-4mm, fungal gnats are attracted to decomposing plant matter. Their clear, glossy larvae can be found in damp plant debris	Clean the rafts of plant debris. Yellow sticky traps at the base of the plants will attract adult gnats. Check that the GH temperature and humidity are not too high. Nematodes can also be effectively used against fungal gnats.

Beneficial	Image	Description	Eats
Lady Bugs		Ladybugs, or Ladybirds (*Coleoptera*) are carnivorous beetles with a red body and black spots.	Aphids Green & black fly Spider mites Whitefly Fleas Colorado Potato Beetle
Praying Mantis		Mantis' have elongated bodies some have wings, but all have forelegs that are greatly enlarged and adapted for catching and gripping prey	Caterpillars Moths Beetles Ghats Crickets
Lacewings		Lacewings (Neuroptera) are insects with long transparent wings	Aphids Whitefly Caterpillars

Fish Diseases

NOTE: Use caution if you are stocking your fish tank from local fish breeders or ponds, as diseases may be present in your fish or may be transferred by the use of contaminated nets, holding tanks or other equipment. Always check that your sources are clean and disease free. Once a disease is introduced into your aquaponic system, it is very difficult or impossible to remove without cleaning, sterilizing and restarting your system.

A single fish displaying signs of a disease does not indicate an outbreak; however, it is best to remove any fish displaying any these symptoms. Five (5) or more fish displaying symptoms may be considered an outbreak and indicate a need to clean and sterilize your system. Fish showing signs of weakness and loss of appetite without other symptoms may not be suffering from a disease, but a lack of oxygen in the fish tanks (especially if fish are seen gulping at the surface). First try increasing your aeration.

Use caution when treating diseases in your system. Certain chemicals and antibiotics that are effective in treating disease (such as copper sulfate) will also kill the beneficial bacteria in your biofilter. Your biofilter is the engine to your aquaponics system. Without it, your plants will not have sufficient nitrate to grow and ammonia will build to toxic levels in your fish tank.

Disease	Image	Description	Solution
Streptococcus & Aeromonas	 	'Strep' is the most common viral disease found among tilapia. Fish are lethargic, weak, have a loss of appetite, and may swim erratically. Red discoloration at the base of the fins and tail, hemorrhaging or protruding eyes, and abscesses on the jaw or the base of the pectoral fin and tail may be visible.	Reduce feeding. Strep and aeromonas may be present in the water, and feeding may facilitate their uptake. Reduce the stocking density and increase the DO to help reduce fish stress and slowly lower the water temperature. Higher water temperatures facilitate the growth of pathogens.

Trichodina		'Trich' is a parasite that infects the scales and gills of a fish. Fish may be seen swimming against the walls or floor of the tank trying to scrape off the parasite. Rapid breathing, weakness and uncoordinated swimming are also signs of Trich.	Remove any fish you suspect of being infected with Trich and exchange your water. Be sure to examine any fish before you introduce them into your system.
Columnaris		A bacterial disease, columnaris is usually associated with overstressed fish. Symptoms include weak and lethargic fish and loss of appetite. Raised white patches may appear on the skin and develop into yellow-brown lesions and ulcers. Lesions along the back create a tell-tale 'saddle' of discoloration. Fin rot is also associated with columnaris.	Columnaris is associated with stressed fish. Check the water quality, DO and stocking density to make sure they are within recommended guidelines. Replace water if needed. Ensure their diet is adequate and there are no sudden changes to their environment (temperature drops or changes in pH). Disinfect all equipment and salt your tanks at no more than 5-10 PPT.

A4: Protocols

Integrated Pest Management Protocol

1. **Set Limits for Action**
    a. When do you begin to respond to an issue?
    b. When do you stop responding to the issue?
2. **Monitoring Action**
    a. Daily pest scouting and identification
3. **Preventative Actions**
    a. Beneficial Insects
    b. Beneficial Plants
    c. Plant Spacing
    d. Window Coverings
4. **Responsive Actions**
    a. Spray Protocols
    b. Removal of Plants

