GESTION DURABLE DE L'AQUACULTURE

TECHNICAL GUIDE

Aquaponics Kit

PROTEGE
PROJET RÉGIONAL OCÉANIEN DES TERRITOIRES POUR LA GESTION DURABLE DES ÉCOSYSTÈMES

Financé par l'Union européenne

Pacific Community
Communauté du Pacifique

DIRECTION DES RESSOURCES MARINES
PU FA'AHOTU MOANA

PROTEGE
PROJET RÉGIONAL OCÉANIEN DES TERRITOIRES POUR LA GESTION DURABLE DES ÉCOSYSTÈMES

The Pacific Territories Regional Project for Sustainable Ecosystem Management (PROTEGE) aims at promoting sustainable and resilient economic development in the face of climate change in the Pacific Overseas Countries and Territories associated to the European Union (OCTs), drawing on biodiversity and renewable natural resources. PROTEGE's «Coastal fisheries and aquaculture» theme works towards a more sustainable and resilient management to address climate change impacts on reef and lagoon resources and aquaculture.

This publication was made possible with the expertise of the French Polynesian company Ava Design, the teams of the Directorate of Marine Resources (DRM) and the financial support of the European Union (11th European regional Development Fund) under the PROTEGE project.

protege.spc.int/fr

Watch the project videos here :

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Table of Contents

Why choose an Aquaponics kit ?
Introduction to the project

Part 1

Assembly Instructions

1. Identifying the main components **P16**
2. Getting your fish tank ready **P17**
3. Getting your filtering system ready **P18**
4. Getting your sump tank and culture bed ready **P21**
5. Getting your gravel grow-bed ready **P24**
6. Final steps regarding the fish tank **P26**
7. Submersible pump and distribution system **P27**
8. Module layout **P29**
9. Final steps regarding the raft-based culture bed **P31**

Part 2

Kit operation : Instructions for use

1. Chanos chanos (Pati) **P36**
2. Eel (Puhi pape) **P40**
3. Feeding fish **P41**
4. Checking pH **P42**
5. Detecting harmful nitrogen levels **P43**
6. Checking water flow rate **P45**
7. Planting **P46**
8. Maintain and promote harvesting : identify deficiencies **P49**
9. Protecting the crops **P51**
10. Summary of suggested products **P52**

Part 3

Activity Forecasts

1. Spatial organization and schedule **P50**
2. Guiding principles **P52**
3. Which vegetables to plant and why? **P53**
4. Proposed cultivation plan **P54**
5. Proposed Chanos Chanos harvest plan **P56**
6. Production costs **P57**

Why chose an aquaponics kit?

To grow fresh vegetables in remote atolls

In the Tuamotu archipelago of French Polynesia, the production of fresh vegetables is a recurring problem. Due to a lack of arable land and a shortage of freshwater, only few lands are suitable for cultivation on the atolls. The Tupuna used to grow taro in pits with considerable effort. Today, a large proportion of vegetables are imported by boat or by plane from Tahiti, making them expensive to buy.

To address this issue, and more specifically the freshwater issue, the Directorate of Marine Resources (DRM), in partnership with the PROTEGE project, wanted to develop an aquaponics kit to ensure a regular, local supply of vegetables at family level, which is essential to the inhabitants of the Tuamotu and more widely of French Polynesia.

To develop a low-cost aquaponics kit based on Chanos Chanos breeding

Until now, aquaponics in French Polynesia has been based on Tilapia or Sunfish, exogenous species that may prove harmful to the islands' environment and aquatic resources, Tilapia being an invasive species listed by the IUCN (International Union for Conservation of Nature). The DRM therefore recommends the use of milkfish, «Pati» or Chanos Chanos, a species that can be easily caught, and live and grow in freshwater to a commercial size.

In this context, DRM requested from AVA Design, a local aquaponics expert, the designing of an aquaponics kit adapted to Tuamotu's environment. In August 2022, 2 kits have been delivered to the DRM's aquaculture technical center (CTA), and a dozen of DAG and DRM staff have been trained to kit's setup and routine operation. Since then, the kits at the CTA have been running smoothly and producing a substantial quantity of vegetables. However, this first version of the kit had its limitations when it came to deployment in the Tuamotu (see table on next page). In October 2023, DRM co-developed an improved 2.0 kit better suited to this type of deployment.

The purpose of this guide is to present this tool: by discovering the principle of aquaponics and following step-by-step the setup of the kit developed, readers may quickly become familiar with it.

First version of the aquaponics kit: Main observations

This version of the aquaponics kit has proved its worth in Tahiti. However, with the perspective of this kit being used by families and in isolated atolls, the following elements should be considered:

Performance

Vegetable production exceeds the average monthly volume forecast.

Harvesting can be done on a daily basis, as long as a suitable cultivation plan is followed.

Chanos Chanos adapts well to the aquaponics environment.

Over 103 days, maintenance was carried out at the rate of 2h45 per week for 2 kits: feed preparation, weighing of harvests and usual measurements.

No breakdowns noted on operating equipment (lift pump and aerator).

1 Kg of vegetables produced would use between 22 and 33 liters of water. To produce 18 Kg of vegetables, we did not exceed 600 liters to compensate for evaporation.

On kit 1, with 6.5 Kg of feed distributed, we harvested 37.8 Kg of vegetables despite the absence of a cultivation plan and irregular management of seedlings.

Limitations

A continuous source of electrical power is required.

A certain quantity of consumables is recommended :
- Fish food.
- Iron chelates.
- Essential oils to treat plagues and diseases

Some equipment has to be imported such as pumps (lifting and air) and XPS rafts.

Potential solutions

Relatively low-power photovoltaic system.

Suggestions for consumables :
- Fish food: grow black soldier fly larvae, grow duckweed (Lemna Minor).
- Use earthworm tea, a built-in mineralization tank with the option of mineralizing potting soil from time to time.
- Plant aromatics and repellent plants (marigold, sage, etc.) to combat possible pests' attacks.

An alternative to XPS or extruded polystyrene panels is to use the kratky method, with panels laid on the rims; the bottom of the pots touches the aquaponic solution.

Would it be possible to do without the water pump ?
- Combined with the Kratky method, water distribution and flow can be designed to promote natural oxygenation by encouraging circulation, eddies and air currents (Venturi).

Second version of the aquaponics kit: More autonomous and adapted

The second version of the aquaponics kit is designed to be more autonomous and continues to address food challenges in respect of the difficulty to supply vegetables in atolls.

Design features :

- The kit has been conceptualized to operate with even less electrical energy to be powered by a small domestic photovoltaic station. Everything is operated using a single aquarium or pond pump. There is no aerator.
- Apart from the cost of the photovoltaic station, which varies per region, the kit is designed to be inexpensive.
- It remains scalable and can be duplicated, modified, or expanded using reclaimed materials by substitution or addition.
- Most of the materials used are accessible and rot-proof with a lifespan of over 10 years.
- Its use and maintenance are meant to be intuitive and simple.

Structure

1 **Solar Panel :** 200 watts.
Further details on the solar system components can be found on page 12.

2 **Fish tank :** 1,000 liters.

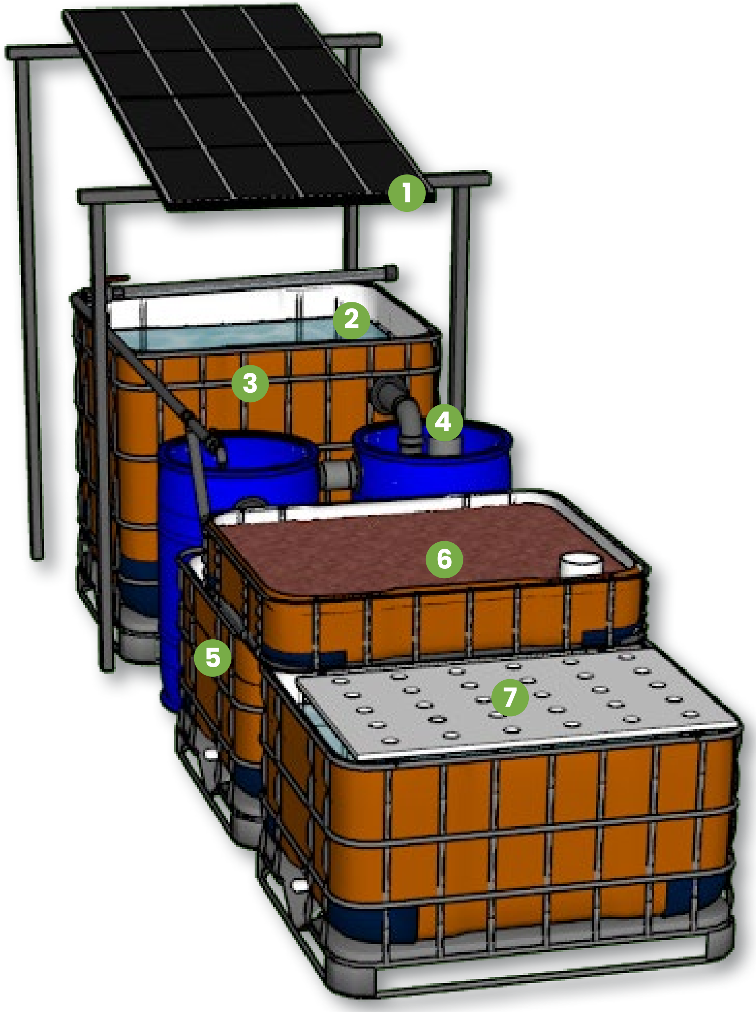
3 **Mecanical filter** 200 liters : This drum contains filtering elements, Japanese matting, shade cloth, fibers, etc.

4 200 liters **Vortex clarifier :** The water from the fish tank creates a slight vortex that carries the suspended solids to the bottom

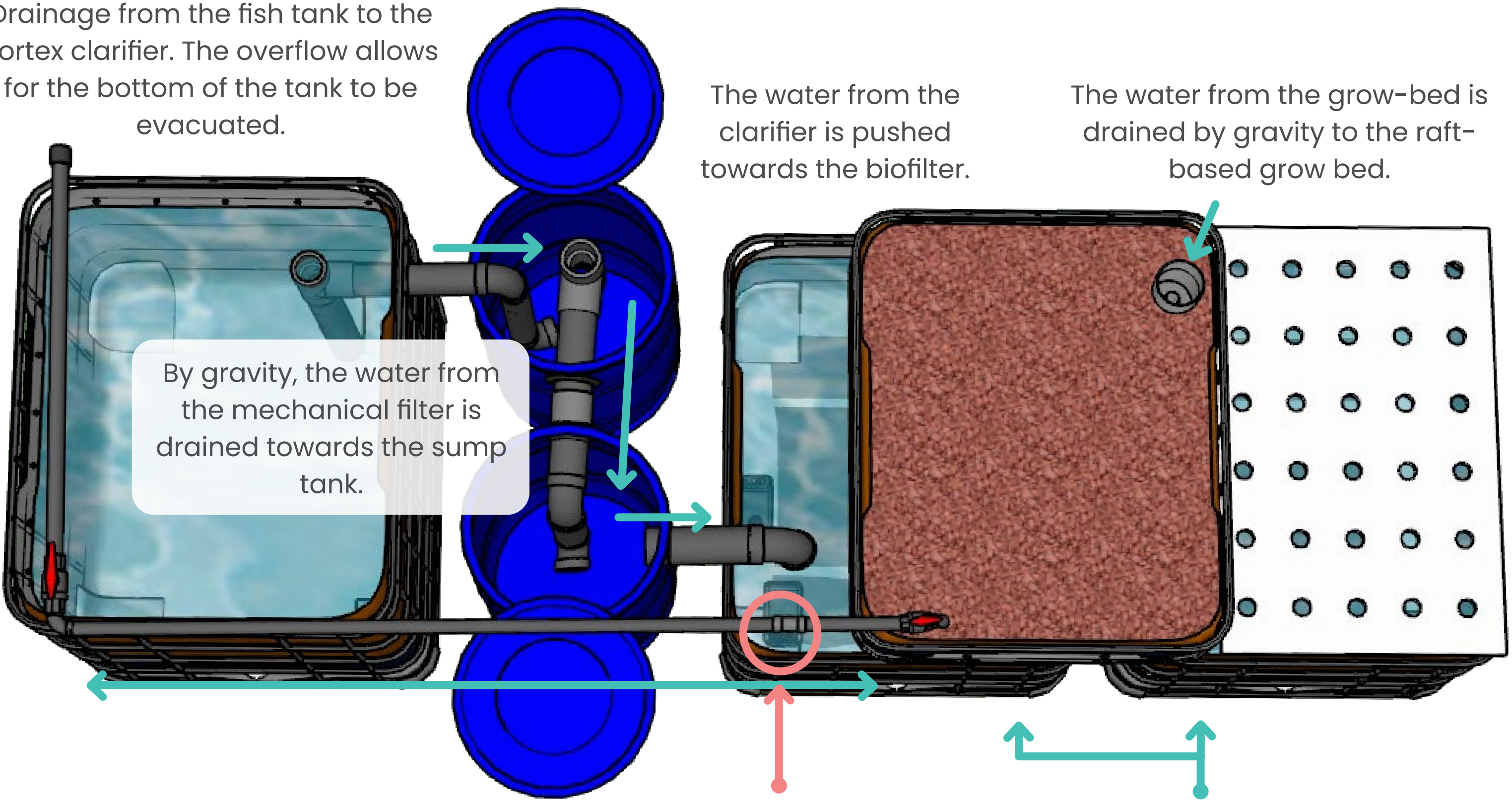
5 **Independent 500 liters sump tank :**
1 submersible pump

6 **Media bed** (contains inert growing media such as volcanic gravels, no coral) 250 liters : This tank actively participates in collecting solids and helps develop the beneficial microorganisms.

