Interreg

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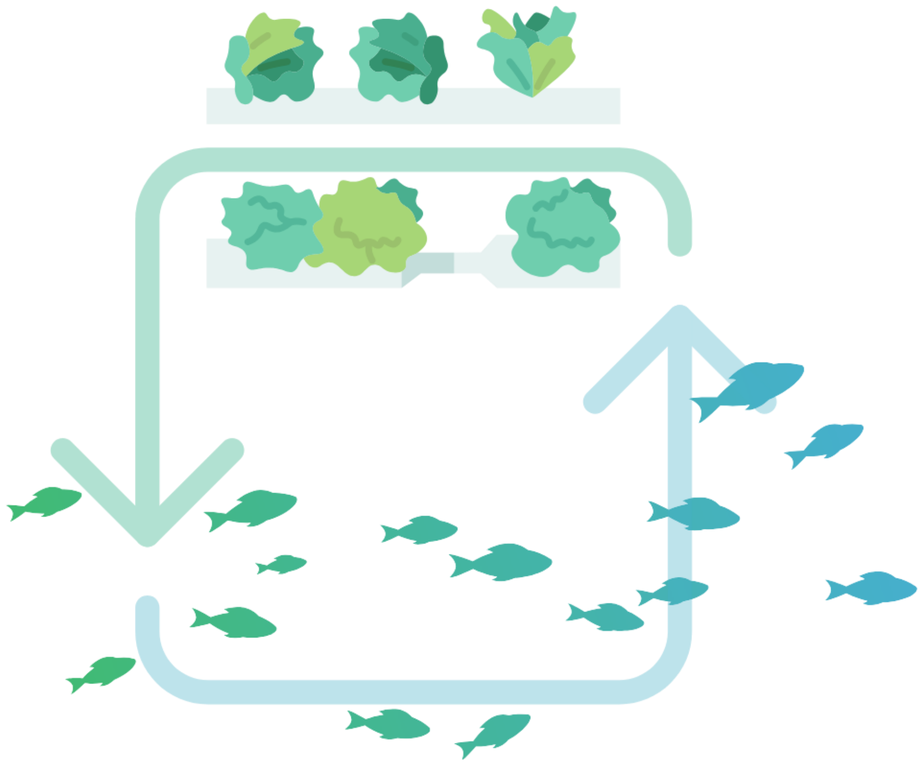
Central Baltic Programme

TransFarm

AQUAPONICS DEMO DESIGN – DEMONSTRATION SYSTEM AT CAMPUS ROSLAGEN, SWEDEN



UNIVERSITY OF TURKU | CAMPUS ROSLAGEN | UNIVERSITY OF LATVIA | Eesti Maaülikool – Estonian University of Life Sciences | COOMPANION – KOOPERATIV UTVECKLING

D.2.1.1. – Short report of the demo design in Sweden

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1. Introduction

1.1 TransFarm project

There are several environmental and social challenges that the food sector has to face: Agriculture is a sector particularly affected by climate change, our seas are overfished and the world population is estimated to continue growing, being about 9,7[1]billion people by 2050.

Countries in the Baltic Sea Region are strongly dependent on food import, especially for vegetables, fruit and fish; in recent years the pandemics and the war in Ukraine have exposed the need of more self sufficient food systems. Moreover, agriculture and aquaculture are among the main contributors to the eutrophication of the Baltic Sea.

To answer these challenges TransFarm project wants to bring food production closer to consumers by promoting soil-less farming methods that can be implemented even indoors and allow to grow all year round. Examples of these methods are hydroponics, where plants are grown in water, and aquaponics, that combines hydroponics with aquaculture.

Aquaponics is a circular, closed-loop system, where water from the fish culture is used to grow plants. The fish waste within the water is microbiologically transformed by a biofilter, absorbed by plants and then cleaner water returned to the fish. The system is completely circular allowing nutrient reuse without emissions of nutrients in the environment. Since the fish, plants and microorganisms in an aquaponics system function in close symbiotic relationship, antibiotics or pesticides are not used, which in turn provides cleaner, healthier produce.

TransFarm will demonstrate aquaponics in Sweden, Estonia and Latvia as well as test alternative water sources such as rainwater and reclaimed greywater: Partners from these countries will build demonstration facilities with different characteristics and aims. The experiences exchange from the different demos will contribute to knowledge co-creation and the facilities will be the opportunity to inspire and educate future aquaponics farmers. The knowledge gathered from the construction and monitoring of the demos will result in education material available for all the actors interested in aquaponics.

The project will also investigate business models, run activities to inform consumers about the quality of the aquaponics produce, educate entrepreneurs that want to start an aquaponics system as well as inform civil servants and policy makers about the reduced environmental impact of circular soil-less farming methods.

[1] UN DESA publications – World population prospects 2022

TransFarm project duration is three years (2023-2026) and it is coordinated by Turku School of Economics at the University of Turku (Turku, Finland). Project partners are the Estonian Univervisity of Life Sciences (Tartu, Estonia), University of Latvia (Riga, Latvia), Campus Roslagen and Coompanion Roslagen & Norrort (Norrtälje, Sweden).

TransFarm project is funded by EU's Interreg Central Baltic program, the total budget of the project is 1,87 million euro, EU financing covers 1,5 million euro.

1.2 Summary

The present report describes the design of the aquaponics demonstration system at Campus Roslagen, a municipal company in Norrtälje. The work has been carried out as part of the TransFarm project, financed by the Interreg Central Baltic programme. This report aims to inspire and provide information to who is interested in starting a small-scale aquaponics system.

The demonstration facility at Campus Roslagen is a small-scale aquaponics systems, where rainwater harvesting will be implemented in the future. An aquaponics system consists of three main units: The aquaculture unit where fish are grown, the biofilter where the waste from the aquaculture unit is convertered in nutrients for the plants and the hydroponics unit where plants are grown in water.

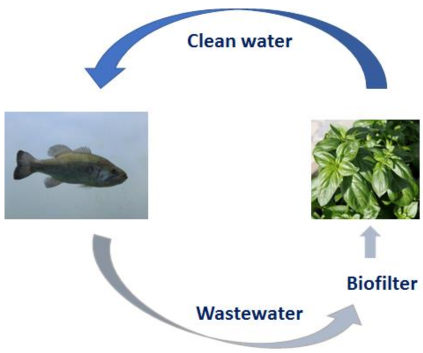

Fig. 1 – Schematization of the three main components of an aquaponics system

The aim of the demo is twofold: i) To show how circular soil-less systems can be integrated in buildings and their potential for food security; ii) To test alternative water sources such as rainwater to implement water circular economy, of paramount importance in a climate change scenario.

