AQUAVET

INTRODUCING AQUAPONIC IN VET:
TOOLS, TEACHING UNITS AND TEACHER TRAINING

Result 3:

Owner's manual

Internal evaluation of the result

Version	
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3; FINAL	Nadine Antenen, Ranka Junge

Lifelong Learning Programme

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Contents

1 Description of the result

This result gives an overview of the different aquaponic systems that have been built within the AQUA-VET project and are operated by the different partners. It is intended to help educational institutions with planning, building and operating an aquaponic system, so to enable practical as well as theoretical application of Aquaponics in their curriculum.

Three partners within AQUA-VET built their own system (P3, P4 and P6) with P0 (ZHAW) already possessing a system for many years. The first part of the result will focus on these different systems. The ZHAW system can be viewed separately, since it is a lot bigger than the other systems due to it having been used for research and education for a longer period of time. For each one, the general structure, a schematic, an overview of system components and the total energy requirements are given.

Chapter 2.5 concerns the amount of work different aspects of the system create. Certain tasks have to be attended to daily, while others are a weekly or monthly occurrence. Things that need to be dealt with are the fish, the plants, the biofilter, the recirculating system and records/logs. The overview will help estimate the manpower requirements of a given (or planned) system. The fish and plants are of course the reason for having an aquaponic system. To know which species can be cultivated, a list with those used in the presented systems will be provided in chapter 2.6.

The last chapter will be a list of site requirements for aquaponic systems. These are essential to be able to build and operate a system. If a site does not fulfil these requirements, it is not suitable for Aquaponics.

For a more detailed account of the processes of installation and maintenance, please refer to R7&8 installations and maintenance for technicians.

2 The Aquaponic Systems – structure, components energy and manpower requirements

2.1 The Aquaponic System at ZHAW

2.1.1 *Overview of the Aquaponic System at ZHAW*

The aquaponic research and training facility of the ZHAW, P0, is integrated into a heated plastic greenhouse at the ZHAW Campus in Waedenswil with an area of 292m^2. The cultivation takes place in three identical recirculating aquaculture systems A, B or C, each being connected to a hydroponic production unit comprised of three channels for tomato production and three modules à 5 channels for NFT. These tanks are connected to the system as shown in the floor plan (Figure 1 showing connection for System A).