7 **Laid out PVC grow tray. The water level is adjusted in order to barely touch the bottom of the 30 net pots.**
The tank volume is about 500 liters.



Fluid dynamics



The Photovoltaic System

Here are some recommendations regarding the photovoltaic unit that works with our 40-watt submersible pump. We strongly encourage you to contact a professional for a suitable and safe installation.

DO NOT FORGET TO PROTECT COMPONENTS THAT ARE NOT WEATHER-RESISTANT.

1 Solar Panels

Opt for a 200W monocrystalline solar panel to ensure efficiency even on less sunny days. A panel of this capacity will provide a comfortable leeway.

2 Charge Controller

(or Charge Regulator):

If you choose a 12V system: A 20A MPPT (Maximum Power Point Tracking) regulator. MPPT regulators are more efficient than PWM (Pulse Width Modulation) regulators and will provide better performance.

3 Batteries

For a 12V system: Choose two 100Ah batteries (or one 200Ah battery) in 12V, preferably AGM or Gel type, suitable for solar installations and for deep cyclic use.

4 Inverter

A pure sine wave inverter (for better current quality) of 300W to ensure some margin for potential pump start-up peaks. Make sure the output is really 220V AC.

If you use a 12V DC pump, no inverter is necessary. Simply connect the pump to the battery via the charge controller.

5 Protection and Wiring

Fuses or circuit breakers suitable to protect each component. Cables of appropriate cross-section to minimize voltage loss. For example, for connections between the solar panel and the regulator, 4mm² or 6mm² cables would be appropriate.

For connections between the battery and the inverter, 10mm² or 16mm² cables may be required, depending on the distance.

6 Structures and Accessories

Supports for fixing the solar panels, ideally tiltable to follow the angle of the sun depending on the seasons.

MC4 connectors to connect the solar panels to the regulator.

A junction box or distribution box if you have several panels.

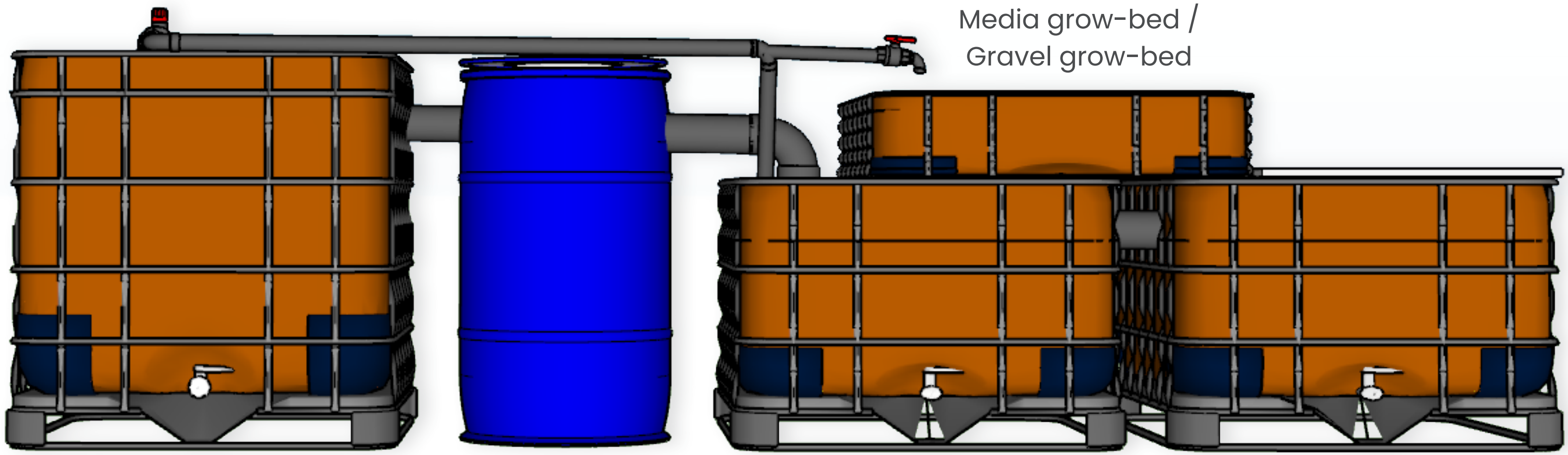
7 Maintenance and Monitoring

A battery monitor or a display for the charge controller can be useful to monitor the condition and the state of charge of your batteries.

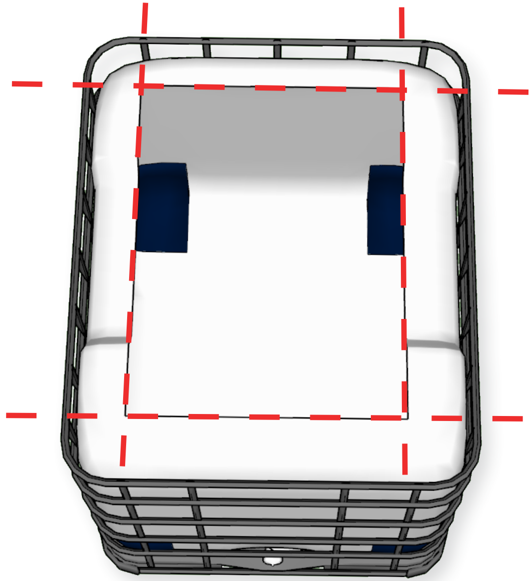
Assembly Instructions

Part 1

1. Identifying the main components



2. Getting the fish tank ready



1

Unscrew the 2 metal bars holding the top of the IBC tank.

2

Draw a frame on the top of the tank and cut it out using a jigsaw.

3

Remove the IBC tank from its cage and paint the exterior to make the tank opaque.

3. Getting the filtration drums ready

3 x Uniseal bulkhead fittings U150
or 1 1/2» for 50 mm PVC

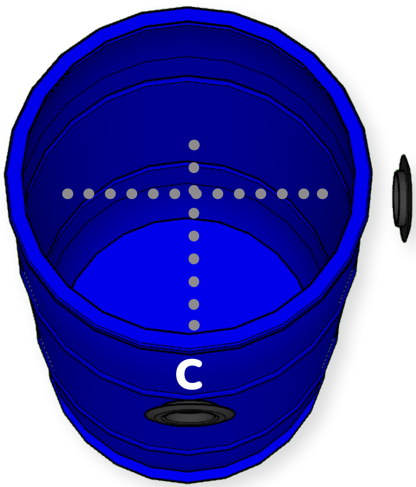
64 mm hole
saw

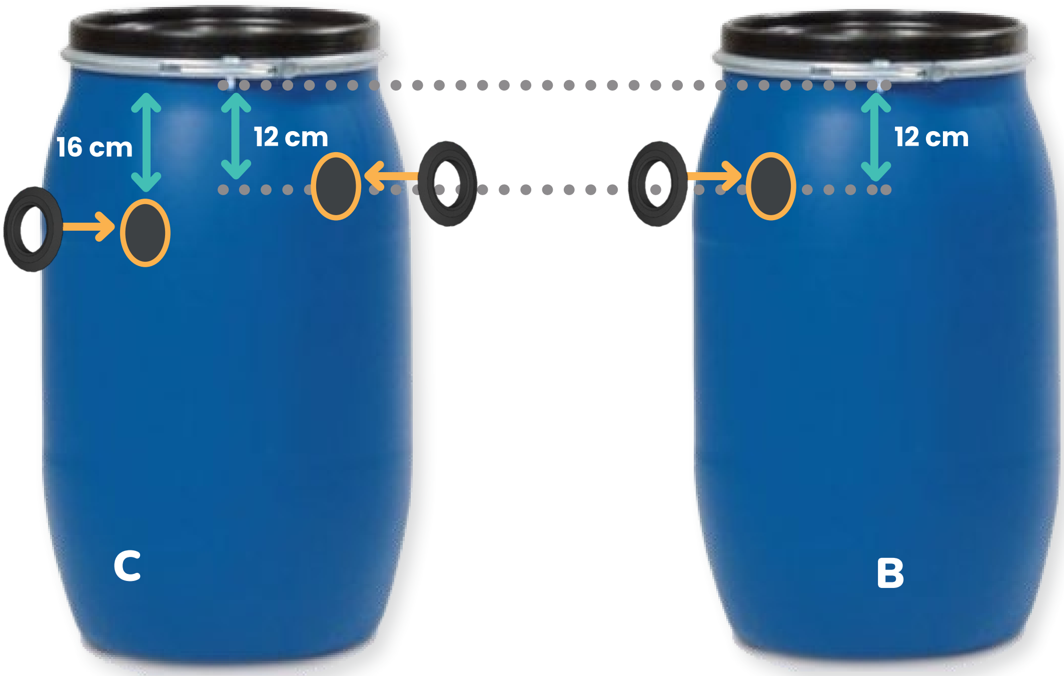
1

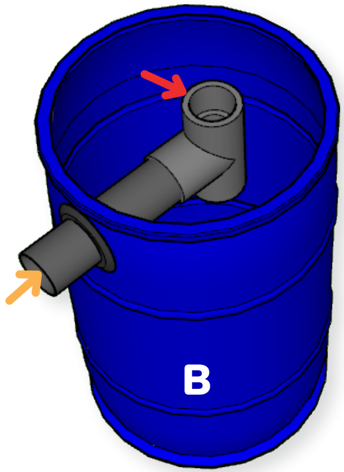
Drill 2 opposite holes, 12 cm from the edge on drums B and C.

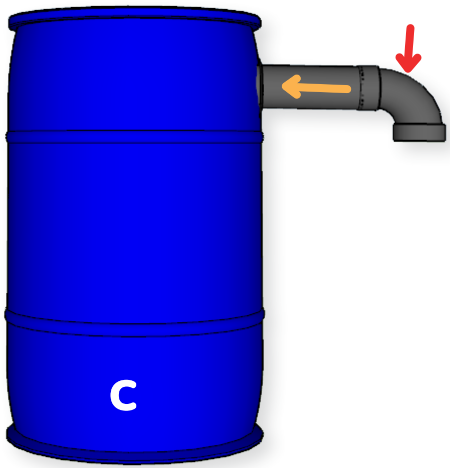
2

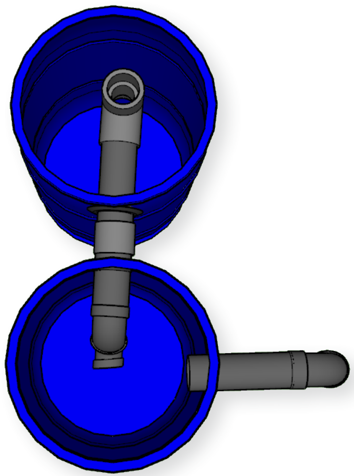
Drill a second hole on drum C, 16 cm from the edge.