With increasing food insecurity and growing population concentration in cities, we need to rethink the space and the roles of buildings within the food system: Small-scale soil-less systems can be adapted to the available space since they allow for vertical farming and can contribute to the well-being of building residents.

The report outlines the design process of the aquaponics system components, excluding rainwater harvesting system that will be described in the deliverable D.2.1.2.

The report D.2.1.3 will describe the second demo of Campus Roslagen, a facility where artificial greywater[2] is created and treated to grow plants.

[2] Wastewater from non-toilet plumbing systems, i.e. from sinks, showers, etc.

2 Principles of design

Aquaponics operation is based on nitrification, a process that is part of the nitrogen cycle and spontaneously happens in nature. Nitrification consists in the conversion of ammonia (or ammonium), forms of nitrogen that are toxic for the fish, in nitrate, a form of nitrogen that is less toxic for the fish and more easily taken up by plants. Nitrification needs aerobic conditions to happen and it is a two steps oxidation process where autotrophic[3] bacteria first oxidize ammonia/ammonium into nitrites and then nitrites are oxidized into nitrates:

$$\underset{\text{(Ammonia)}}{NH_3} \xrightarrow{\substack{\textbf{AOB} \\ \textit{Nitrosomonas}}} \underset{\text{(Nitrite)}}{NO_2^-} \xrightarrow{\substack{\textbf{NOB} \\ \textit{Nitrobacter}}} \underset{\text{(Nitrate)}}{NO_3^-}$$

Fig. 2 – Schematization of the nitrification process

More detailed description of water quality and nitrification can be found in the TransFarm report "Water quality in aquaponics".

The correct design of the aquaculture unit, the hydroponics unit and of the biofilter can ensure a balance in the nutrients content and a favourable environment for fish and plants.

If the three main units of an aquaponics system (aquaculture, hydroponics and biofilter) are not correctly dimensioned the balance is not respected and the system can face different scenarios:

a) The biofilter is under dimensioned: In this case the biofilter does not have the capacity to convert all the ammonia in nitrates, with ensuing ammonia accumulation that can lead to fish death;
b) The biofilter is correctly dimensioned but there are too many fish compared to plants: In this case there will be nitrates accumulation, but this is a less severe scenario because nitrates are a form of nitrogen less toxic for fish and it is possible to foresee this situation and to act in time;
c) The biofilter is correctly dimensioned but there are too many plants compared to fish: In this case the plants are not going to have enough nitrogen and they will present nutrient deficiency.

[3] Bacteria that can produce their own food starting from simple substances such as carbon dioxide

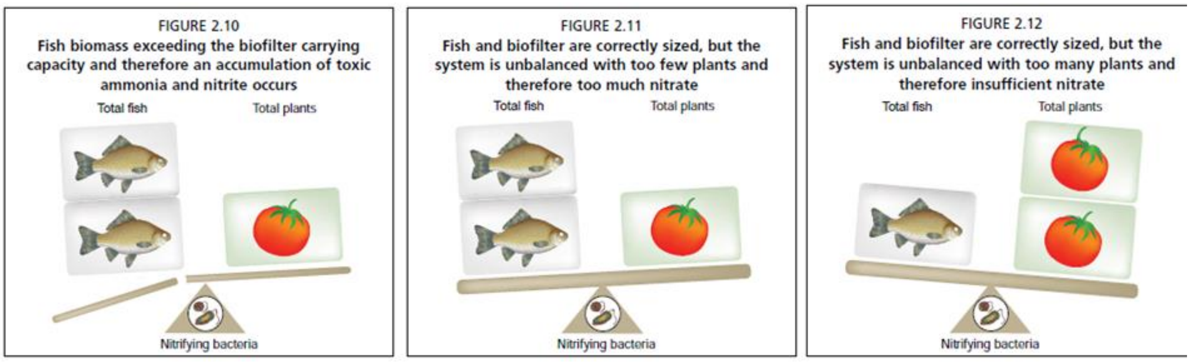

Fig. 3 – From Somerville et al. 2014, design imbalances in an aquaponics system

A first rule to ensure the correct dimensioning of the aquaculture and the hydroponics unit is based on the calculation of the feed rate ratio, a parameter that indicates how much feed per day and per square meter is needed to grow vegetables, these being classified in leafy or fruiting vegetables.

$$\text{Feed Rate Ratio} = \frac{\textbf{feed/day}}{\textbf{growing area}}$$

[4]

Leafy vegetables: 30 - 50 $g/m^2/day$
Fruiting vegetables: 50 - 80 $g/m^2/day$

The first number of the range is to be used in case of cold water fish, while the second for warm water fish since nitrification is slower with lower temperatures.

A first calculation to design an aquaponics system is based on the relationship between the growing surface and the amount of fish feed provided per day!

The correct dimensioning of the hydroponics unit, the biofilter and the aquaculture unit is paramount to make the system work.

[4] Somerville et al., 2014

3 Choice of the room

General criteria to choose the location of an aquaponics system are the accessibility to water, to the sewerage and to electricity.

In the case of Campus Roslagen's demo two extra criteria determined the choice of the room where the demo is located: Accessibility to wheelchairs and the presence of two exits to comply with safety requirements.

4 Dimensioning of the demo

Campus Roslagen aquaponics system is a demonstration facility, hence the design of the system did not start from economic considerations.

The main constraint to start the design was the area of the room where the demo has been built, which is of 36 m^2.

The steps we followed to design the demo are the following:

- Defining the **growing area**, considering that it has to be easy to reach the whole growing bed to harvest and plant. The total growing area is A = 5,76 m^2;
- For a first calculation we assumed we were going to grow leafy vegetables;
- We did the conservative hypothesis of having a temperature below 24 ◦C, hence we chose the value of FFR related to cold water systems;
- With **FFR = 30 g/m^2/day** we obtain 173 g/day of fish feed;
- Under the assumption that an adult fish at those temperatures eats about 1% of its weight we obtain a total fish weight W = 17, 3 kg → rounded up to **20 kg of fish;**
- At our temperature tilapia (the fish species we chose, see par. 6) should reach a maximum weight of 500 g, so the number of fish needed is about 40. We bought the double because of high mortality risk;
- We decided to have a low stocking density to start with. Considered that we were going to have about 20 kg of fish, we chose a fish tank with a volume of 2,2 m^3 and that provided a water volume of 1,3 m^3 .