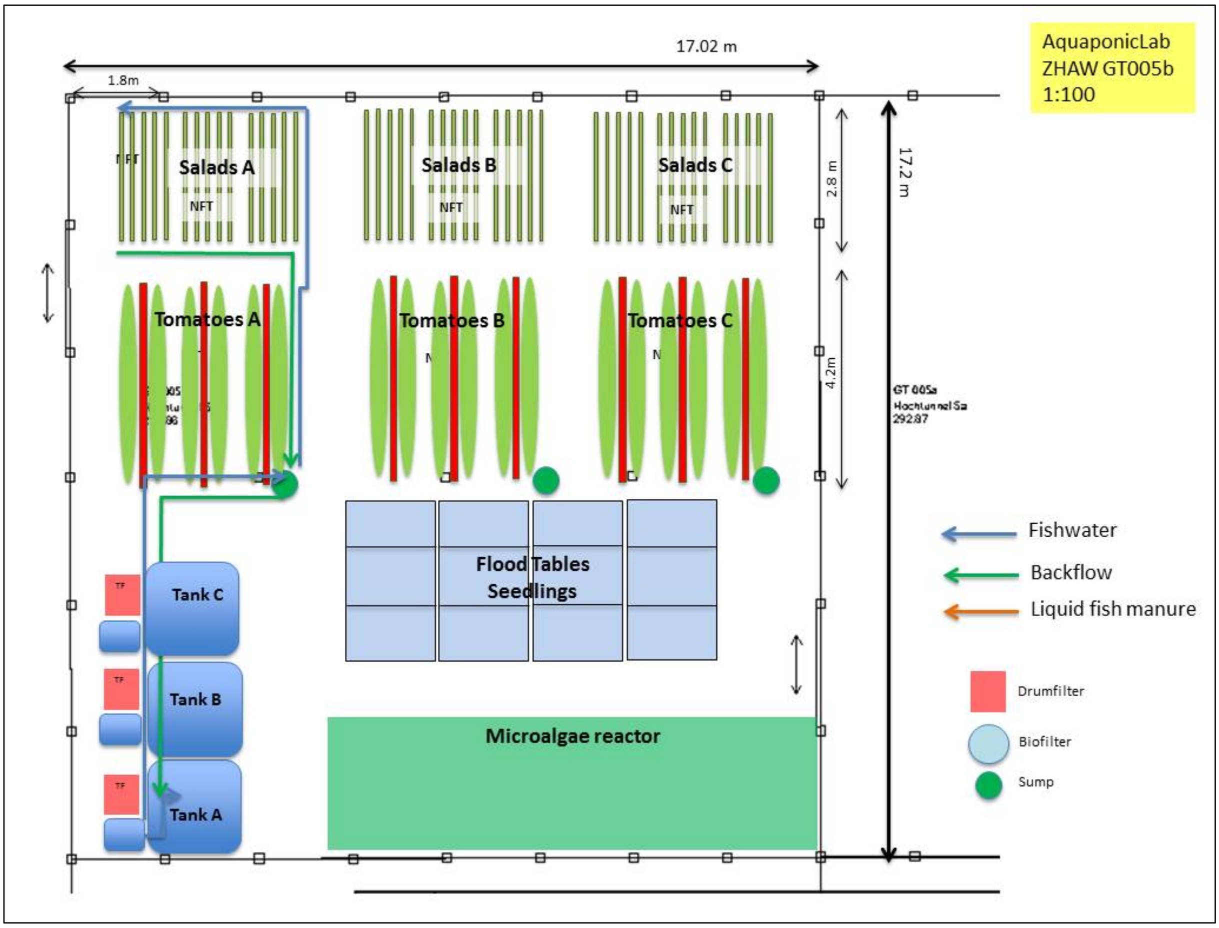


Figure 1: Floor plan of the Aquaponic research and training facility.
The facility is enclosed in a heated plastic greenhouse at the Campus Gruental of ZHAW in Waedenswil, Switzerland (Situation in 2013). The total area is 292 m2 the area of tomato cultures is 70 m2, the area of the salad cultures 47m2.

The greenhouse has an automatized climate control, allowing for adjustments according to the plant cultures. The elements of the climate control are heating, aeration (if the temperatures are too high) and humidity control (60-85% relative humidity). At this point, no additional lighting is provided, as the focus was on cultures that can strive at natural ambient lighting.

The evaporated water by the plants is compensated from the fish tanks, and a periodic backflow into the fish tanks takes place from the plant sumps. The system loses water through the drum filter, which continuously removes fish faeces and causes a loss rate of 10 % of fish water daily. A fresh water supply in the fish tanks from tap water ensures levelling. Each fish tank builds the centre and the starting point of one circulating system (Figure 2).

This aquaponic lab was setup during a cooperation project from ZHAW with its spin-off company UrbanFarmers to develop the UF Controller software and the world's first commercial aquaponic rooftop farm was built in Basel.