3

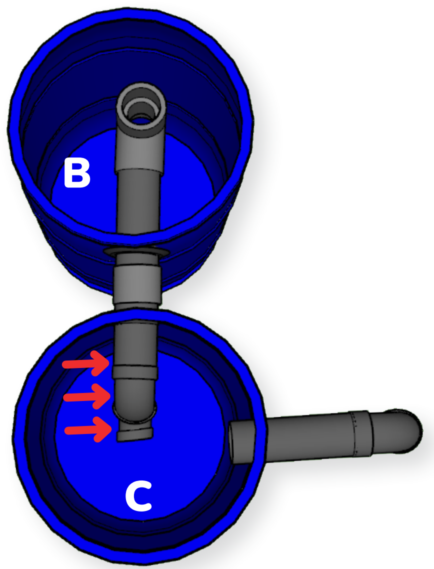
Fit a section of 50 mm PVC into drum B. Let it protrude 10 to 15 cm. Fit a 50 mm T on the inner end. There is no need to glue it.

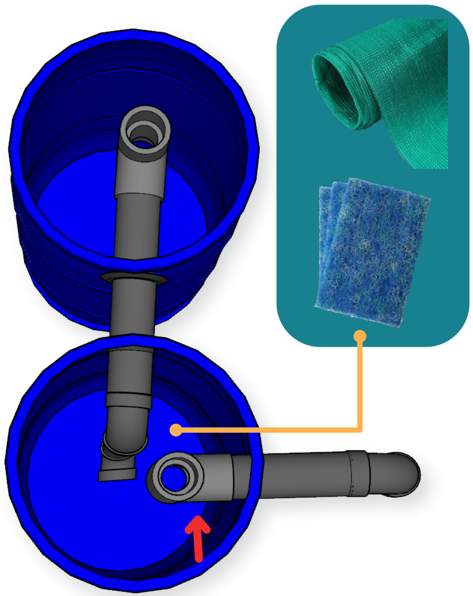
4

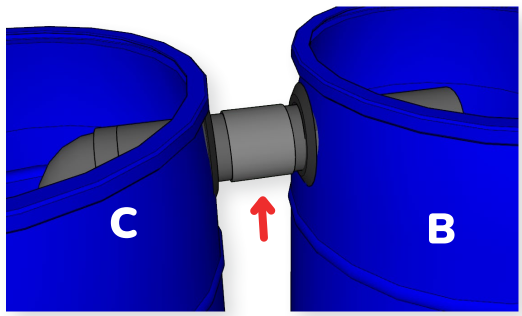
Fit a section of 50 mm PVC into drum C on the side that exits towards the sump tank. Add an elbow to the end.

5

Fit a section of 50 mm PVC into drum C on the side communicating with drum B.







6

Fit an elbow and then a section of PVC approximately 45 cm long, followed by a second elbow oriented as shown in the drawing above.

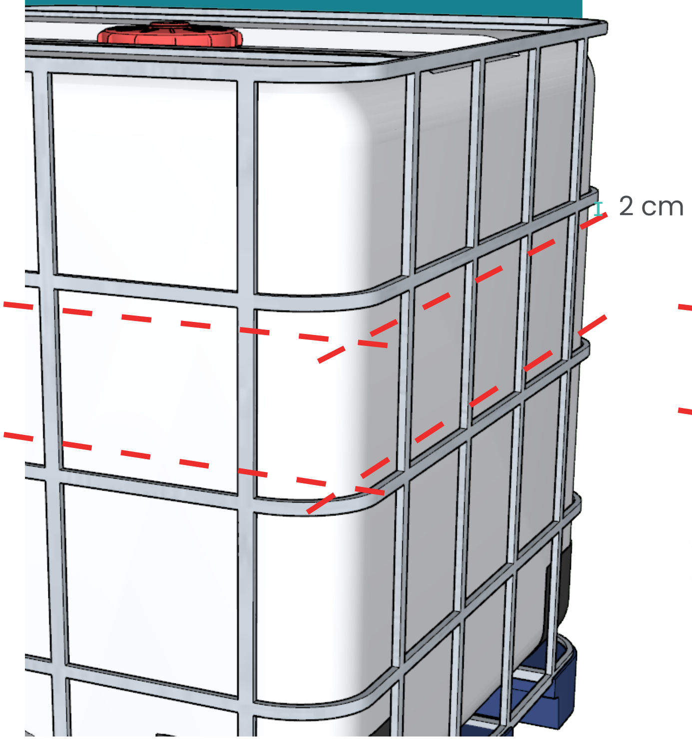
7

Fit a 50 mm diameter T at the exit of drum C. Insert filtering material. You can use nylon shade cloth.

8

Join the two devices using a female coupling with stop for 50 mm diameter PVC.

Make the markings on both IBC tanks D and E.

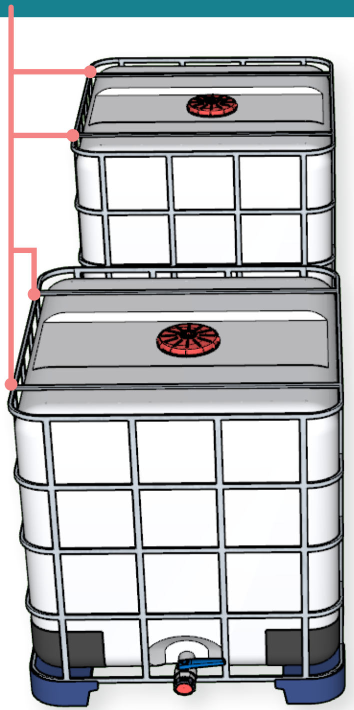


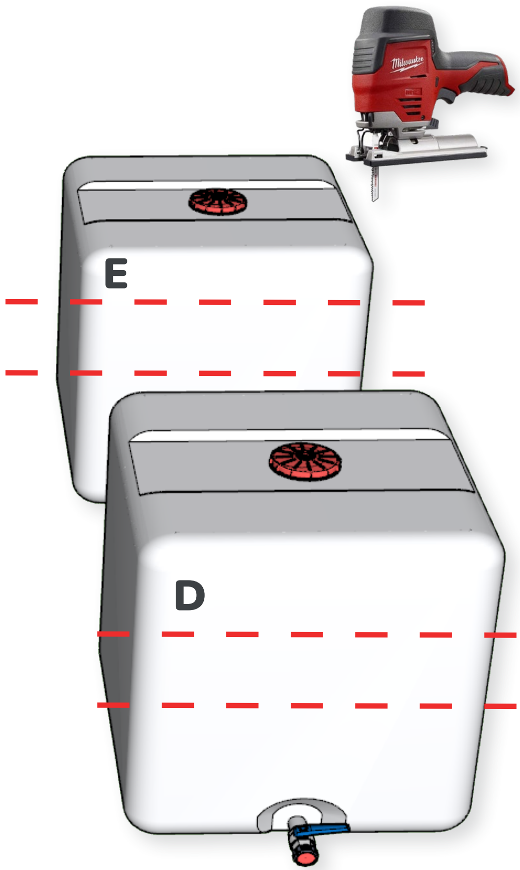
1

Use the cage to mark the cutting line on the tank. The upper line should be marked 2 cm below the cage bar. The lower line can be drawn along the cage bar as shown in the drawing.

2

Unscrew the bars that hold the tanks in their cage. Remove the tanks to proceed with the cutting.





3

Cut the tanks following the previously traced lines.

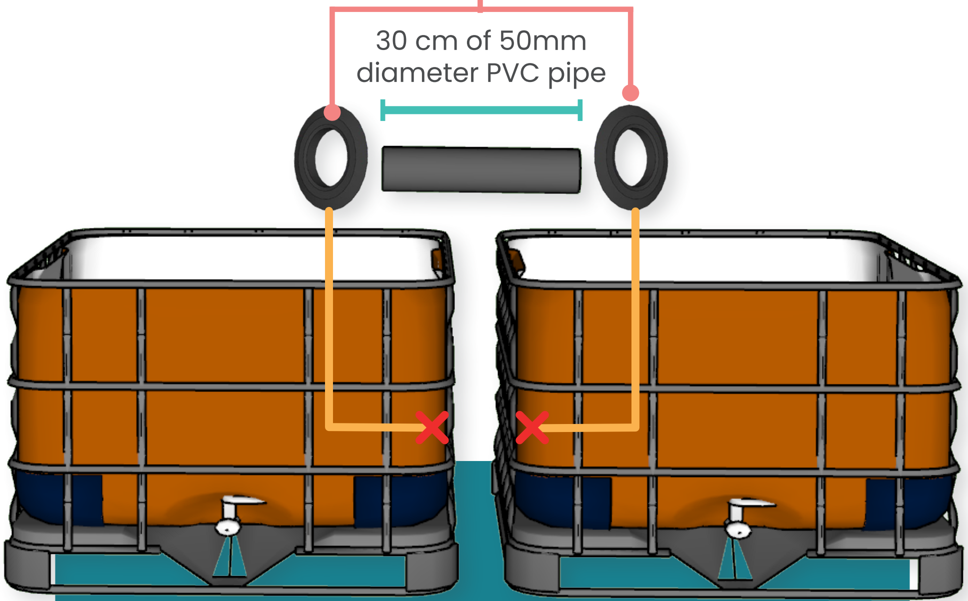
4

Deburr the edges using sandpaper or a sharp blade like a utility knife.

5

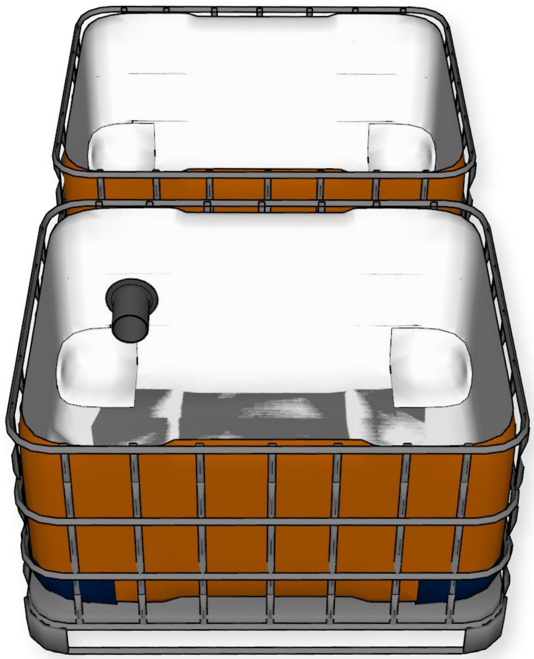
Paint the outside of the tanks after deburring and cleaning them.

Place the 2 uniseals well aligned and oriented in the same direction to facilitate the pipe insertion.



6

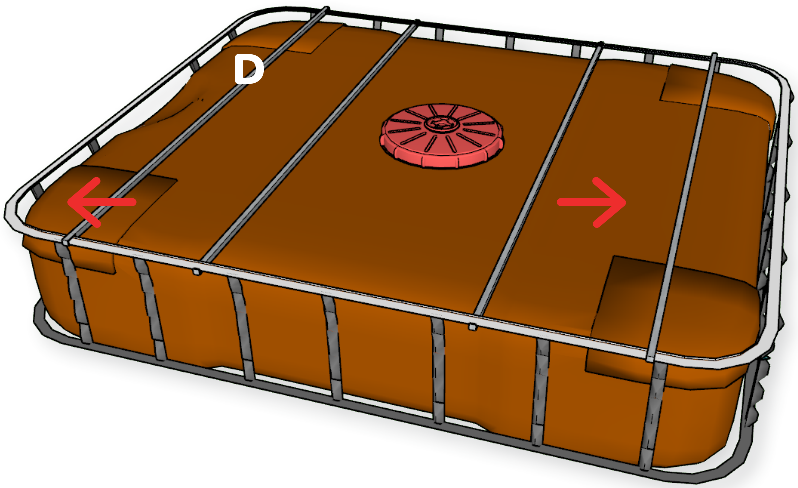
Drill 2 aligned holes using the drill and the 64 mm hole saw. It is recommended to aim at mid-height of the tank while positioning yourself well at the center of one of the cage's squares.