In a commercial aquaponics the dimensioning of the system depends on economic calculations: You calculate which production rate of vegetables and/or fish you need to reach in your system.

In a non-commercial system the design and selection of the species depend on the space and environmental conditions where you build your system.

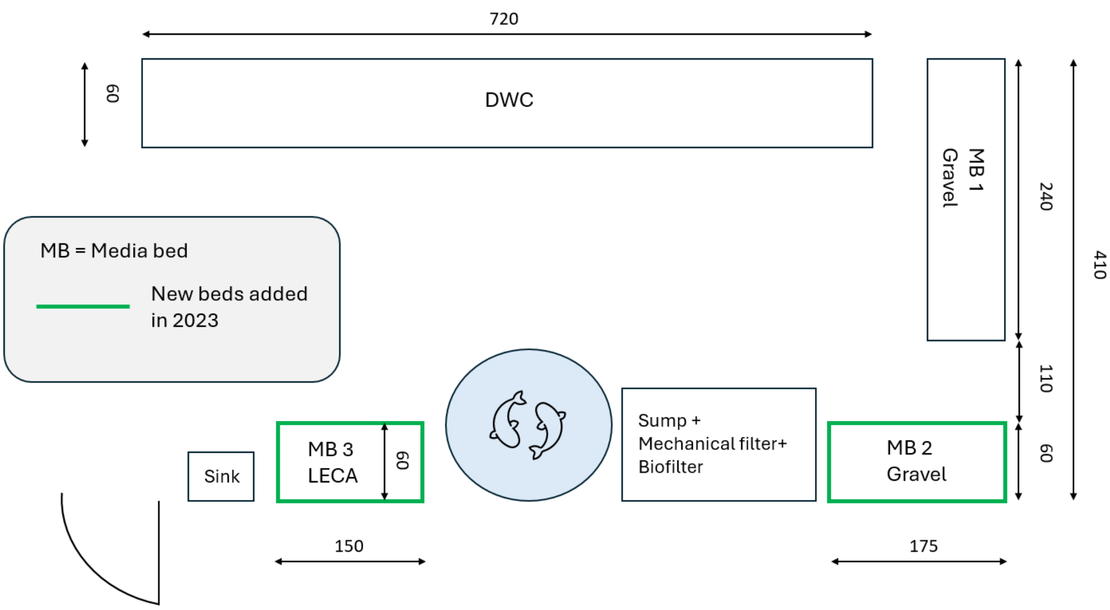

Fig. 4 – Scheme of the demo at Campus Roslagen. New media beds were added in 2023 because of a fish stocking density higher than what designed originally. Measures are in cm.

5 Systems design

5.1 Fish tank

The parameters to choose the fish tank are shape and material.

The tank shape has to guarantee a good circulation in the tank and avoid anoxic zones. For this reason we chose a circular tank with flat bottom, where waste accumulates in the centre tanks to the centripetal force.

The material has to be inert, i.e. does not have to leak elements that are toxic for fish and for humans. The tank we chose is in food graded polyethylene and it is white to allow a better visibility of the fish and of the accumulated waste.

Regarding the size, our main constraint was that the height of the tank should be minor than the width of the room door (90 cm). To guarantee a good fish density we chose a tank with a total volume of 2200 l and a water volume of 1300 l.

Fig. 5 - Fish tank in the demo at Campus Roslagen.

d = 157 cm, h_{water} = 70 cm, water volume V_{water}=1,3 m^3

5.2 Sump tank

The main purpose of the sump tank is to provide a water volume buffer, allowing some evaporation etc. without affecting fish tanks or growing beds. In systems with ebb and flow beds the sump tank also has to provide spare volume for filling and emptying the ebb and flow beds.

In the demo at Campus Roslagen the sump tank is also used to provide space for a biofilter (par 5.4) and the mechanical filter, but this does not affect the active volume of the sump.

The dimensioning of the sump tank at Campus Roslagen was made considering media bed(s) and evaporation.

The media bed (ebb and flow system, described in par. 5.5) has a volume of 2,50 m*0,60 m*0,30 m = 0,45 m^3 and is filled with a fine gravel (d = 2-4 mm). The porosity of the gravel is 50%, making the maximum volume of water in the media bed 0,45 m^3*50% = 0,225 m^3 = 225 l. The media bed is never completely empty, roughly 5 cm (1/6 of the height) of the bed is always saturated (225/6 = 37,5 l). The volume of the media bed then varies between 38 and 225 liters and the sump has to provide allowance for this difference (225-38 = 187 liter).

The sump has also to provide water storage during power outages, or in case some pump is not working, that is why a low placed sump tank is preferable, then gravity is enough to evacuate water from other tanks to the sump.

At Campus Roslagen demo site, the height of the room is limited, making the preferred design of the sump low and wide. The final dimensions of the sump at Campus Roslagen is 1,7 m*0,9 m*0,45 m = 0,69 m^3 in order to provide the volume displacement needed for the ebb and flow systems and also allowing for substantial evaporation before system failure due to water shortage.

5.3 Mechanical filter

The function of the mechanical filter is to stop the bigger particles (faeces, uneaten food). Big particles can harm the fish by stopping in their gills.

An excess of organic matter can increase the number of heterotrophic[5] bacteria, that compete with the nitrifying bacteria (autotrophic) for space and oxygen affecting the nitrification process.

Figure 6 - Sump tank during construction, the inside of the tank was later coated with a rubber sheeting.