2.1.2 *Schematic of one Aquaponic Unit*

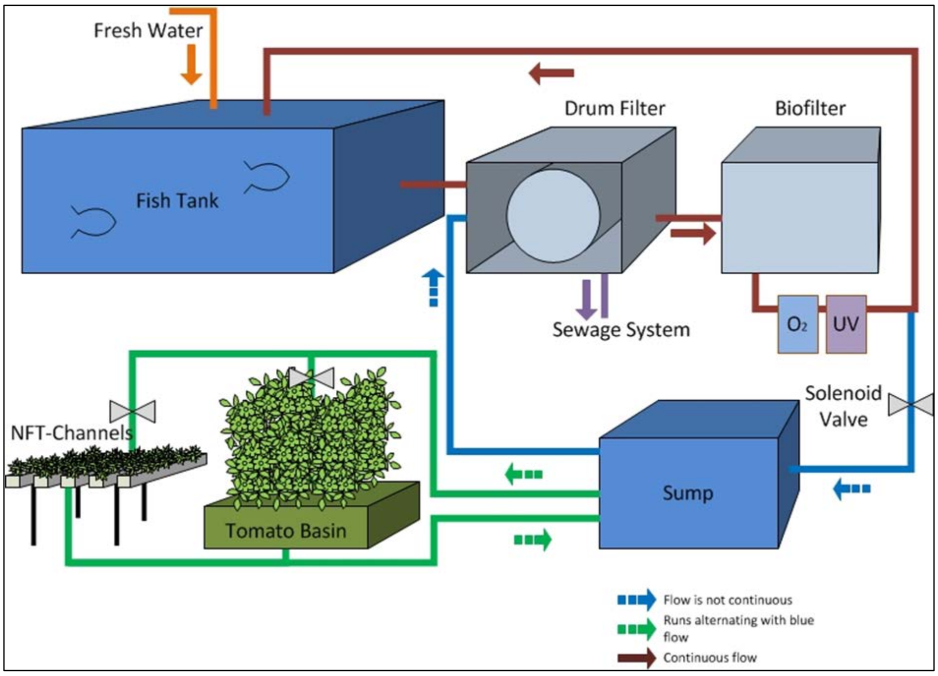


Figure 2: Schematic of one circulating Aquaponic system within the Aquaponic Lab at ZHAW in 2013.

2.1.3 *Components of one Aquaponic Unit*

Table 1: Brief technical description of the components of one aquaponic module (the three modules are identical).

Components	**Short description**
Fish tank	GFK circular current basin
Tank insulation	XPS 30 mm
Drum filter	Lavair L500 with SPS control
Drum filter base	Kanya System

Drum filter pre-filter	Arkal ¾“
Biofilter	IBC Tank with GEA biocarrier media
OxiJet	LINN OxiJet 5
UV-light	Aqua Ultraviolet UVC-Ozone Combo
Circulation pump	Unitech perfect pond dry 9‘000
Aquaculture piping	Tank outlet: PP 110 mm Pump line: PVC 63 mm
Water supply to plants (time-controlled via UF Controller)	Magnetic valve 1“ 24V NC 32 mm PE piping white
Return pipe from plants (Level-controlled via UF Controller)	Pump Oase Aquarius Universal 4000 32 mm PE piping white
Heater	Gas heater 15 kW, secondary circulation
Heating element	Torgen heat exchanger 1"
Pool cover	Twin wall sheets 6 mm
Oxygen generator	Koi-Teich Oximaxx
Feeder	LINN Profi 5 kg
Controller (Regulates temperature and O_2-dosage in OxiJet)	ARC Controller

2.1.4 *Total energy requirements*

Each circulating system uses around 18 kWh/day.

2.2 The Aquaponic System at BC Naklo, SL

2.2.1 *Overview of the Aquaponic Unit at BC Naklo*

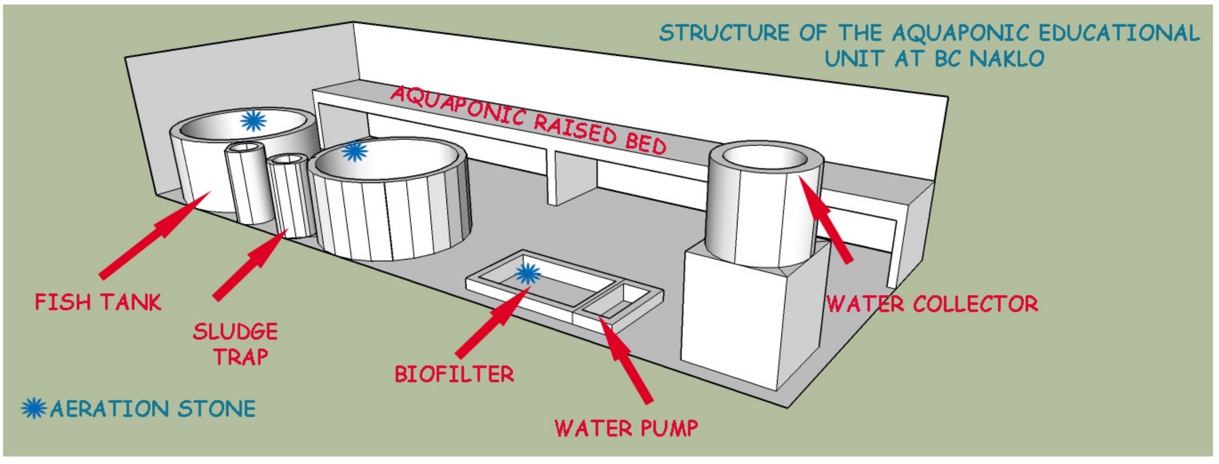


Figure 3: 3D model of BC Naklo aquaponic system.