7

Fit the 50mm PVC section by passing it through both tanks.

5. Getting your media grow-bed ready

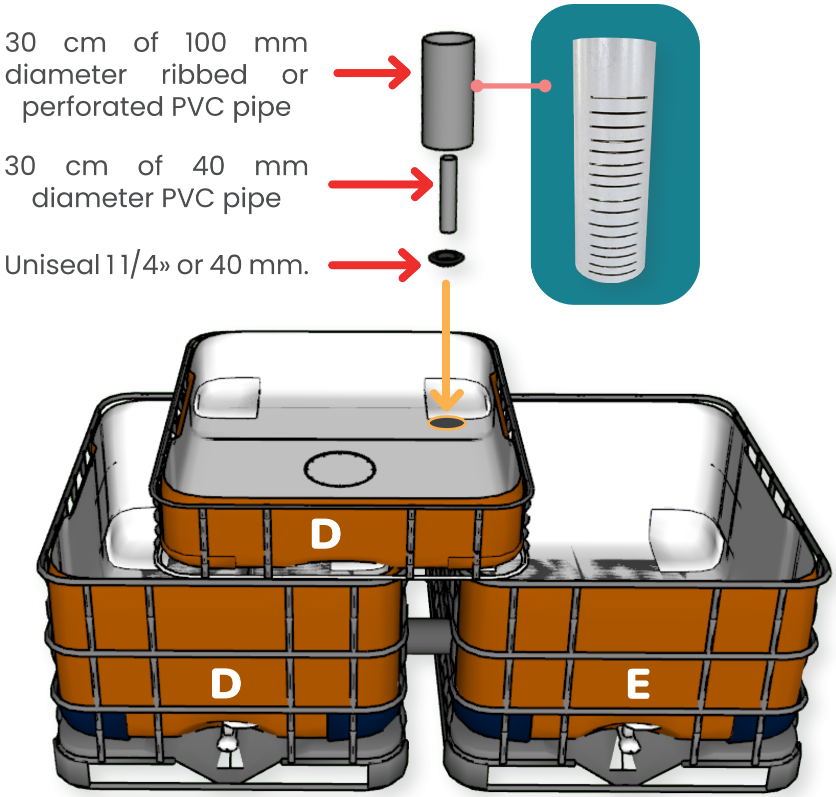


Put the tank D top part back into its cage. Ensure to replace the bars as they originally were.

Retrieve 2 bars from tank A and insert them as shown in the drawing above. The 2 added bars will be stopped by the last vertical bars of the cage.

1

Position the grow-bed straddling tanks D and E in such a way that it extends over E to accommodate the drainage.

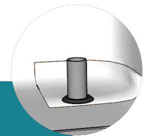


2

Drill using a 51 mm hole saw and then place the 1 1/4» or 40 mm uniseal.

3

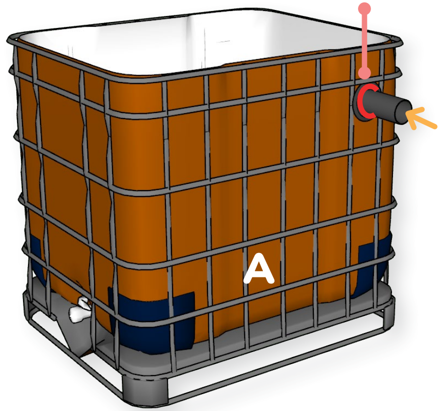
Insert a section of 40 mm PVC pipe, leaving 10 cm protruding inside the grow-bed.

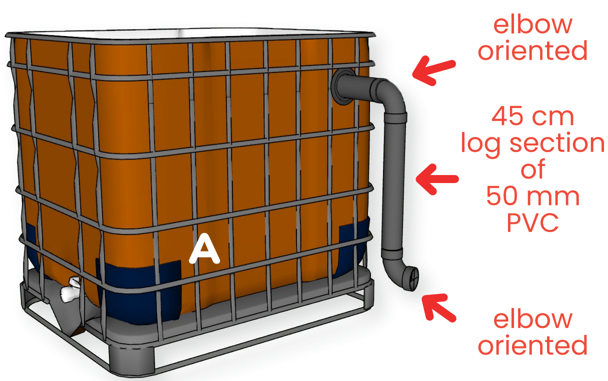


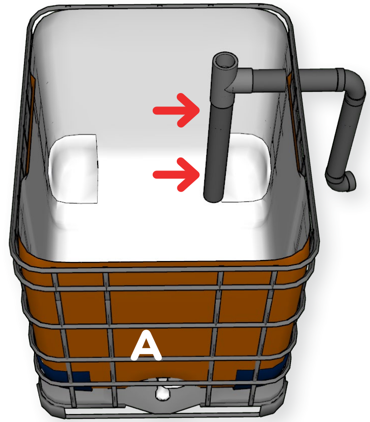
4

Position the 100 mm ribbed or perforated pipe with several holes. This device will prevent the gravel from blocking the drainage and will enable the solution to pass through.

6. Final steps regarding the fish tank







1

Drill a hole using a 64 mm hole saw, position a 1 1/4» or 50 mm uniseal, and insert a 30 cm section of 50 mm PVC. Let it protrude outward by 10 to 15 cm.

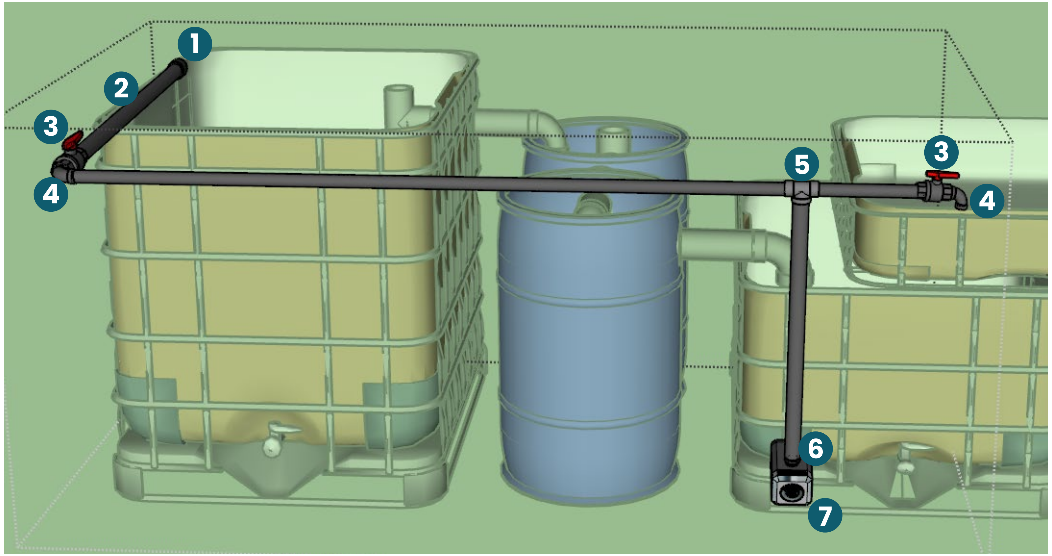
2

Place an elbow oriented downwards. Insert a 45 cm long section of 50 mm PVC. Position an elbow oriented outward.

3

Place a T facing downwards inside the tank. Insert a 50 mm section of PVC running all the way to the bottom of the tank.

7. Submersible pump and distribution system



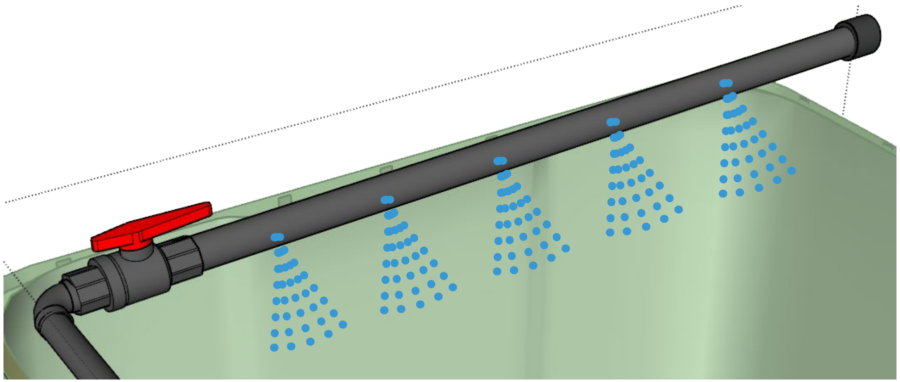
1. Endcap that fits the pipe
2. Diffuser
3. Ball valve
4. Elbow
5. T connector
6. Fitting provided with the pump
7. Sumersible pump

For this kit, we have installed a variable-flow pump with a maximum of 40 watts. At 0 cm elevation, it has a flow rate of 6 m^3/hour. For this kit, we recommend not to exceed 40 watts, nor to go below 3 m^3/hour.

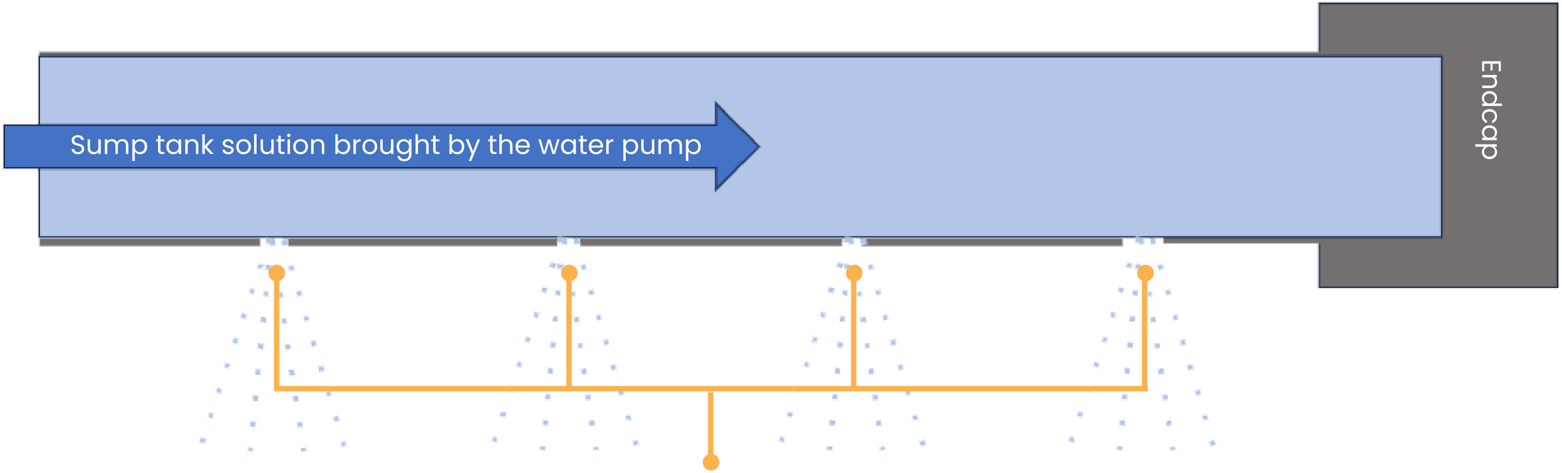
The principle is to set up the distribution from the sump tank, which is divided using a T-connector to simultaneously supply the gravel grow-bed and the fish tank.

The flow rates of the fish tank and the grow-bed are controlled by a valve.