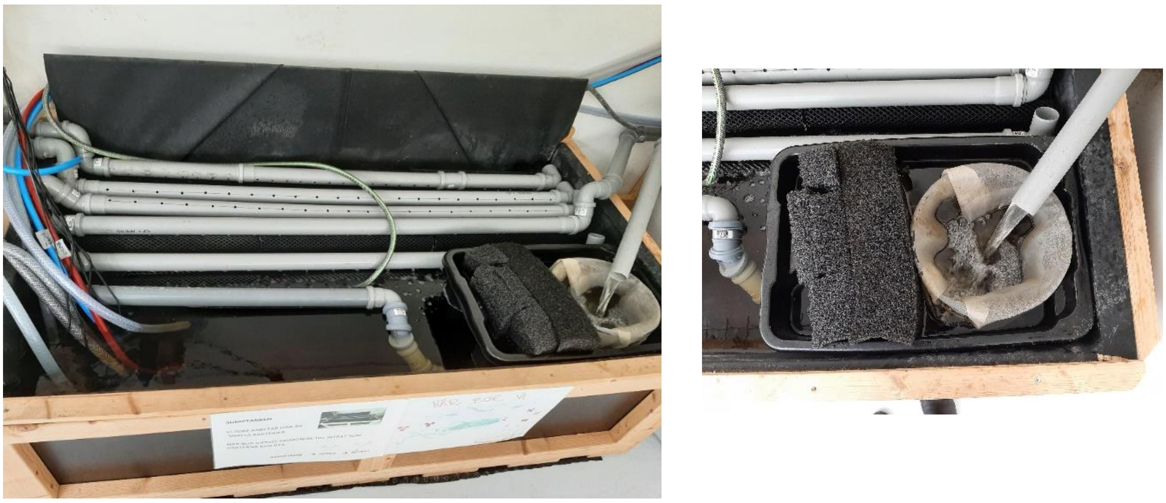

Fig. 7 – The sump tank in the demo at Campus Roslagen has the main purpose to provide a volume buffer: If water level variations happened in the fish tank this would stress the fish. In this case the sump is also used to have the biofilter and the mechanical filter.

[5] Bacteria taking their nutrition from organic carbon

5.4 Biofilter

The main function of the biofilter is to provide growing surface for the bacteria. Since it is important to have control over all parameters and functions in the system, the filter material needs to be inert, i.e. chemically stable, and not emit any substances into the water or affect the water values. In the biofilters a film of bacteria and other microorganisms will establish itself on each filter particle and create a so-called biofilm.

The biofilm will fill up parts of the space between the material in the filter and it is therefore important that the material is not too fine-grained. Sand has a large surface area but due to its size the biofilm will soon clog the space between the grains of sand and prevent the flow of water through the filter. The filter material also has, in some systems, the function of creating a stable attachment surface for various plants.

5.4.1 Material and Surface Specific Area

A biofilter is classified for its Surface Specific Area (SSA), i.e. its total area per volume, that is expressed in m^2/m^3. Different materials have different SSA, partly depending on the construction of the material and partly on the material's particle size.

The material in the filter must also be heavy enough that the water flow cannot flush the material out of the system. In systems with constant water flows most materials work. In systems with an ebb and flow function (see par. 5.5), light materials such as LECA (Light Expanded Clay Aggregate) or various plastic materials can sometimes float up and follow the water flow.

For industrially produced biofilter (e.g. the biofilter material used in wastewater treatment plants) the information about SSA is found in the technical sheets.

Table 1 shows the available surface area for different filter materials.

Specific surface area of selected biofilter media, including calculations of ammonia conversion of daily feeding, assuming 32 percent protein in feed

Type of media	Specific surface area (m^2/m^3)	Feed (g) processed per litre of media	Media required (litres) per 100 g of feed
Coarse sand (0.6–0.8 mm)	5 000	75.0	1.3
Bead filtration	1 400	21.0	4.8
Bioballs®	600	9.0	11.1
Foam	400	6.0	16.7
Fibre mesh pads	300–400	4.5–6.0	16.7–22.2
Corrugated structured packing	150–400	2.3–6.0	16.7–44.4
Volcanic gravel	300	4.5	22.2
Clay balls (LECA)	200–250	3.0–3.8	26.7–33.3
Coarse gravel	150	2.3	44.4

Tab. 1 – Specific surface area of selected biofilter media, Somerville et. al 2014

5.4.2 Dimensioning of the biofilter

To dimension the biofilter it is first necessary to estimate the amount of ammonia produced in our system, available in the water and subject to nitrification. This amount depends on serveral factors, such as the quantity of proteins in the feed, fish species, temperature, waste removal rate of the system.

About 30% of the nitrogen contained in the fish feed is retained in the fish body, while the other 70% is lost. About 87% of the lost nitrogen is extrected by the fish in form of ammonia and 13% is not digested and is present in the system in form of faeces and uneaten feed.

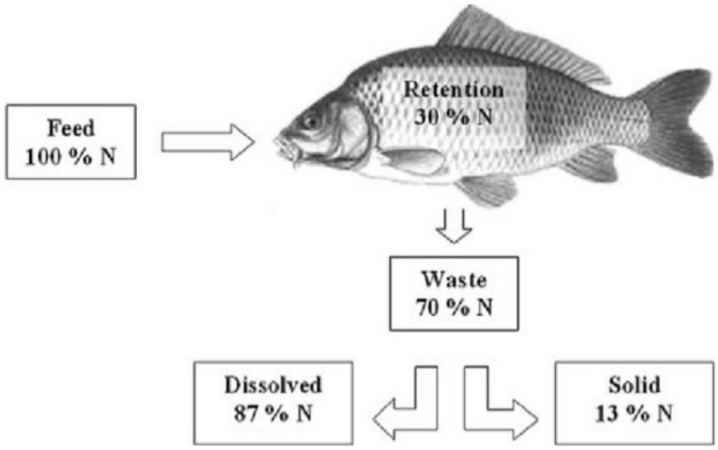

Fig. 8 – Nitrogen retention in fish, Jirásek et al. 2005

About 60% the solid waste present in the water is retained by the mechanical filter[6] , leaving about 6% of the solid waste to be degraded into ammonia in the water. For our calculation we will consider that 66% of nitrogen in the feed becomes ammonia available for nitrification.

The following calculation is very simplified, for a full understanding we recommend specialised literature on recirculating aquaculture systems.

In our system we considered to have 20 kg of fish (par. 4) and a feed with 32% proteins, with the assumption that proteins contain 16% of nitrogen (Somerville et. al):

- 20 kg fish eat 2% of their weight every day (at maximum) -> **400 g feed/day**
- The feed contains 32% of proteins and the proteins contain 16% of nitrogen ->
  400 *0,32*0,16 g = **20,5 g nitrogen/day (input from feed)**

[6] Somerville et al., 2014

- 66% of nitrogen is wasted -> 20,5*0,66 g = **13,5 g nitrogen/day (wasted)**
- For each gram of wasted nitrogen 1,2 g ammonia is produced -> 13,5*1,2 g = **16,2 g/day (ammonia available for nitrification)**
- In literature can be found the ammonia removal rate by nitrifying bacteria per square meter per day. The rate depends on different parameters.