Sample Spray Protocol							
		MON	**TUE**	**WED**	**THU**	**FRI**	**SAT**
A	**Pesticide + Foliar**	**Water**	Seaweed Neem	**WATER**			Botanigard Maxx
	Fungicide + Foliar	Revitalize (Blitz)			Cueva Fulvic Acid		
B		**MON**	**TUE**	**WED**	**THU**	**FRI**	**SAT**
	Pesticide + Foliar	**Water**	Seaweed Baking Soda Fulvic Acid	**WATER**			M-Pede
	Fungicide + Foliar	Revitalize (Blitz)			Cease Seaweed		c

AMENDMENT RECIPES			
Lightly wet but do not drench plants. Only mix what will be used in one day. Apply only in the evening once the temperature is cool			
TYPE	**IMPERIAL**	**METRIC**	**NOTES**
Neem Oil	0.75 oz neem + 2 tsp soap per gallon	6ml Neem + 3ml Soap/liter	
Seaweed	4.0 oz per 6 gal	5ml/liter	**You may Drench plants
Botanigard Maxx	1.0 oz Botanigard per gal	1ml/liter	0.75% Pyrethrins; 0.06% Beauveria bassiana Strain GHA
Baking Soda Mix	1.5 TBS Baking Soda + 1 TBS Vinegar + 1 TBS Olive Oil + 1 TBS soap (per gal)	6ml Baking Soda + 4ml Vinegar + 4ml olive oil + 4ml Soap (per liter)	
Cease	1.5 oz per 4 gallons.	3ml/liter	**This is harmful for fish. Be careful
Fulvic Acid	1.5 oz per 4 gallons	3ml/liter	
Revitalize	1 tsp/gal	1.5ml/liter	98.85 % Bacillus Amyloliquefaciens sstrain D747
Cueva	2.5 oz per 4 gallons.	5ml/liter	
M-Pede	5.0 oz per 4 gal	10ml/liter	49% Potassium Salts of fatty acids

Water Additive Protocol

1. **Check pH Level**
    a. The pH must be between 6.5-7.5 prior to moving forward
2. **Check Nutrient Levels as Possible**
    a. Using test kits, measure levels in grow bed water. Nitrate, Ammonia, Iron, EC.
3. **Monitor Plant Health**
    a. Much can be learned from visually looking at plants for nutrient deficiencies or toxicity.
4. **Create Additive Plan**
    a. Based on the knowledge gained from water tests and plant health, create a plan of what nutrients are needed.
    b. Sometimes, only foliar spray would be needed and no water additive is necessary.
    c. Another possibility is that nutrients are not the issue you need to fix. Perhaps the air temperature or humidity is inadequate.
5. **Calculate Mix Ratios**
    a. Based on your additive plan, calculate the mix recipe to add to the system
6. **Add Nutrient Solution to System**
    a. This is normally done at the beginning of system water, in the Sump Tank.
    b. Do not forget to record in your Water additive log.
7. **Check Water Quality Result**
    a. You must wait until the water has cycled through the system at least once prior to testing the results.
    b. Understanding what
8. **Adjust Recipe, Add, Check, Monitor**
    a. With the results in hand, you may now begin to understand what different nutrients will do to your system water. Adjust your mix recipe, add when necessary and check again.

EXAMPLE

ADJUST pH						
Type	**Level Before**	**Additive**		**Amount (liter or gram)**		**Level After**
ph Level	8	Nitric Acid		1		6.8
ADJUST NUTRIENTS						
Nitrate	50	Potassium Nitrate		550		120
Iron	1	Iron		50		1.5