2.2.2 *Schematic of the Aquaponic Unit at BC Naklo*

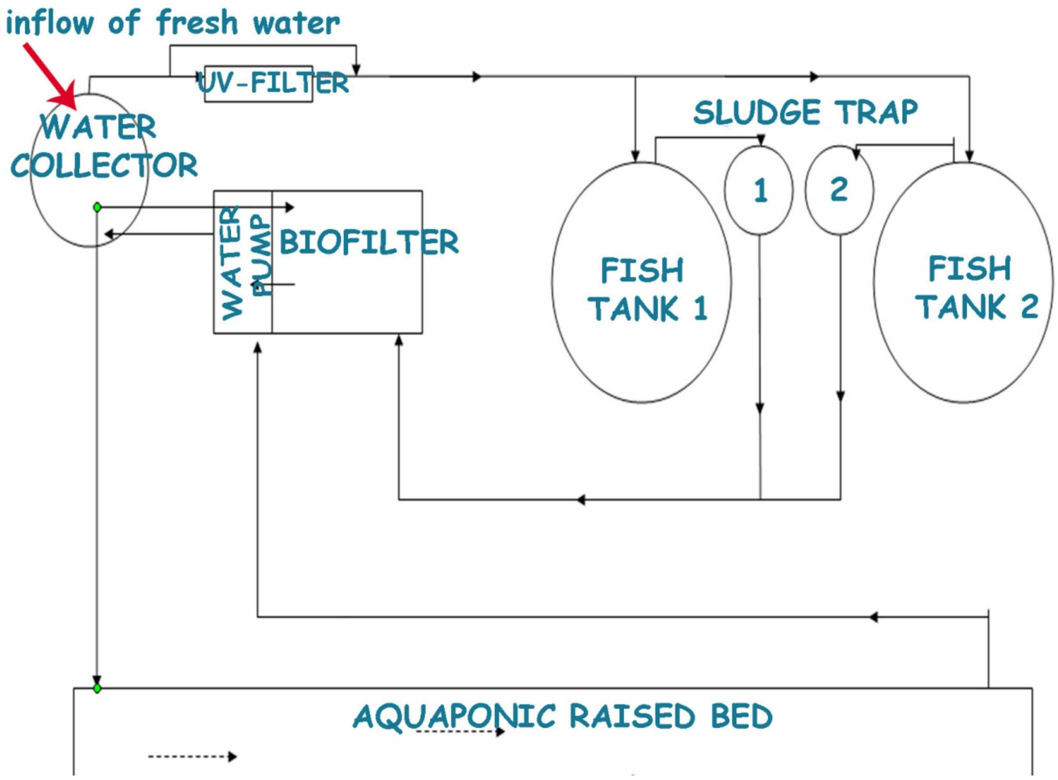
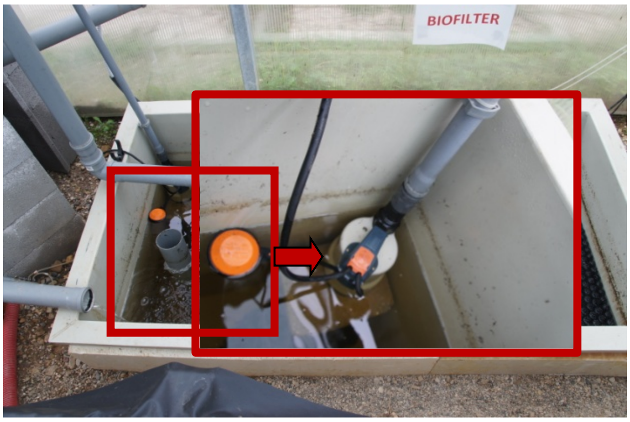


Figure 4: Floor plan of BC Naklo aquaponic system. Arrow indicates direction of water flow.