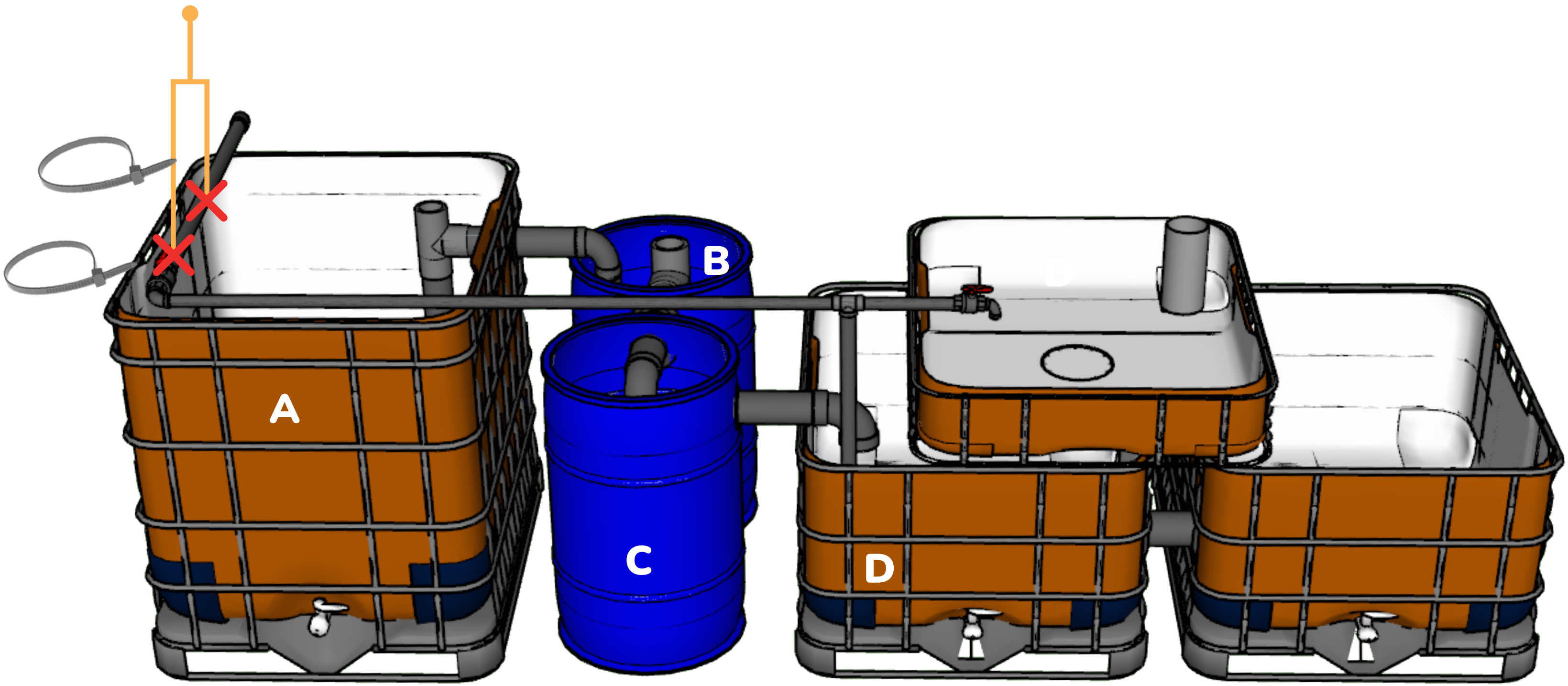
The distribution within the fish tank will be through a homemade diffuser which will foster eddies and aeration of the solution.



- The diffuser's principle is to maintain a small amount of pressure to expel the solution through holes drilled with a drill.
- 8 holes of 4 to 6 mm (depending on the drill bits available) are scattered along its length. Make sure you don't drill too close to the edges of the tank, to avoid possible water loss through run-off or the likes.

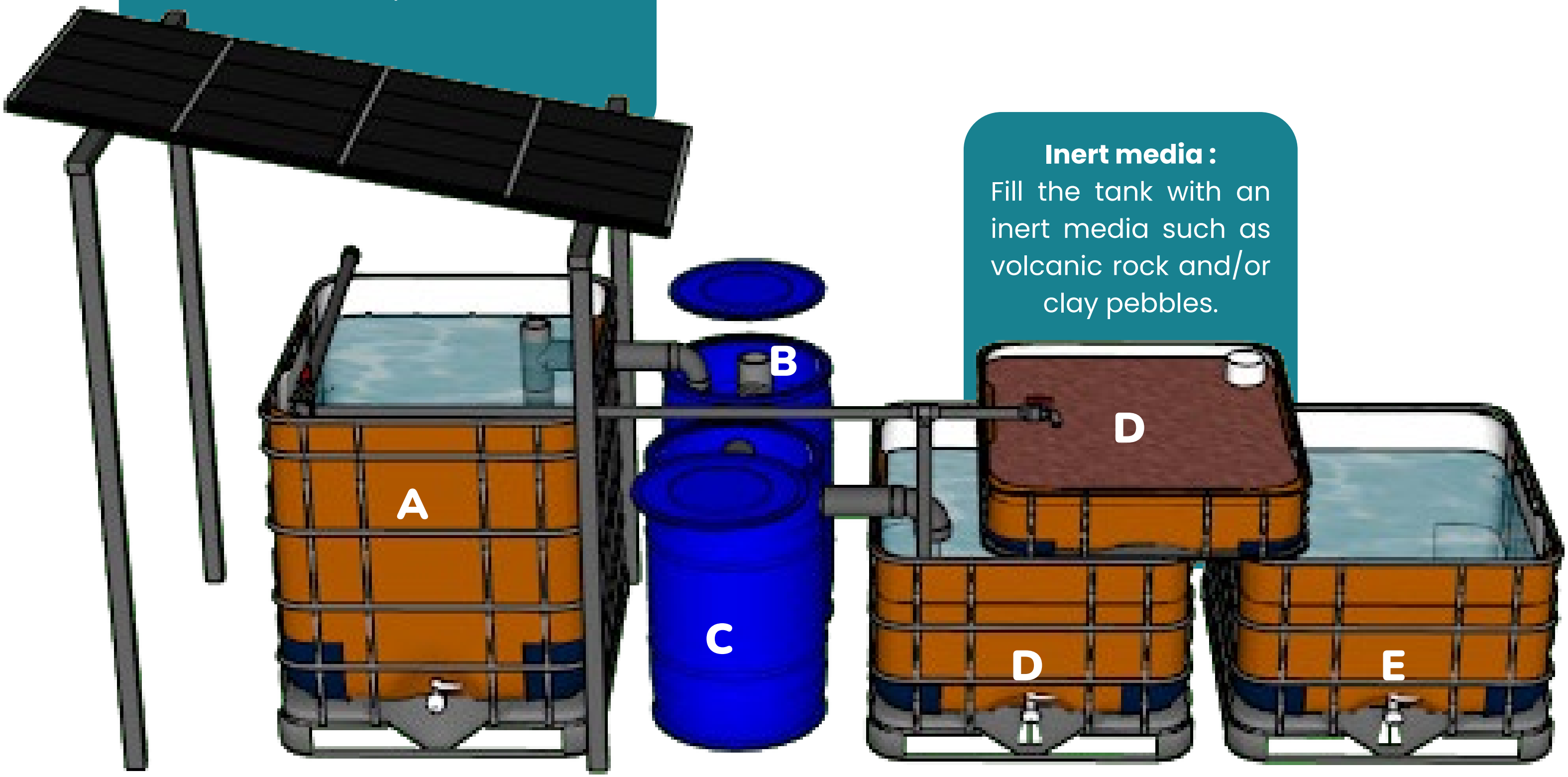


Use plastic cable ties to secure the diffuser and the valve of the pond.



A 175-watt **photovoltaic panel** connected to a smart battery with 720 w/h capacity. The battery is stored in a waterproof enclosure.

Inert media :
Fill the tank with an inert media such as volcanic rock and/or clay pebbles.



9. Final steps regarding the raft-based culture bed : the grow tray

Laid-out grow tray :
a 16 mm PVC plate was selected.

1

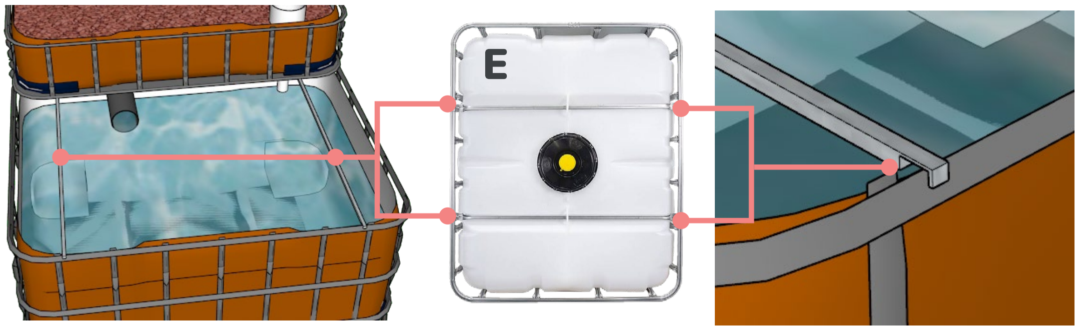
The dimensions of the tray allow it to fit inside the tank. Measure and cut with a jigsaw.

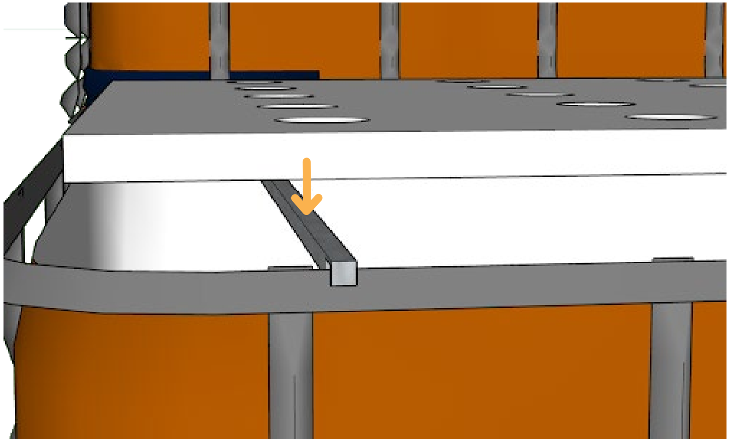
2

Drill 30 holes with a 50 mm hole saw, which is the diameter of the net pots. Choose the diameter according to the net pots you have. Note: For the tray, use an inert, untreated material and make holes corresponding to the diameter of the pots you have.

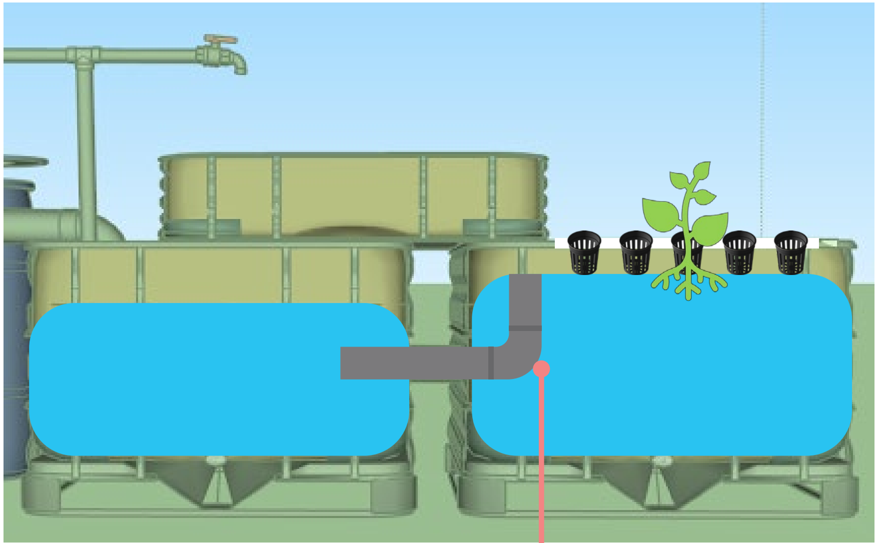
3

Retrieve the 2 bars from tank E and place them as shown in the drawings below.





By doing so, the grow tray may sit on the support bars that were previously added.



4

Add a section of PVC to act as an «overflow». The water level should touch the bottom of the pots. This technique allows the plants to «breathe» and feed from the solution at the same time.