  We consulted an ecologist working with aquaponics since many years and he provided us the following rates:

  0,2 – 1 g/m^{2}day for temperature below 25 ◦C;

  1 -2 g/m^{2}day for temperature between 25 - 30 ◦C;

  This value depends on many environmental factors, we decided to have a conservative rate of **0,6 g/m^{2}day**

- The area needed by nitrifying bacteria is -> 16,2 / 0,6 m^2 = **27 m^2**
- The biomodules chosen for our biofilter have a specific surface area (SSA) of 600 m^2/m^3 -> **45 l volume needed for the biofilter**

As discussed in 5.2, the biofilter in Campus Roslagen demo was installed in the sump tank that has a volume of 0,69 m^3. In the back of the sump a structure suitable for providing habitat for biofilms (originally produced as biofilters for on-site sewage sanitation) was installed, with a volume of 0,35 m^3 providing much more volume than the minimum calculated.

An air pump provides oxygen to the biofilm by even distribution of air in the bottom of the biobed structure. Water effluents from the fish tank and the different plant beds are distributed over the biofilter as they return to the sump tank.

Fig. 9 – Biomodules chosen for the biofilter at the demo at Campus Roslagen.

These biomodules are used for infiltration beds in on-siste wastewater systems.

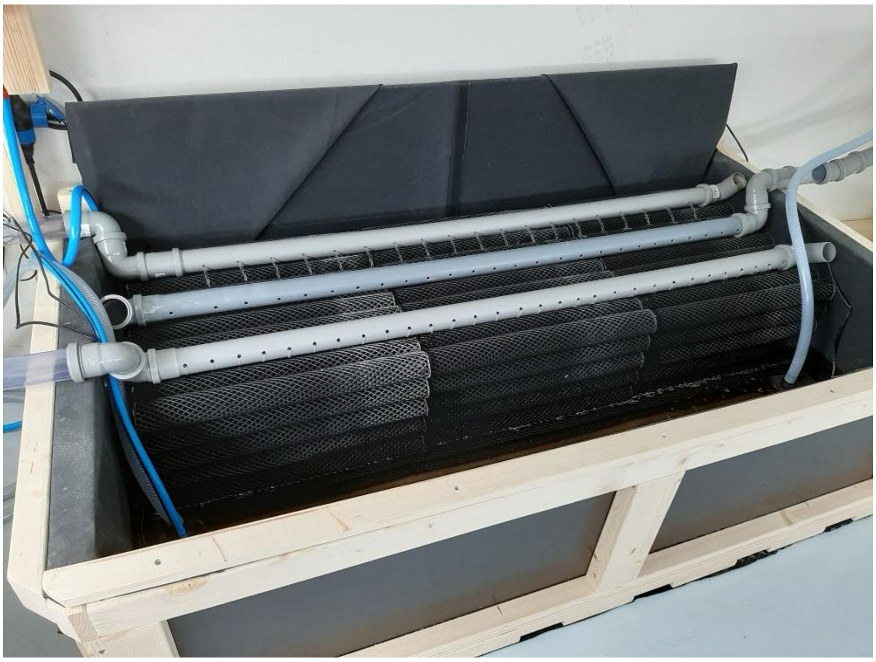

Fig. 10 – Biofilter installed in the sump tank. The biomodules chosen are used for on-site wastewater systems.

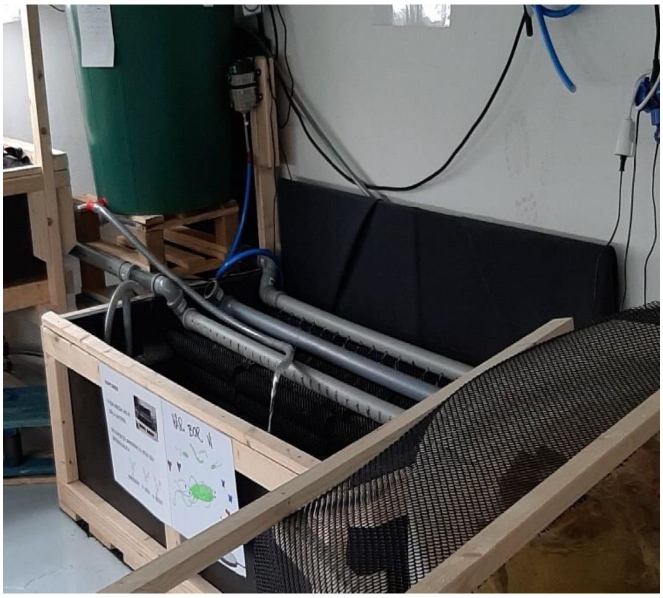

Fig. 11 – The image shows the aerator in the biofilter and a temporary tank used to fill in the sump with tap water (about 10 % of the total volume of water evaporates every month)

5.5 Growing beds

In soil-less farming there are three types of growing beds that can be used and they allow to adapt the system to the available space:

- Deep water culture (DWC): In this system, that consists of floating rafts, the plants have the roots fully in the water. There are 5 aerators in our DWC that is 7,20 m long to avoid the risk of anoxic environment that would lead to the loss of nitrates and the formation of toxic ammonia

Fig. 12 a – The Deep Water Culture (DWC) at Campus Roslagen when it was filled with water.

Fig. 12 b – DWC system at Johannas Stadsodlingar (Sweden), showing the plant roots.

- Media bed: The media-filled bed are often used for plants with bigger root area and they also have the function of biofilter, since bacteria can multiply in the vacuum spaces among the media particles. The media chosen must be neutral pH and inert, i.e. doesn't leak any potential toxic substance. The type of media usually used are gravel, volcanic stone, perlite, vermiculite, LECA (Light Expanded Clay Aggregate).

Fig. 13 a – One of the media beds filled with gravel.

Fig. 13 b – Detail of the gravel in one media bed

- Nutrient Film Technique (NFT): The plants are grown in pipes, allowing to grow vertically. It is recommended to give some slope to the pipes so that the roots do not stop or slow down the water flow. This type of growing bed will be used in the second demo of Campus Roslagen.

Fig. 14 – NFT at the system in Gröna Solberga, it allows to grow vertically.