2.2.3 *Components*

Fish tank	Short description
	diameter: 2 m height: 1 m material: polyurethane accessories: semi-automatic feeder FIAP (3kg/12 hours), aerator stone

Sludge trap	**Short description**
	diameter: 0,5 m height: 1 m material: polyurethane Sludge trap uses bell siphon principle.
Water collector	**Short description**
	diameter: 1 m height: 1 m material: polyurethane
Biofilter	**Short description**
	Length: 2 m Width: 1 m Depth: 1 m material: polyurethane

Water pump	**Short description**
	Submersible water pump PEDROLLO II: - max: 800L/min - 0,75 – 1,1 kW
Water aeraetion	**Short description**
	Water aeration system, Air active pump 10 000 FIAP - 100 W - 220-240 V Pipes connect the air pump with aerator stones.
Hydroponic systems/Raised beds	**Short description**
	**Aquaponic bed on top of a fish tank.** Half of the fishtank is covered with wooden cover and coated with pond foil. Inflow: a pipe that leads into the fish tank Outflow of water: is enabled by gravity, water flows into the fishtank

	**Floodable aquaponic bed** Length: 3 m Width: 1 m Depth: 0,5 m Aquaponic bed is filled with expanded clay balls.
   	**Aquaponic raised bed** Length: 6 m Width: 1 m Depth: 0,3 cm An aquaponic bed contains styrofoam holders. Roots of plants can absorb water directly from the aquaponic system. Water flows into the aquaponic bed through special pipe and flows out through a drain. Water level regulation system in the aquaponic raised bed.
UV lamp	**Short description**
no picture available	FIAP UV, 35W

2.2.4 *Total energy requirements*

Aerator pump and water pump are the main consumers of electricity of the system. We do not know the exact power consumption of the system since we do not have an electric meter in the aquaponic system at BC Naklo.

2.3 The Aquaponic System at Strickhof, CH

2.3.1 *Overview*

The aquaponic system from Strickhof was built at the back of an old greenhouse on a nearly 36m2 large area of 5.7 m width and 6.3 m length. The water and electricity connections were already present.

Due to the system being installed in an existing building envelope, no building permit was required. The aquaponic system at Strickhof is a small unit with a 3m[3] fish tank and only 5 NFT channels as well as 2 ebb and flow tables. Thus, not all fish effluent can be cleaned by the plants. Hence, the system was designed with two circuits, the fish circulation and the plant circulation.

Figure 5: The old greenhouse, where the aquaponic unit is located.

2.3.2 *Schematic*

Figure 6 shows the schematic of the Strickhof system. For the time being, the flushing water of the drum filter is discharged into the sewage system. However, there are plans to collect this fish effluent and use it as fertiliser in an adjacent greenhouse.