Kit Operation : Instructions For Use

Part 2

1. Chanos Chanos (Milkfish, Pati)

The aquaponics kit can be operated by incorporating Chanos Chanos (Milkfish, Pati) into the system.

This fish is interesting because :
It is disease-resistant.
It even adapts to poorly oxygenated waters.
It adapts to a wide range of salinities.
It also adapts to a wide pH range.
It is caught using a locally-developed eco-responsible method.
It is omnivorous.
It accepts high-density storage, without being cannibalistic.
Its flesh is very good to eat if fed a healthy and appropriate feed.

From lagunas to aquaponics kits:
how to catch it, transport it and incorporate it into the kit?

Principle :
Depending on its metabolism/physiology, Pati fish is able to live in «fresh water», with a more or less rapid transition from seawater.

Where to find it ?
On the atolls, it can easily be caught in the «kopara ponds». Kopara are microbial mats made up of bacteria, cyanobacteria and microalgae that accumulate in atoll ponds.

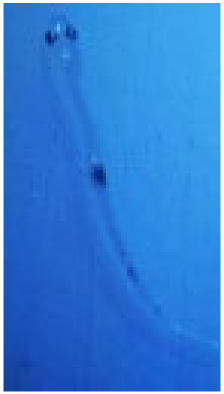
Post-larvae :
The recruitment period for this species in the Tuamotus is well known. It runs from October to February. For their development, post-larvae will colonize fresh and brackish waters, preferably on moonless nights. They swim upstream in the current that flows out of the freshwater laguna channel. Once captured, larvae can be transferred directly to freshwater tanks.

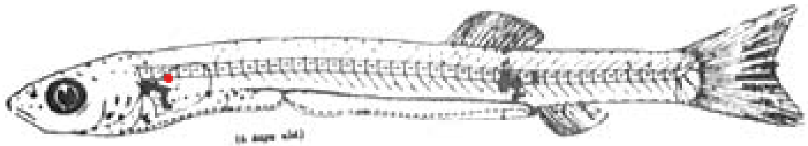
Juveniles :
These can be caught in the lagoon at a weight of around 50 to 200 g. For these fish, a process of adaptation to freshwater needs to be put in place. Such process takes about 2 weeks.

How to collect Pati (Chanos Chanos) post-larvae ?

This small system collected an average of 10,000 post-larvae per site at Arutua and Aratika over 20 nights.

This small system collected an average of 10,000 post-larvae per site at Arutua and Aratika over 20 nights.





The transparent stage IV post-larvae, 11 to 14 mm long and 16 to 18 days old, are very vigorous. They will always swim up the tidal currents of fresh and brackish water (outflow towards the lagoon). Transparent post-larvae prefer to enter on moonless nights (new moon, cloud cover).

How to catch Pati juveniles (>10 g) and adapt them to freshwater fishing?

Catching fish:

1. Catch fish alive without damaging them (with a net)
2. Place them in a tank with a salinity of 10°/°° (see box) and an aerator
3. Add fresh water every week to lower salinity by 5°/°°
4. Check that animals are feeding well at a salinity of 0°/°°
5. Transfer them to the rearing tank

Once in the tank, observe your fish :

Note that it takes 1 to 2 weeks for Pati juveniles to adapt to 100% freshwater. Check that they are behaving normally: swimming, feeding, staying active.

If any unusual behavior is noticed:

- Abnormal swimming (unbalanced, sideways, upside down, or as if partially paralyzed ...),
- Remain motionless at the bottom,
- No longer eating,
- All come to the surface to gulp air.

→ Proceed to the usual measurements (pH, nitrites, water flow) described in the rest of the technical guide.

WARNING :
Pati tend to jump when frightened: a shade or anti-jump net should be placed over the fish rearing tank to prevent fish from jumping out of the tank.

Ideal environment for growing Chanos Chanos in aquaponics :

- A **biomass of 5 Kg** of fish (do not exceed 20 Kg).
- Temperature 26°C to 37°C. **Ideal temperature is 29°C**.
- **Dissolved oxygen between 4 to7 ppm*** would be ideal, but it adapts to 2 ppm as well.
- **pH 6.5 + is ideal**
- **Free ammonia: ideal is 0ppm** (1ppm will slow its growth and 2 ppm may prove fatal).
- **Nitrites : 0.3 ppm or less** (they can survive higher concentrations, but after-effects are to be expected (affected immune system, illness, etc.).
- **Nitrates: resistant to 200 to 300 ppm**.

*1 ppm = 1 part per 1 million or 1 mg/liter

NB

Definition of salinity :
salt content, expressed in °/°°.
While seawater's salinity is around 37°/°°, freshwater has a salinity around 0°/°°.

Volume of fresh water to be added, to reach target salinity of a mixture :
(Initial salinity - targeted salinity) / seawater salinity x total volume

Example :
to make a total volume of 200 L with 10 °/°°

Volume of fresh water required =
(35 - 10)/35 x 200 = 142 L

Seawater volume =
Total volume - freshwater volume =
200 - 142 = 58 L

2. Eels (Puhi pape)

The aquaponics kit may also be operated by incorporating eels into the system. In fact, the kit works with several freshwater fish species found in French Polynesia. For this reason, the choice of species is based on access to the resource. The high islands of Polynesia have access to a larger resource and can therefore use fish such as tilapia, eel, guppy, carp or any other freshwater fish sold in the aquarium trade. As for the atolls, freshwater fish resources are very limited. For these particular islands, we decided to work with eels (puhi pape) and Chanos Chanos (pati).

This fish is interesting because :

It is disease-resistant.
It even grows in poorly oxygenated waters.
It adapts to a wide range of salinities.
It also adapts to a wide pH range.
It is easy to catch.
It is omnivorous.
It does not cannibalize.

From laguna to aquaponics kit: how to catch it, transport it and incorporate it into the kit ?

Principle :
Eel larvae have a pelagic phase in the ocean. The larvae are pushed by ocean currents to find themselves close to the coast, where they seek out freshwater. These larvae, called elvers, are attracted to freshwater and spend the rest of their lives in rivers, until they reproduce at sea. As the atolls have no rivers, some larvae will adapt to Kopara ponds, which salinities are between 5 and 20°/°°.

Fishing :
Eels in kopara ponds are often undernourished and react very quickly to food stimulation. This makes them easy to catch with a net or hook.

Transfer to aquaponics kit :
Once caught, eels can be transferred directly to freshwater. After a 2- to 3-day observation phase, the eels may be transferred to the aquaponics kit.

Breeding :
It is imperative to cover the eel rearing tank tightly with a shade or net. Indeed, eels are constantly trying to escape and can get out of the tank and/or up the pipes if they are not protected.

3. Feeding fish

With this family kit, it is possible to accommodate a maximum of 20 Kg of fish. Initial trials were conducted with 35 individuals weighing 100 g each or 18 individuals weighing 200 g each, and based on early observations, it is recommended to feed them about **1% of the total body weight of fish in the tank**. For the kit proper operations and maintenance, there is no need to go beyond 5 Kg of fish biomass.

Maintain this dosage and adjust according to the mass of fish if there are slightly more or less than 3.5 Kg or 35 fish of 100 g each. You can give 35 g of feed for a 3.5 Kg biomass.

- Use a feed rich in protein, **at least 30%**.
- Feed in several batches: for example, half early in the morning and the rest in the late afternoon.

If additional culture units are added, the fish biomass will need to be increased. Make sure not to grow over 20 Kg of fish in this kit's fish tank.

Note : the use of a feeding mat allows distributing the feed dose over 12 or 24 hours. If chosen, such option will require an additional purchase.

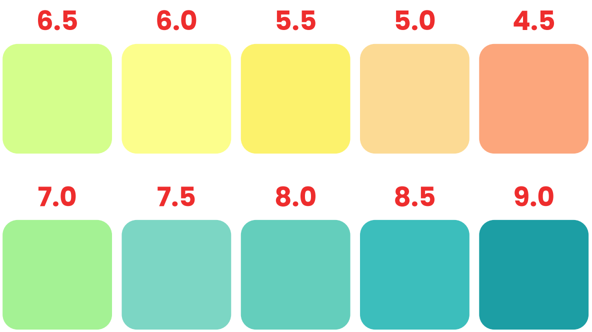
Use an electronic food scale to determine the amount of feed. Always use the same container so you can estimate your portions without weighing them later exceeding by a few grams is not a problem.

4. Checking pH

pH :

Over time, pH will tend to decrease, which is normal! This is due to waste transforming into fertilizer. That is the reason why taking pH measurement on a regular basis is necessary: performing this every 2 or 3 days is recommended.

- Therefore, check the pH and add approximately 130 g* of oyster shell powder or other limestone components should the value reaches 6.0 or 6.1.
- Ideal pH is between 6.4 and 6.9. If higher values like 7 or even 8.5 are observed, do not worry. Continue to feed the fish and operate the kit. The pH will gradually decrease.



There are liquid colorimetric tests available to measure the pH. Make sure to read instructions carefully.

The ideal tool is the electronic pH meter. Once turned on, you just need to dip the probe into the sump tank or the fish tank for at least 30 seconds or until the numbers on the screen stabilize.

* Half a glass is approximately 130 grams or a cup of oyster shell powder.

Ammonia levels :

- With the SERA colorimetric test, for instance, take 10ml of water from the fish tank in the provided test tube after rinsing it several times using the tank water.
- Add 6 drops from bottle 1, then 6 drops from bottle 2, and mix by gently shaking the solution.
- Finally, add 6 drops from bottle 3, close with the provided cap; then shake vigorously and let stand for 1 to 3 minutes to interpret the results.
- Compare the color of the liquid with the colors on the provided color scale. The reading should be between 0 and 0.5 max.

- If the ammonia concentration is higher than 0.5 mg/l, the fish may die:

→ Check if a dead or decomposing fish is hidden in the pond and remove it.

→ Perhaps the amount of food given is too much. Stop feeding for 2 days and adjust the quantity according to the instructions on page 16.

→ If the situation persists, stop feeding until the ammonia levels return below 0.5 mg/l, change half of the tank water if possible.

→ Increase the water flow by adding a pump if possible.

→ Add bubblers in the biofilter and in the fish tank if possible.

a	0 mg/l	0.5 mg/l	1 mg/l	5 mg/l	10 mg/l
b	0 mg/l	0.5 mg/l	1 mg/l	2 mg/l	5 mg/l

Nitrites levels :

- With the SERA colorimetric test, for instance, take 5ml of water from your fish tank in the provided test tube after rinsing it several times using the tank water.
- Add 5 drops from bottle 1 and then mix by gently shaking the solution.
- Add 5 drops of solution 2, close with the provided cap; then shake vigorously and let stand for 1 to 3 minutes to interpret the results.
- Ensure that the nitrite concentration does not exceed 0.5 mg/l. Compare the color of the liquid with the colors on the provided color scale. The reading should be between 0 and 0.5 max.
- The presence of nitrites might be due to insufficient water circulation through the tank. Use the “4. Checking the water flow” procedure.

0.0 mg/l   0.5 mg/l   1.0 mg/l   2.0 mg/l   5.0 mg/l

Rate to ne not exceed

6. Checking water flow rate

The water flow in the fish tank :

- It is advisable to aim for a flow that allows for one turnover per hour, i.e., 1,000 liters/hour for our 2.0 Family Kit.
- The system can function correctly with a minimum flow of 500 liters/hour or one turnover in 2 hours.
- For the kit's flow to be optimal, it is recommended to procure a tank pump that delivers a flow of 2,500 to 3,500 liters/hour.

Time how long it takes to fill 1 liter of water.
The ideal time to fill 1 liter for the kit's tank is a minimum of 4 seconds to a maximum of 8 seconds.

If the time exceeds 8 seconds, it means that the water in the tank is not being renewed quickly enough :

→ Remove the pump and check that nothing is clogging the suction.

→ Disconnect the hose connected to the pump inside the tank and ensure nothing is hindering the water flow.

→ Disconnect the valve at the tank and check on both sides if anything is blocking the water entry.