The beds have been constructed with plywood and coated with rubber cloth to impermeabilize the beds. The DWC has been realised with styrofoam where the holes for the plants have been made manually. Both the pieces of plywood and of styrofoam had a width of 1,20 m, but due to the shape of the room we constructed the beds with a width of 60 cm otherwise it would have been very difficult for a person to reach the whole bed to harvest or plant.

While in the DWC the water flow is constant, in the media bed it is possible to choose either to have a constant water flow or to use a ebb and flood system (also called flood and drain system), where the bed is alternatively submerged and drained with water which ensures a good aeration of the bed. This method is the one used for all the media beds in Campus Roslagen. A commonly used methode of filling and emptying an ebb/flood system is using a bell siphon in a tank that has a constant water supply. The bell siphon is a construction where a bell that covers a high outlet pipe is creating a siphon when the water level rises enough to fill the bell. When the water the exits through the outlet pipe inside the bell, a siphon with a suction is created. The outlet pipe has a dimension large enough to allow a flow higher than the constant supply to the tank.

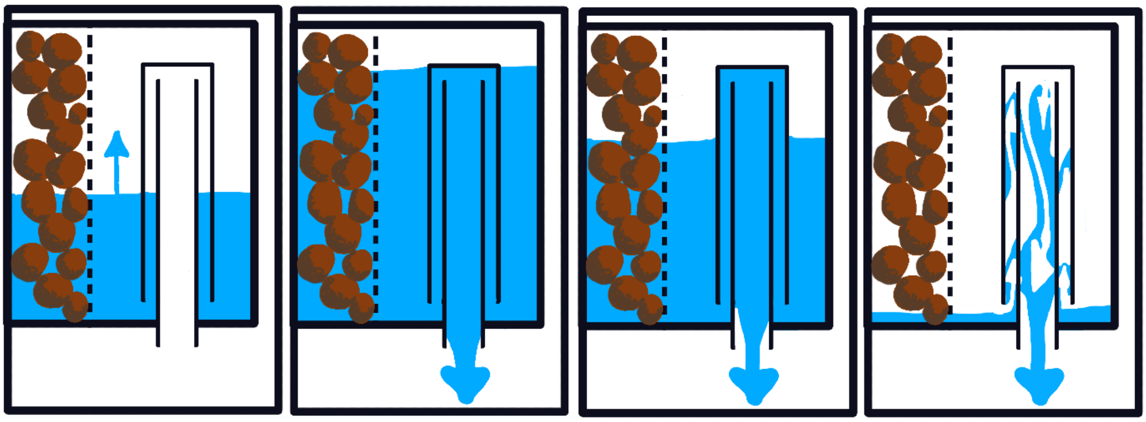

Fig. 15 – Representation of the bell siphon working principle.

As long as the water level outside the bell is higher than the bell opening at the bottom, the construction acts as a siphon and the water is sucked out of the tank. When the water level is low enough to allow air in to the bell, the siphon is disturbed and the suction stops, until the water level is high enough to start the cycle again.

In Campus Roslagen's demo we used another method to fill and drain, the ebb and flow system. Instead of a constant water supply we set a timer to the pumps that pump the water from the sump tankt to the media beds. The water is pumped for 30 minutes every three hours, filling the media beds to the desired maximum water level. The outlet from the media beds consits of a standing pipe with the height of the desired maximum water level, but the pipe also has a small hole at the height of the desired minimum water level. The lower hole in the pipe is not large enough to empty the tank when the pump is active; when the pumping cycle starts the water level rises until the top of the pipe is reached. The outlet pipe then keeps the maximum water level until the pumping cycle ends, and the water slowly exits the tank through the smaller hole until the minimum water level is reached.

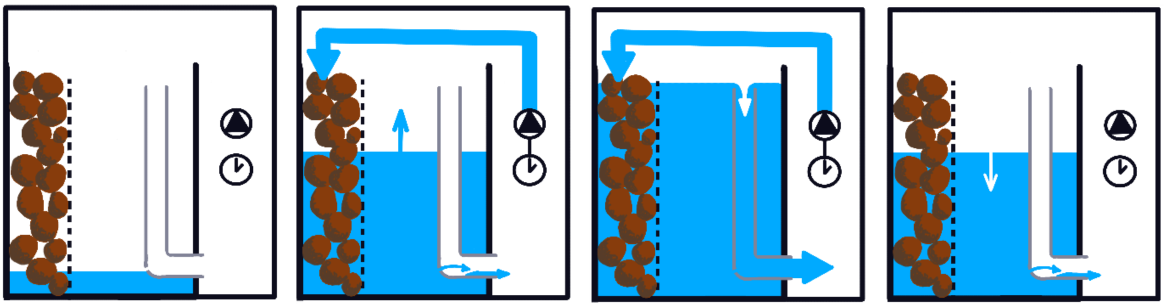

Fig. 16 – Representation of the ebb and flow working principle.

Media beds need to have three layers, from up to bottom: 1) the dry layer (max 5 cm), protects the roots from the light to prevent algae growth; 2) wet/dry layer (10-20 cm) where most of the biological activities happens thanks to the aeration provided by the ebb and flow system; 3) wet layer (max 5 cm), where mineralization happens, a process where solid particles are decomposed in smaller partciles that are easier to be absorbed by the plants.

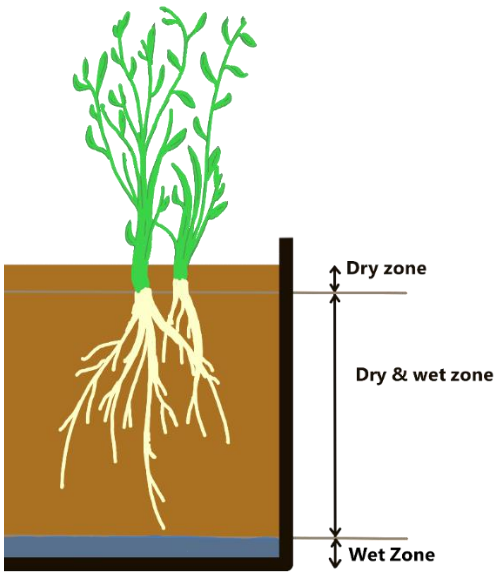

Fig. 17 – Stratification in a media bedd

The construction needs to be done in such a way to garantee the depth of these three layers, i.e. the position of the inlet and outlet of the siphon will determine the start and end of the wet/dry zone.