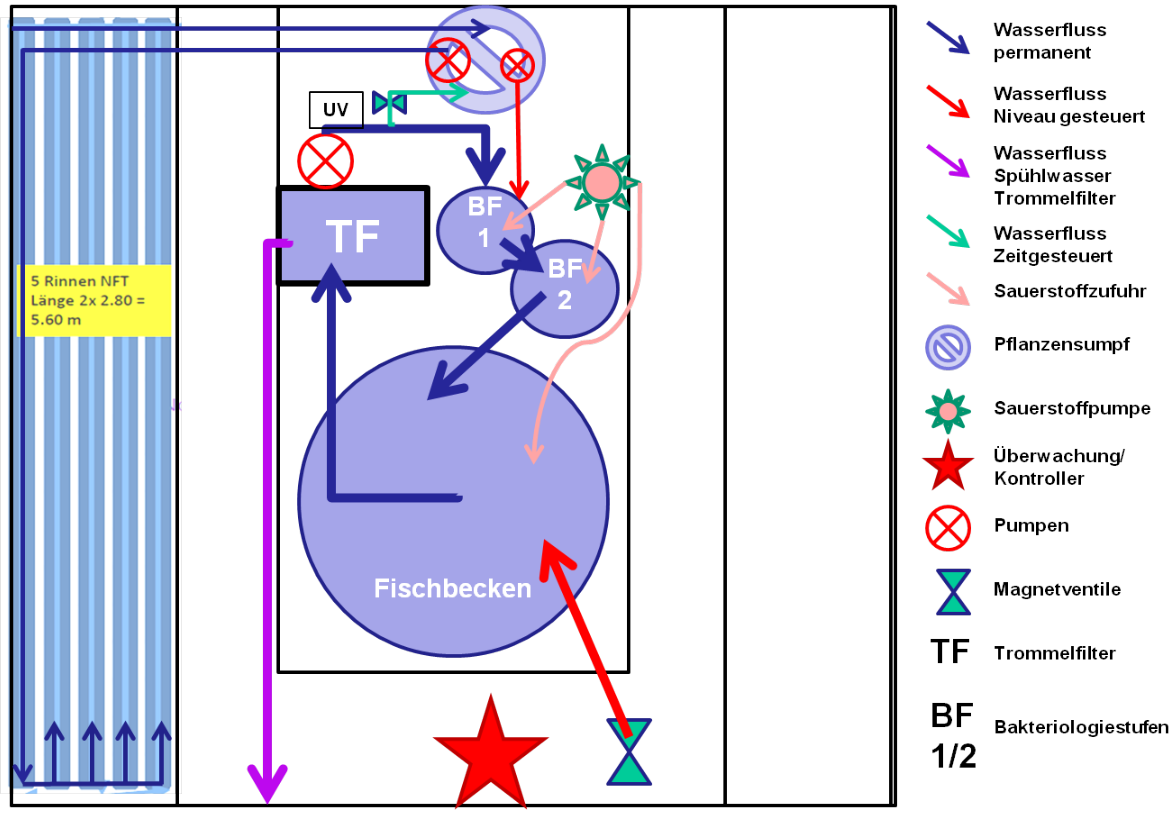
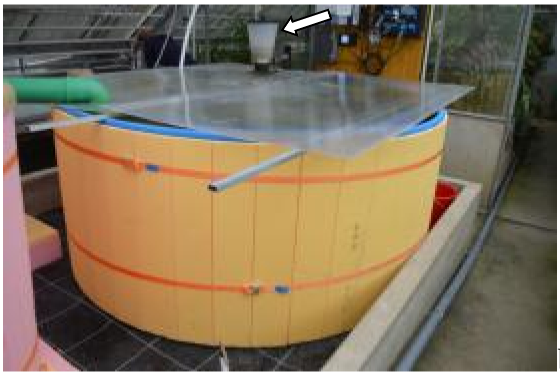
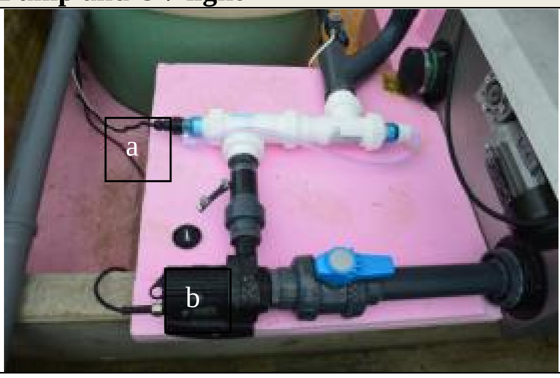
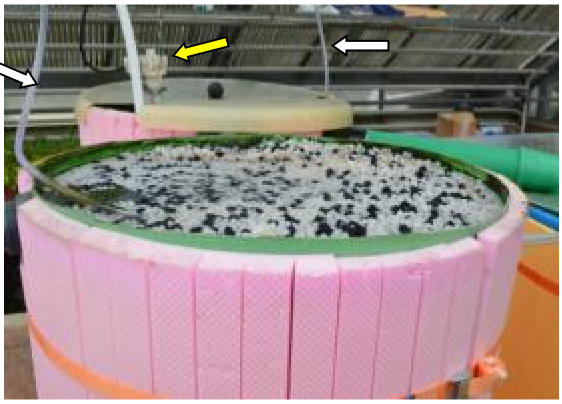
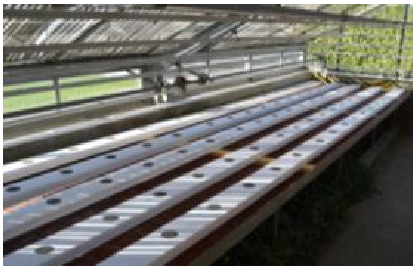