→ If the pump is running slow, perhaps it needs to be replaced.

Seedlings

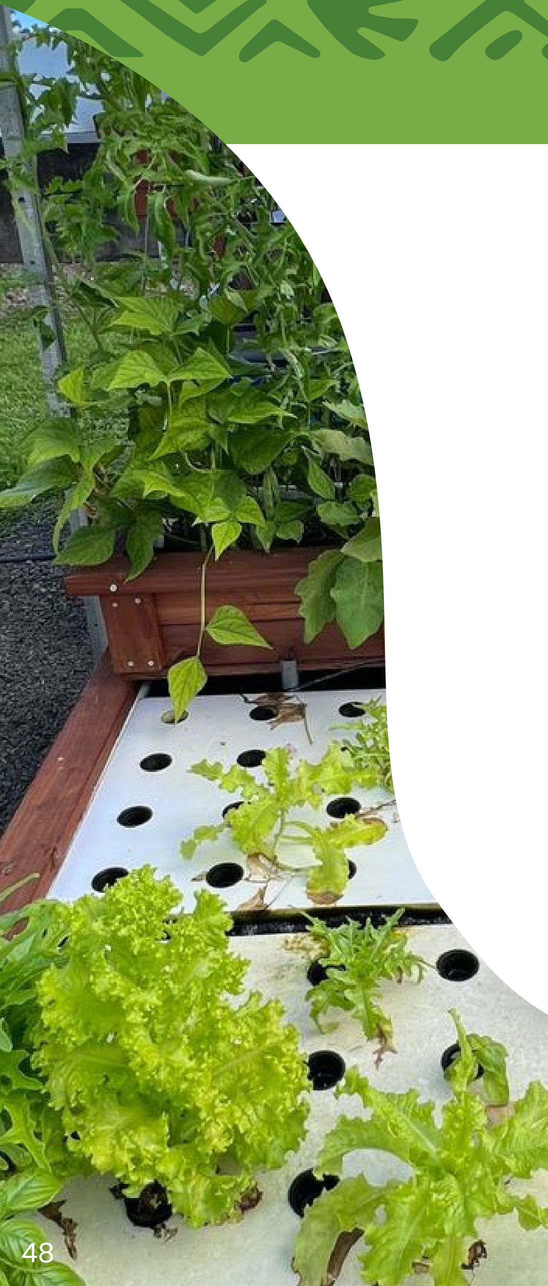
1. Use a seedling tray or egg boxes with crushed coconut coir or rock wool as a substrate.
2. Monthten the substrate and plant the seed. Place it in a dark area.
3. Depending on the plants chosen, germination will take 2 to 8 days (note that peppers and parsley may take 2 to 3 weeks to germinate).
4. When stems appear, it’s time to place them in daylight.
5. Preferably water the substrate from underneath every 2 days starting from the moment they are exposed to light.

Note : seeds may also be planted under a shelter (in case of rain) that gets light, let them germinate and then grow until they are ready to be transplanted into the aquaponics system.

Transplanting seedlings
into the media bed

- In general, after 2 weeks, the seedlings are ready to be transplanted into the kit. There are two scenarios: planting in the gravel or on the rafts.
- In the gravel bed, rinse the roots a bit to remove most of the crushed coconut coir without damaging the roots.
- Clear the gravel until you see the water.
- Gently place your roots **ON** the water. There is no need to submerge them up to their stems in water.
- Gently close by replacing the gravel around the plant without crushing it.

Note : Seeds could be sown on the montht part before covering with gravel and letting them germinate.



Transplanting onto the grow tray

The second scenario involves transplantation onto the tray using the pots provided with the kit.

- Carefully remove the seedlings from their seedling tray
- Place them in the pots
- Place the pots in the holes prepared for them
- Ensure that the plant is not drowning (no growth, black spots, and visible wet rot) and that the stem is not submerged. Should this be the case, remove the plant, add some gravel in the pot to elevate it, and place the plant on top before replacing it on the rafts.

Note : In principle, if the assembly instructions have been followed, the overflow and the water level just touch the bottom of the pots, preventing the plants from drowning.

8. Maintain and promote harvesting : Identifying deficiencies

Nitrogen deficiency

Lettuce plant

Calcium deficiency

Plant de laitue

Magnesium deficiency

Bell pepper plant

Iron deficiency

Tomato plant

Calcium deficiency

Tomato plant

Potassium deficiency

Tomato plant

Iron Deficiency

Add 6% EDDHA Iron chelates
- 6 doses of 10 g and observe.
The leaves should return to green within 3 to 4 days.

Nitrate (Nitrogen) Deficiency

Feed more, or add more fish.

Potassium Deficiency

If the pH has been corrected upwards with potassium bicarbonate, there should not be a deficiency. Otherwise, add 200 g of Langbeinite or equivalent.

Magnesium Deficiency

Add Epsom salt 1 to 2 teaspoons.


Calcium Deficiency

Be careful: if there is too much potassium in the system, your plants might show a calcium deficiency.

If pH is low (6.1 or below), add oyster shell or coral powder.

Remember that correcting deficiencies takes time, often 1 to 4 weeks, so add small quantities and wait to see the results. Adding too much of any of these substances can sometimes cause more problems than the deficiency itself !

Another reason for calcium deficiency may come from:
Too high levels of humidity combined with high temperature or poor aeration.
Add shade cloth and aerate more.

9. Protecting the crops

To combat pests both in a preventative and curative way, use natural essential oils that are also non-toxic to your aquaponics ecosystem.

Note : Consider planting fragrant aromatic plants to help manage pests.

Insecticide

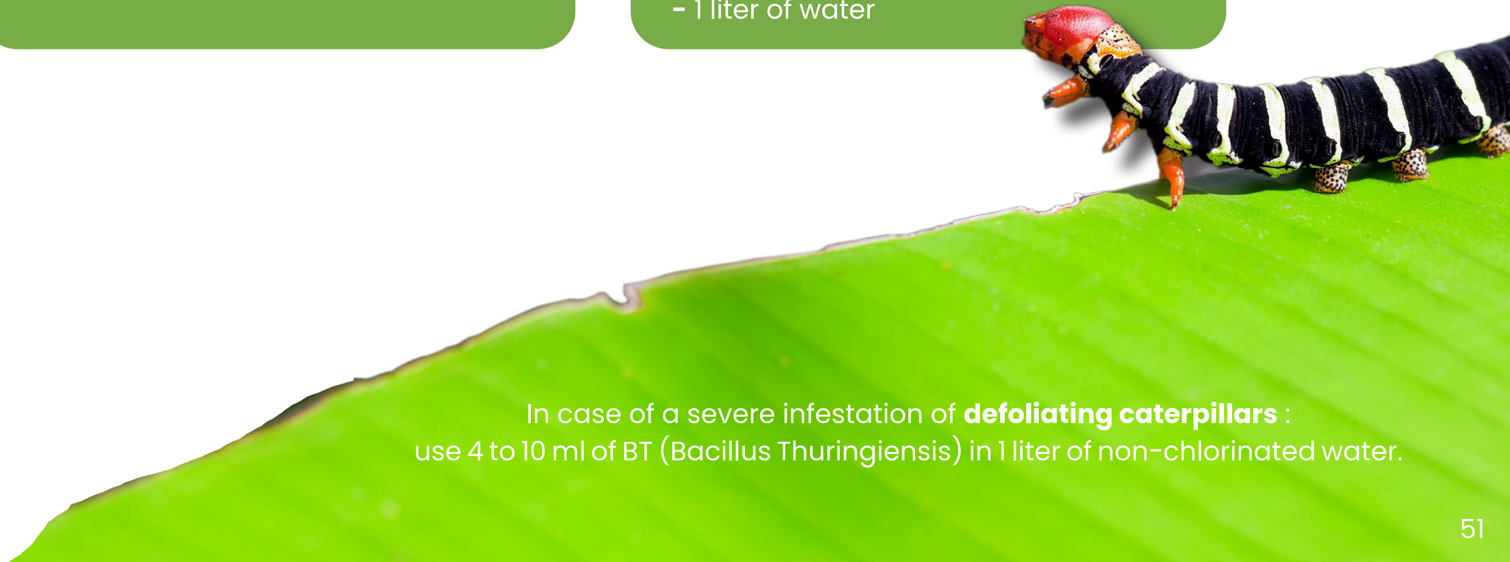
Add in a 1-liter sprayer :

- 30 drops of garlic essential oil
- 20 drops of peppermint essential oil
- 100 to 150 ml of black soap
- 1 liter of water

Antifungal

Add in a 1-liter sprayer :

- 30 drops of garlic essential oil
- 15 drops of tea tree (Melaleuca) essential oil
- 100 to 150 ml of black soap
- 1 liter of water



In case of a severe infestation of **defoliating caterpillars** :
use 4 to 10 ml of BT (Bacillus Thuringiensis) in 1 liter of non-chlorinated water.

10. Summary of suggested products

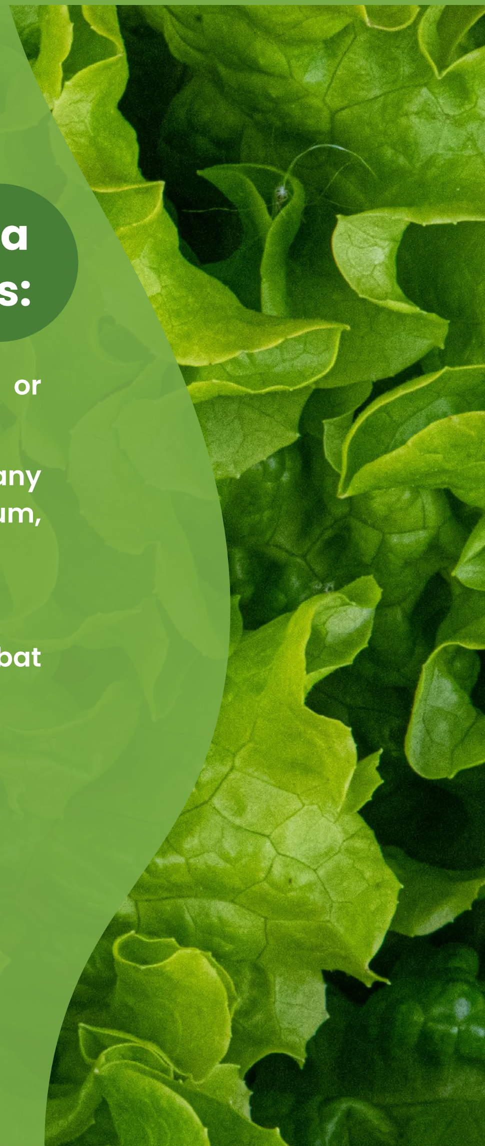
To correct a few deficiencies :

- EDDHA or DTPA iron chelates to correct an iron deficiency.
- Epsom salt to compensate in case of a magnesium deficiency.
- Langbeinite or potassium bicarbonate in case of a potassium deficiency.
- Dolomite, hydrated lime, or oyster shell powder in case of a calcium deficiency. These elements contain calcium carbonate.

Caution: Potassium bicarbonate and carbonates in general will raise the pH.

To combat pests and a few common diseases:

- Antifungal essential oils: tea tree or Melaleuca, garlic, cinnamon...
- Effective essential oils against many pests : garlic, peppermint, rose geranium, lavender, cinnamon...
- Organic black soap.
- BT or Bacillus Thuringiensis to combat defoliating caterpillars.



Activity Forecasts

Part 3

Green Beans

SEEDS

Operations

- Sow in the gravel 4 bean plants every 25 days.
- Daily harvest starting from 60 days after transplanting the first green bean plants into the kit.
- Transplant 4 plants every 25 days and remove the previous four when necessary.