5.6 Flow rate calculation & pumps

The water flow principle of the demo at Campus Roslagen is such that the water is pumped from the sump to all the other tanks (fish tank, DWC and media beds) separately, and the tanks have separate outlets pipe connected directly back to the sump. The fish tank and the DWC has a constant flow of water, provided by two pumps with a flow rate up to 3 m^3/h (ideally, since the system has a head of roughly 0,5 meter and some meters of water hoses creating friction the water flow can be expected to be slightly less). But the flow rate is high and the water exchange rate is around 3 (exchanges per hour) in the DWC and 2 in the fish tank, enough to ensure a stable water quality with no significant differences between the inlet and outlet of the tanks.

The media beds with ebb/flow have smaller pumps that provide around 1 m^3/h to the beds which is a suitable flow for filling the beds with some margins in 15 min. The principle of the ebb/flow system in Campus Roslagen media beds is described in chapter 5.5. The timers controlling the pumps to the three different media beds are programmed to start with one hour delay from the start of filling the previous bed in order not to empty the sump by filling two media beds at the same time. This principle makes 15 minutes of filling time suitable, allowing for 45 minutes to empty the bed before the next bed is filled.

All the pipes in the demo are in food graded plastic material.

5.7 Back-up system

A back-up system is crucial when unexpected faults occur. Before designing a back-up system, efforts has to be put in to a risk assesment (see par. 7) in order to back up the most important components that are most likely to fault.

For example, in Campus Roslagen demo the most fragile system, sensitive to technical failiure, is the fish tank. If the pump that pumps water to the fish tank faults, the fishes will be harmed by decreasing oxygen and rising levels of toxins in the water. One obvious risk for this to happen is a power outage, but just as likely the pump itself might (or *will*, sooner or later) stop working. By installing a second, smaller pump besides the main one the concequense of a pump failure was easily reduced from crucial to slightly problematic.

As for a power outage at Campus Roslagen demo site, the main issue is to keep the fishes healthy. The growth rate of the plants will of course be reduced due to lack of lighting, the plants in the DWC might be disturbed by the lack of water flow and the room temperature will slowly drop, but the hydroponic unit will not be permanetly damaged by a power outage.

There is of course a wide range of back-up systems in capacity and cost. The system designed for Campus Roslagen demo site is a very small and cheap one, but fairly fail-safe and capable of running a water pump and an air pump for several days.

The system consists of a set of 12V acid lead batteries (deep cycle batteries usually used in of-grid solar systems or leisure boats), a battery charger for keeping them in shape, two voltage converters (12VDC -> 230VAC and 230VAC -> 12VDC) and a relay.

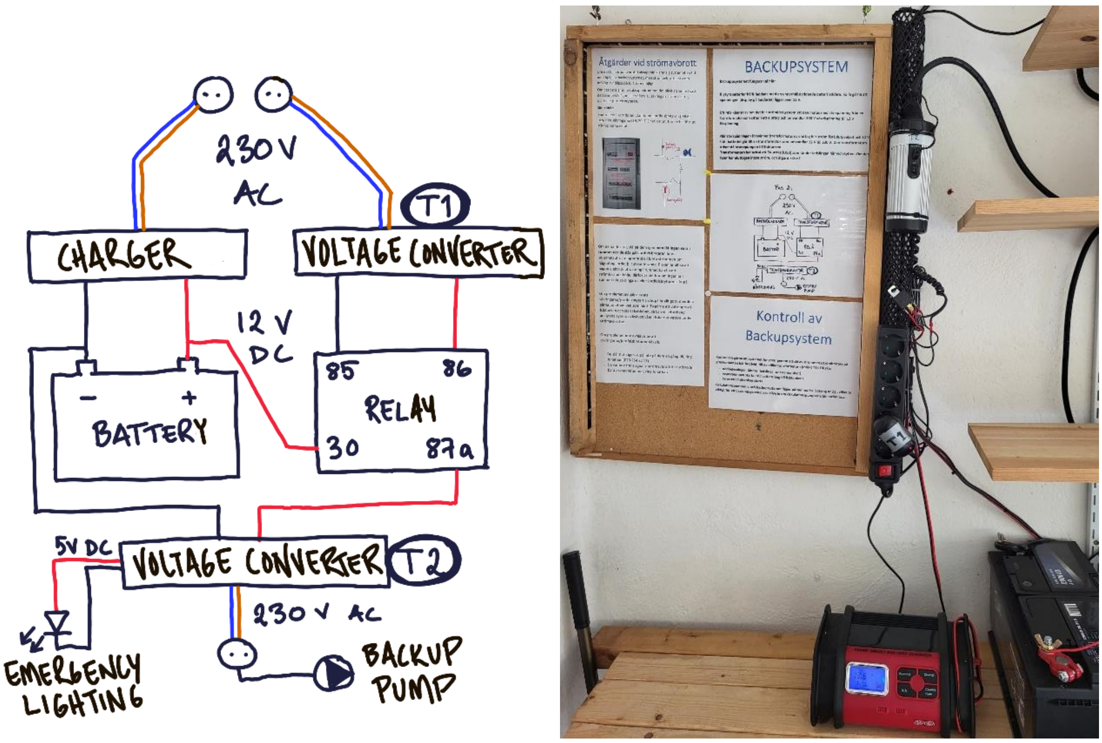

Fig. 18 – Schematization of the back-up system

5.8 Lights

Plant growth require both light and darkness. During the day, sunlight helps the plant producing energy through photosynthesis, while during the night energy is broken down for plant growth. It is important to give plants both light and darkness and at least 8 hours of darkness.

Most of fish species thrive in conditions with alternation of light and dark periods. However, depending on the species, some fish prefer light conditions while others thrive better in darker conditions.

In Campus Roslagen's demo full spectrum LED (Light Emitting Diode) lights are used. Plants use red and blue light to grow, therefore it is necessary to look at the distribution of red and blue light when choosing the lamp. However, full spectrum lamp are more pleasant to look at, especially since we will have visits to our demo.