Figure 6: Schematic of the aquaponic unit at Strickhof

2.3.3 *Components*

Fish tanks and feed dosage station	**Short description**
 a  b	Diameter : 2 m Water depth: 0.95m Water volume: 3m^3. Because the door to the greenhouse is only 70 cm wide, it was not possible to use a compact PVC tank, as is used at the ZHAW, for this system. Therefore, a fish tank was selected, which consists of a roll-up wall (a) and an insert sheet. In addition, the wall was isolated with insulating plates (Austrothern XPS Top P-GK, 30mm). The insulating plates were held together with two clamping sets. Due to the interior water pressure the fish tank remains in its round form. (b) In the background (arrow, b) the feed dosage station can be seen, that discharges feed every half hour.
Drum filter	**Short description**
	Inazuma ITF-30 MKII with integrated waste pump, 70µ sieve made of stainless steel. The drum filter was installed later. Beforehand a sedimentation box was used. The filter of this box regularly clogged, so that high maintenance costs arose. The drum filter halved those maintenance costs.
Pump and UV light	**Short description**
	The pump (a) that circulates the water in the system. It is installed immediately after the drum filter. It pumps the water passed the UV light (b) into the biofilters.

Biofilter	Short description
	The system has two biofilters. The first is open and the second closed in the background. The biofilters are filled with plastic chips so that the bacteria can attach to them and the surface area is greatly enlarged. The biofilters are also insulated with Austrothern XPS Top P-GK, 30mm. In addition, both tanks are supplied with oxygen (white arrows). The circulatory system is set with a temperature of 28°C due to the Tilapia. The temperature control (yellow arrow) is carried out with a milk heater.
Monitoring system	**Short description**
	The aquaponic system is monitored by an iks aquastar controller. The pH value of the water, the conductivity of the water, water temperature, oxygen content and the water level are measured and recorded. The data is regularly sent to the maintenance team by SMS. If the values are outside a defined range, an alarm is sent to the team. Moreover, in case of power failure, an alarm goes out and the fresh water inlet valve is opened to ensure a minimal oxygen supply.
NFT channels	**Short description**
 	The plant part of the system at Strickhof is not large enough to clean the entire amount of fish effluent. Therefore, the fish effluent is regularly diverted from the fish circulation for plant supply. The fish effluent is pumped to the plant sump (interim storage for fish effluent). From there, the NFT channels are continuously supplied.

2.3.4 *Total energy requirements*

The energy demand of the system cannot be obtained, since the unit was attached to existing electrical infrastructures.

The water consumption of the drum filter is approximately $1 m^3$ per week.

2.4 The Aquaponic System at I.S.I.S.S, IT

2.4.1 *Overview*

Figure 7: Overview of the Aquaponic Unit at I.S.I.S.S.

The aquaponic plant built at P6 was made for didactical use. For this project the team decided to breed Koi Carp (*C. carpio communis* L.) and not edible fish.
The fish breeding tanks were well structured and roomy, they have a minimum capacity of 2 to 3 m^3 and are able to raise 20-30 fish at the same time. The tanks were in fiberglass and equipped with a bottom, which can be opened and connected with the water recirculation systems. They were purchased from a local company, which is specialized in the construction of facilities for aquaculture. In one tank (Grey tank) four Tech-IA floating mats (PAN, P8, Italy) were positioned. This structure allows herbaceous plants to float on the surface of the water, doing their purifying function without the aid of a substrate. Four equal-sized plants of yellow iris (*Iris pseudacorus* L.) were transplanted in each Tech –IA. In both breeding tanks 9 carps were inserted and given a daily dose of feed (protein 24.4%, fat 3.7%, fibre 2.6%) corresponding to 6 g.
The vegetables production was structured with two plastic tanks filled with expanded clay. The pumps were placed in a tank between the two hydroponic ones. They were very simple and had a prevalence of at least 1.2-1.5 m and a minimum flow rate of 1.2 m^3/hour in order to ensure a rapid hydraulic parts several times a day.
The water flowed from breeding tanks to hydroponic one then to the pumps one and then back to the first one.