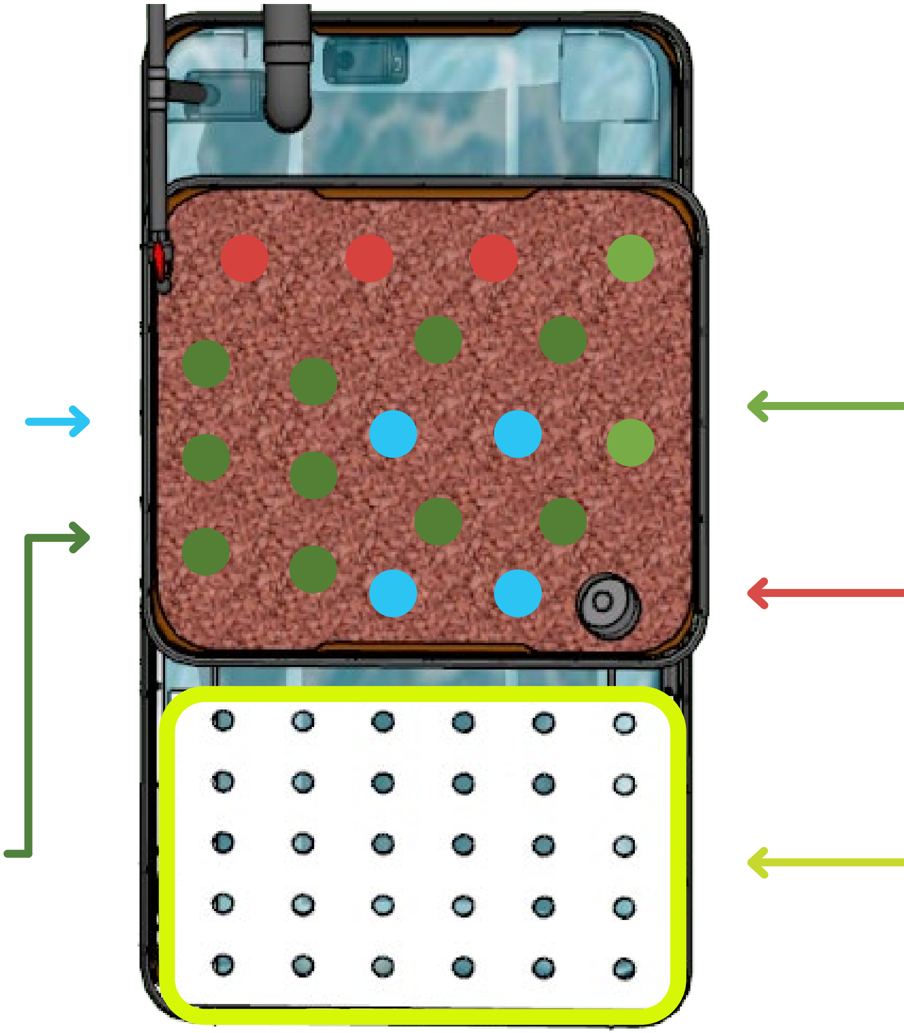
Pota

LEAFY VEGETABLES

Weekly Operations

- Sow 2 pota plants.
- Harvest 2 pota plants after the first 40 days.
- Transplant 2 pota plants.

Note: Young seedlings can be inserted between advanced-growing potas.



Cucumbers

FRUITS

consider staking and growing them outward

Operations

- Sow 2 cucumber plants every 25 days.
- Daily harvest starting from 50 days after transplanting the first cucumber plants into the kit.
- Transplant 2 plants every 25 days and remove the previous two when necessary.

Lettuces

LEAFY VEGETABLES

Weekly Operations

- Sow 6 lettuce plants on the grow tray.
- Harvest 6 lettuce plants.
- Transplant 6 lettuce plants.

Determinate and Cherry Tomatoes

FRUITS

consider staking and growing them outward

Operations

- Sow in the gravel 4 tomato plants (including 1 cherry tomato) every 30 days (adjust based on growth).
- Daily harvest starting from 60 days after transplanting the first tomato plants into the kit.
- Transplant 2 to 4 plants every 30 days and remove the previous ones when necessary.

2. Guiding Principles

The system's productivity was designed based on a compromise between :

- Minimum floor area to become adjustable
- Ease of use and maintenance
- Daily harvest for 4 people (2 adults and 2 children)
- Optimal consumption of fresh water and reduced need
- Low-energy system operating on solar power

The World Health Organization (WHO) recommends 400 grams of fruits and vegetables spread over 5 servings per person per day. In French Polynesia, where the kit was tested, this quota is only met by a minority. For a family of 2 adults and 2 children, a daily harvest of 1.6 Kg, or 48 Kg per month, would be required. In a context like the Tuamotu atolls, this recommendation may seem unattainable and utopian. The family kit aims for a decent daily production of fresh vegetables, from 400 grams to 1 Kg per day for a family of 4.

3. Which vegetables to plant and why ?

The family kit allows for a daily harvest of more than half a kilogram of vegetables.

It is recommended to focus on two categories of vegetables depending on what is consumed:

Leaves
(lettuce, arugula, pak choi, watercress, etc.)

Fruits and seeds
(eggplants, tomatoes, cucumbers, beans, peas, etc.)

Some flower vegetables could be considered. However, priority is better given to those with short or medium cycles to optimize the growing space. Cauliflower and broccoli, for instance, will take up space over a long cycle, which will not optimize daily production.

Similarly, root vegetables will require technical adjustments, making their cultivation more complex. Therefore, it is sensible to focus on the first categories: leaves, fruits, and seeds.

4. Proposed cultivation plan

Available Spots **30**

Lettuce
(Short Cycle)

Nutritional Value : Fibers, Vitamins B, C, E, K

Available Spots **4**

Tomatoes
(Medium Cycle)

Nutritional Value :
Fibers, Vitamins C, A, B3, B6, E, K, Trace elements (Potassium, Manganese, Copper), Antioxidants (Lycopene)

Available Spots **2**

Cucumbers
(Medium Cycle)

Nutritional Value :
Fibres, Vitamines K, C, B9, et oligo-éléments (Potassium, manganèse, calcium) & antioxydants (polyphénols)

Available Spots **4**

Green Beans
(Medium Cycle)

Nutritional Value :
Fibers, Carbohydrates, Proteins, Potassium, Antioxidants (Polyphenols), Vitamin C, Beta-Carotene

Available Spots **10**

Pak Choi

Nutritional Value :
Fibers, Vitamins C, A, K, Calcium, Manganese, Iron, Antioxidants (Polyphenols and Carotenoids)

For several kits, the following production levels can be expected :

Plants Proposed	Weekly Production (Kg)	Daily Production (Kg)	Monthly Production (Kg)	Value per Kg (XPF) (Juil 2022) Hypermarkets from Tahiti	Daily Savings (XPF)	Monthly Savings (XPF)
Lettuce (Short Cycle)	1.02	0.15	4.37	2 000 XPF	291 XPF	8 743 XPF
Tomatoes (Medium Cycle)	0.77	0.11	3.28	900 XPF	98 XPF	2 951 XPF
Cucumbers (Medium Cycle)	0.32	0.05	1.38	900 XPF	42 XPF	1 246 XPF
Green Beans (Medium Cycle)	1.01	0.14	4.32	700 XPF	101 XPF	3 024 XPF
Pak Choi (Short Cycle)	0.53	0.08	2.25	800 XPF	32 XPF	960 XPF

Total per day 676XPF

Total per month 20 299XPF

5. Proposed Chanos Chanos harvest plan

	Integration of Chanos Chanos juveniles	Chanos Chanos (Milkfish) harvest
1 Month	**Chanos Chanos groupe 1 dans le bassin** : 75 individuals of 10g	✕
3 Month	**Introduce group 2 :** 75 individuals of 10g	✕
6 Month	**Introduce group 3 :** 75 individuals of 10g	Harvest of group 1 expected weight of 100g per fish
9 Month	**Introduce group 4 :** 75 individuals of 10g	Harvest of group 2 expected weight of 100g per fish
12 Month	**Introduce group 5 :** 75 individuals of 10g	Harvest of group3 expected weight of 100g per fish

Less than 75 g of fish food daily

The principle of this breeding plan is to rotate on 75 individuals of 10 to 20 g introduced every 3 months.

In 6 months, each group should allow for a harvest of approximately 10 Kg of Chanos Chanos.

Therefore, every 3 months, after the first 6 months following the installation of the kit, a harvest of approximately 7.5 to 8 Kg of biomass is to be expected.

To anticipate such results, it is necessary to introduce 75 juveniles of 10 to 20 g every 3 months and to feed them less than 75 g of food per day.

Each harvest of Chanos Chanos adds value to the yield of the kit, even though this is not accounted for in the productivity balance shown on slide 29. Indeed, Chanos Chanos is a product that is not yet on the market. With that said, this production should be regarded as an additional economic potential for the kit owner.

6. Production costs

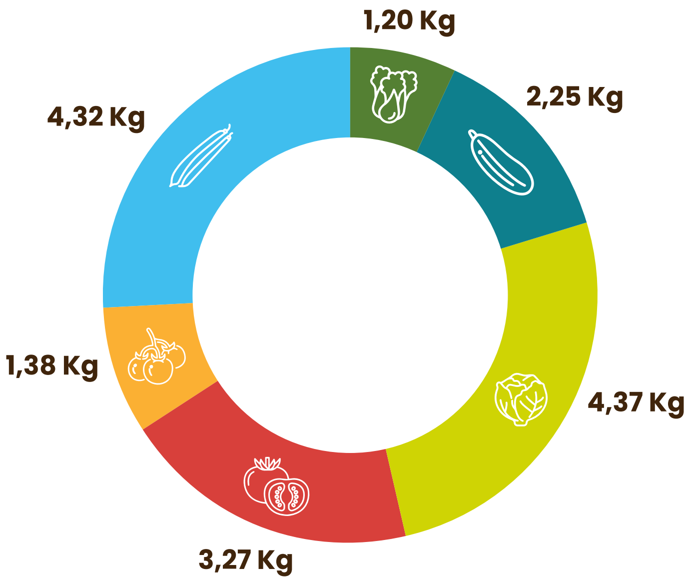
Designation	Features	Monthly specific consumption	Cost	No.	sub-total
Energy	40 w/h	960 watts/day 28 Kw/month	0		0 XPF*
seeds	Bags of 400 to 700 seeds	266 XPF/month	266	1	266 XPF
Mineral supplements	Soluble Minerals (Iron, various mineral salts)	Fer EDDHA 430g**	4070	0,25	1 018 XPF
Biological treatment	Essential oils, organic solutions	5000 XPF/4 month	5000	0,25	1 250 XPF
Fish food	Feed : 15 Kg bags	4 500 XPF each	4500	0,2	900 XPF

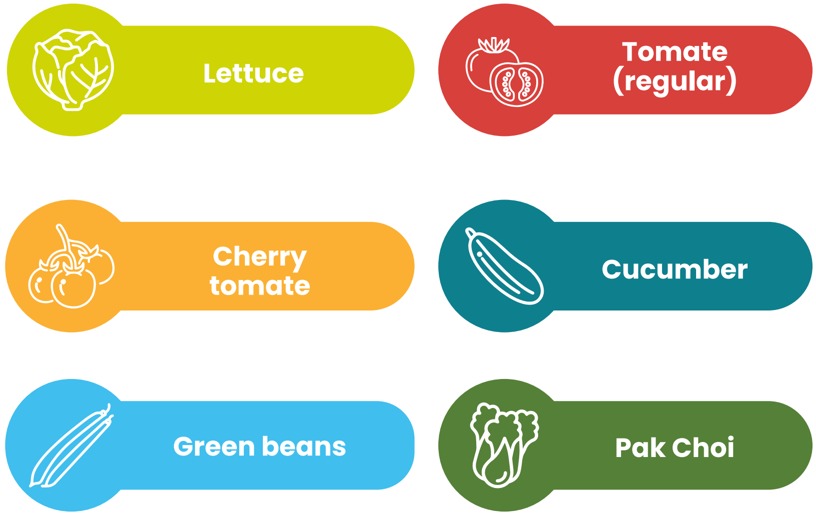
Total	3 434XPF

*To be calculated as per the type of system you choose

**Mineral supplement that enhances performance and care

Potential monthly production





Total production in Kg	Total production cost per Kg
16,80	204 XPF***

***Cost to produce 1 Kg of vegetables

DIRECTION DES RESSOURCES MARINES
PU FA'AHOTU MOANA

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