PH ABSORPTION CHART

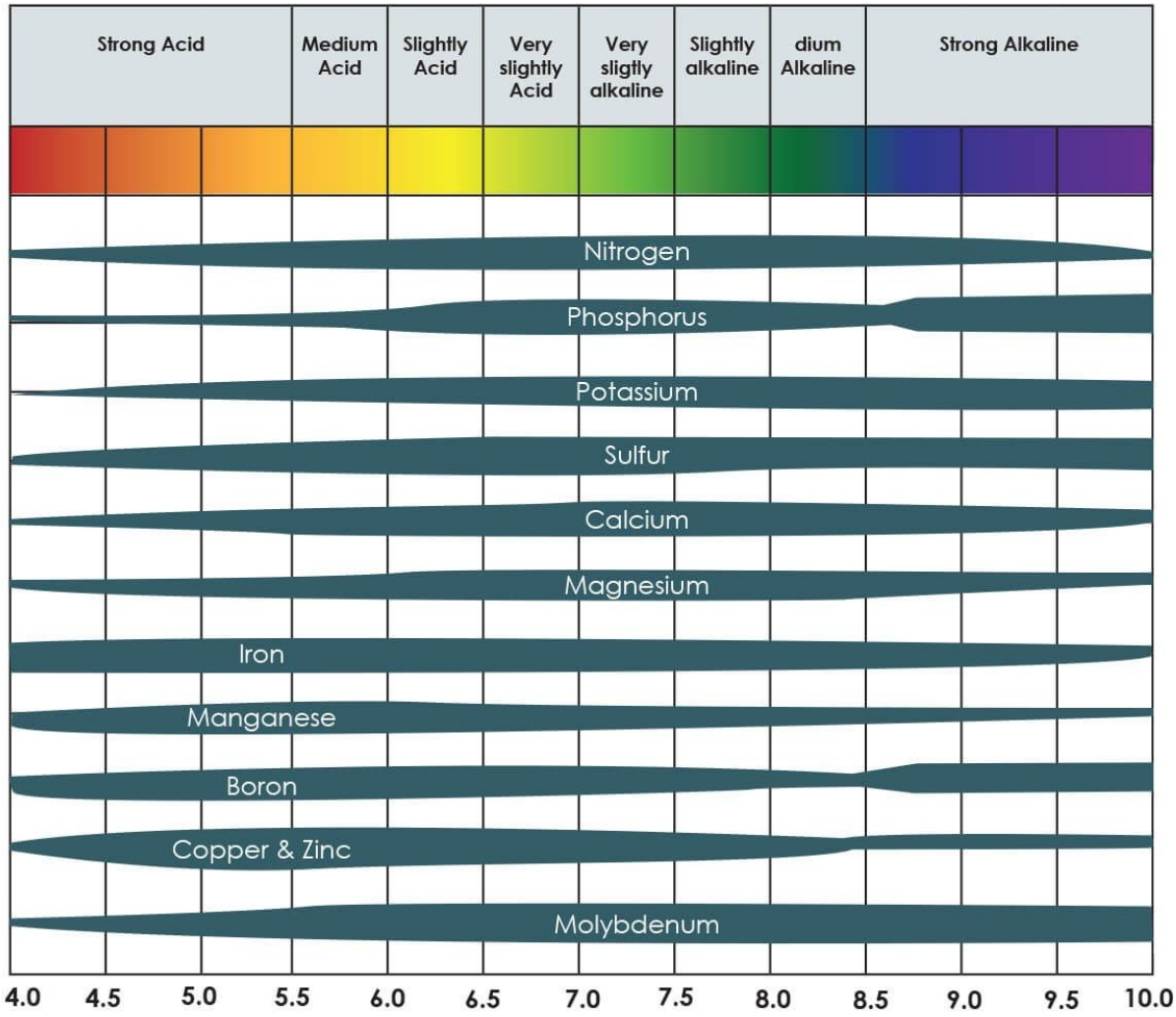


*Chart from Upstart University https://university.upstartfarmers.com/blog/overview-hydroponic-nutrient-management

A5: Data Logs

Additive & Spray Log

Date	Time	Type of additive or spray	Total Quantity applied (mg, l)	Place of Application			Initials
				All Beds	Into Sump	Other (Specify)	
Notes							

Fish Log

Date		Feed AM (g)	Feed MID (g)	Feed PM (g)	Deaths	Temp.	DO	Notes
Monday	Tank 1							
	Tank 2							
	Tank 3							
Tuesday	Tank 1							
	Tank 2							
	Tank 3							
Wednesday	Tank 1							
	Tank 2							
	Tank 3							
Thursday	Tank 1							
	Tank 2							
	Tank 3							
Friday	Tank 1							
	Tank 2							
	Tank 3							
Saturday	Tank 1							
	Tank 2							
	Tank 3							
Sunday	Tank 1							
	Tank 2							
	Tank 3							
pH :		NH4 :			NO2 :			NO3 :

Environment Log

Date	Time	Temperature	Humidity	Notes	Initials

Water Chemistry Log

Date	Location	pH	NH4	NO2	NO3	Temp

Planting Log

Date	Seed Type	Count	Germinated %

Repair & Maintenance Log

Date	Issue Found/Notes Problems/Location	Date Completed