2.4.2 *Schematic*

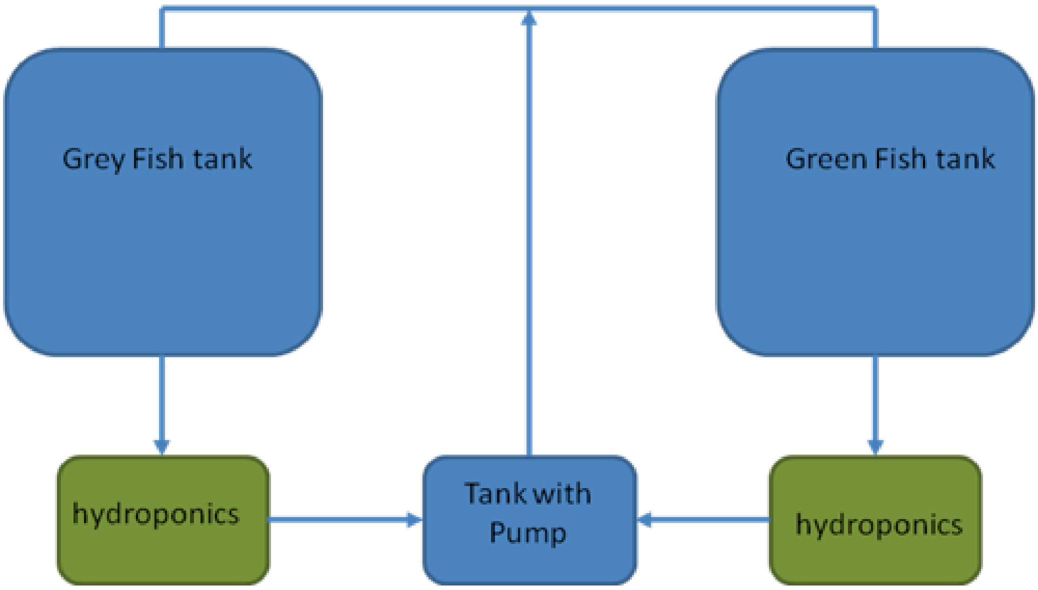
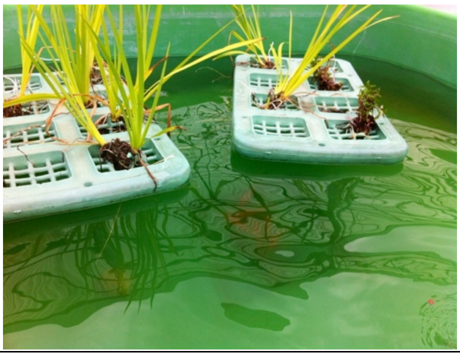


Figure 8: Schematic from the Aquaponic Unit at I.S.I.S.S.

2.4.3 *Components*

Breeding tanks	**Short Description**
	Width: 2 m Length: 2 m High: 0,6 m Quantity: 2
Hydroponic tank	**Short description**
	Width: 1 m Length: 0,8 m High: 0,7 m Quantity: 2

Pump tank	**Short description**
	Width: 1 m Length: 0,8 m Quantity: 2 High: 0,7 m
Submersed pump	**Short description**
	12-55 W
Pipes	**Short description**
n.a.	Diameter: ¾ inches Quantity: 4 m
Floating mat	**Short description**
	Tech-IA with yellow iris (*Iris pseudacorus* L.) 4 mats in one breading tank

2.4.4 *Total energy requirements*

The only energy user is the water pump, which uses 0.57 kWh/day.

2.5 System operation – manpower

Small aquaponic units similar to those built at P3, P4, P6 need approximately 25 hours of maintenance per month including the following daily/weekly/monthly tasks:

- Feeding fish
- Observing fish behaviour
- Observing water quality, measuring
- Observing plants
- Controlling biofilter functions
- Controlling recirculating system
- Write records and log

2.6 Overview of possible crops

2.6.1 *Tested fish species*

Species	**Successfully used in system at**
Tilapia (Oreochromis niloticus)	ZHAW, Urban Farmers, Strickhof
Koi carp (*Cyprinus carpio haematopterus*)	I.S.I.S.S, BC Naklo
Carps (*Cyprinus carpio*)	BC Naklo
Sturgeon (Acipenser oxyrinchus)	BC Naklo

2.6.2 *Tested crops*

Crop	**Successfully used in system at**
Tomatoes	ZHAW, BC Naklo,
Capsicum (Pepper)	ZHAW, BC Naklo
Culinary Herbs	ZHAW, BC Naklo
Microgreens	ZHAW
Salad	ZHAW, Strickhof, BC Naklo, I.S.I.S.S.
Celery	BC Naklo
Chicory	BC Naklo
Mint, Melissa,	BC Naklo
Strawberry	I.S.I.S.S.
Flowers	I.S.I.S.S.

2.7 Potential sites – requirements

- Space
- Greenhouse
- Water source
- Electricity
- Sunlight