<u>LED ligts used in the demo:</u>

- LEDlife 50W Philips LED plant light
  112.5 cm, RA95, full spectrum (White light), IK05, IP65

Actual consumption:	50W
Input:	100-277V 50/60Hz
LED Brand:	Philips
Wave-length:	Full Spectrum
Dimension:	28*1125*50mm
Working temperature:	-20 to 45°C
Light diffusion:	120°
Height above plants:	20cm to 60cm
PAR (center value):	280 ppfd 15 cm, 150 ppdf 30cm, 80 ppdf 60cm
Light hours per day:	10-12 hours
Size:	50 cm x 112.5 cm

Lifetime:	50,000 hours
Weight:	0.6 kg

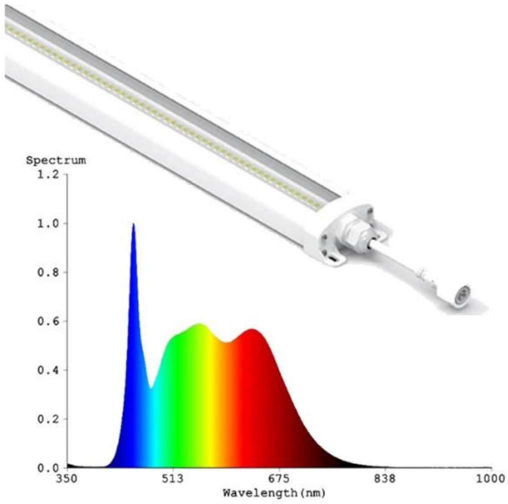

Fig. 19 – Spectrum of LED life 50W Philips

- LEDlife Pro-Grow 2.0 plan light
  120cm, 18W LED, full spectrum (White light), IP65

Actual consumption:	18W
Voltage:	230 V
LED Brand:	Philips
Wave-length:	Full Spectrum
Dimension:	1200 x Ø25 mm
Height above plants:	10cm to 25cm
PAR (center value):	128 ppfd 10 cm, 77 ppdf 25 cm
Lifetime:	50,000 hours

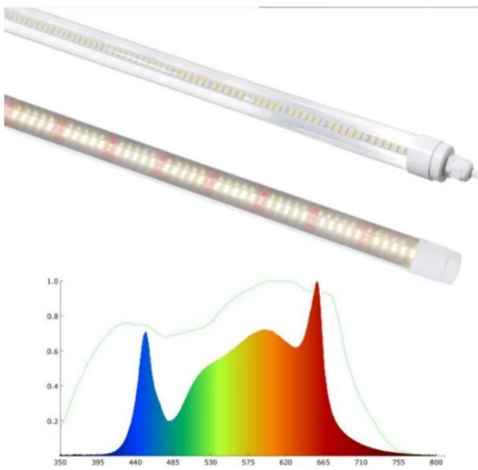
Fig. 20 – Spectrum of LEDlife Pro-Grow 2.0 plan light

- LEDlife 30W LED plant lamp
  E27, RA97, full spectrum

Actual consumption:	30W
Voltage:	230 V
LED Brand:	Philips
Wave-length:	Full Spectrum
Dimension:	1270 x Ø95 mm
Neutral white color:	5000K
Lifetime:	20,000 hours

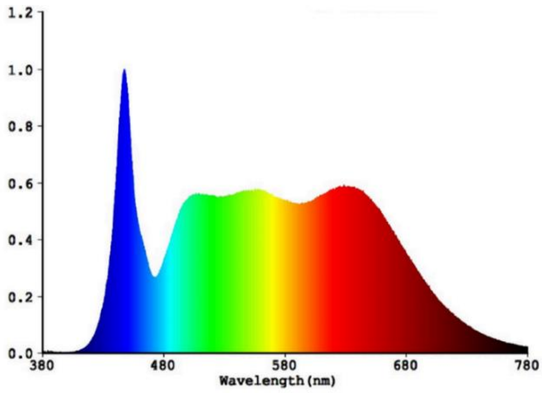

Fig. 21 – Spectrum of LEDlife 30W LED plant lamp

6 Fish and plants selection

When selecting the species to have in an aquaponics system it is important to keep in mind that fish and plants have to be able to live under similar environmental conditions, especially temperature and pH.

The selection of species started from the choice of the fish species: We have chosen tilapia, the most farmed species in aquaponics in the world, since it is very resistant to changes of water quality.

The temperature range for tilapia is 17-36 ◦C, while it thrives and grows faster between 26 – 30 ◦C. The wide range of temperature that this fish can stand allow to grow a variety of plants.

So far spices such as basil, thyme and dill have been grown and performed well.

7 Risk assessment

Before starting an aquaponics system, it is necessary to assess all the problems that could happen and be as prepared as possible to face them. A risk assessment is a tool that classifies risks depending on their likelihood to happen and the impact that the risk has if it happens. The actions to take to mitigate the risks is based on cost-benefit analysis. A way to conduct a risk assessment that is as complete as possible is to organise a workshop with experts; if this is not possible then conducting one-to-one interviews in an alternative.

For the risk assessment of the aquaponics demo at Campus Roslagen we used a 1-3 scale for likelihood and impact, the resulting risk matrix is the following:

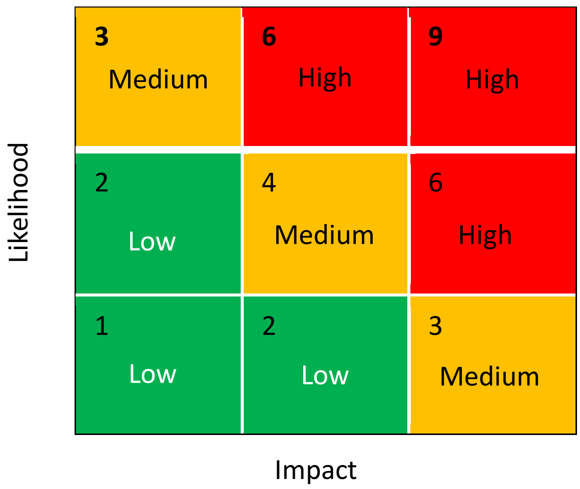

Fig. 22 – Risk assessment matrix. Risk value is the combination of likelihood and impact. The values coloured in green indicate low risk, the ones in yellow medium risk, the ones in red high risk.

The classification in low, medium and high risks allows to prioritise the risks.

The risk assessment needs to be updated periodically, in attachment 1 reported the first risk assessment that was implemented.

After the risk assessment it is necessary to elaborate a risk assessment plan, where to every action is assigned a responsible person, a deadline to carry on the action as well as a follow up schedule.