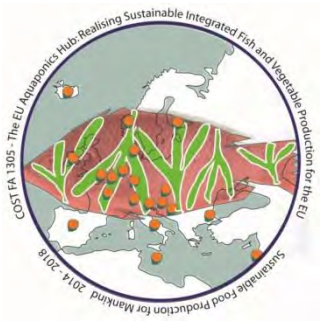


Zurich University of Applied Sciences

zh aw

Life Sciences and Facility Management

Institute of Natural Resource Sciences

Aquaponics research at ZHAW, Switzerland: past, present, future

Ranka Junge, Andreas Graber, Alex Mathis, Zala Schmautz

International conference “Aquaponics research matters”
Ljubljana, 22 March 2016




The Past: 1999 - 2012




Main Questions 1999-2012

- Does it work?
- How to build a (simple) system for temperate climate?
- Which plant varieties are possible?
- Comparison with traditional cultivation
- Where can AP be implemented?

R & D projects 1999-2011

- 1999 – 2001 Ecological Improvement of Greenhouse Cultivation by Integration of Aquaculture: Tropenhaus Ruswil (CTI Project)
- 2004 – 2007 Aquaponic as new source of income for swiss farmers (FOAG)
- 2005 – 2008 Play with Water: Introducing Ecological Engineering to Primary Schools (EU FP6 Science and Society)
- 2006 – 2008 Construction of an aquaponic system as a sustainable agricultural model; Bohorok, Sumatra (Indonesia). (SwissContact)
- 2009 – 2010 VeggieFish - Development of nutritionally balanced diets for Nile tilapia using cheap and locally available ingredients for sustainable rural aquaculture development in Uganda KFH Development Cooperation

1999-2001: Ecological Improvement of Greenhouse Cultivation by Integration of Aquaculture

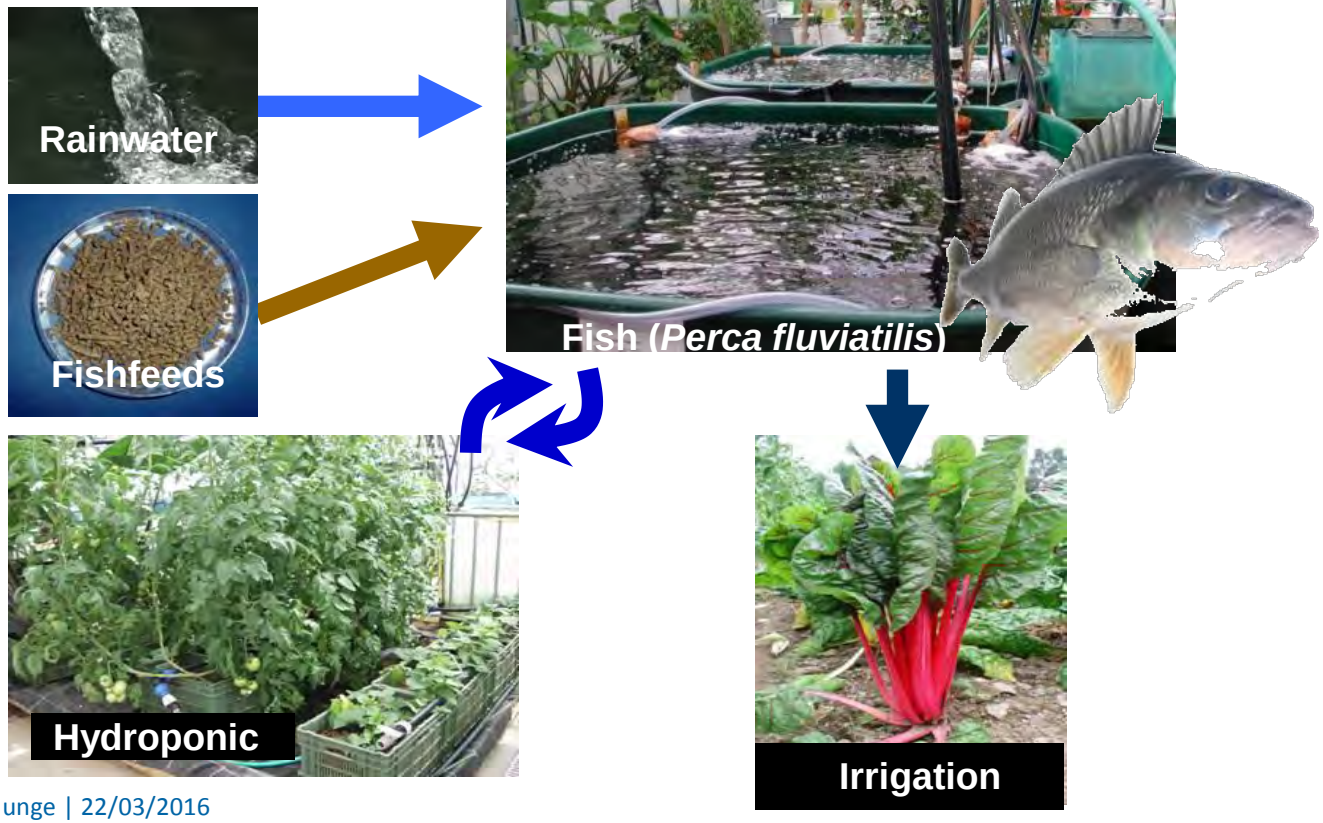
Basins with floating plants

Basins with Tilapia

Tropenhuus RUSWIL

IG ABWÄRMENUTZUNG

2004-2007: Aquaponic as new source of income for swiss farmers ➔ AquaLab 1



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Volkswirtschaftsdepartement EVD
Bundesamt für Landwirtschaft BLW

Recirculating Aquaculture Systems for an integrated fish and plant production

The project aimed at technical development of the systems, and their implementation into commercial production sites.

According to the frame conditions, two forms of Aquaponic were tested:

- technically sophisticated intensive cultures of Eurasian perch *(Perca fluviatilis)* and with higher infrastructure costs
- low-cost, extensive cultures for brown trout *(Salmo trutta fario)* and herb production in the Swiss mountainside, coupled with agrotourism development and direct marketing (restaurants, hotels)

The project was financed by Swiss Federal Office for Agriculture, 2004-2007.

Bundesamt für Landwirtschaft
Office fédéral de l'agriculture
Ufficio federale dell'agricoltura
Swiss Federal Office for Agriculture

Fish species tested in Aquaponic

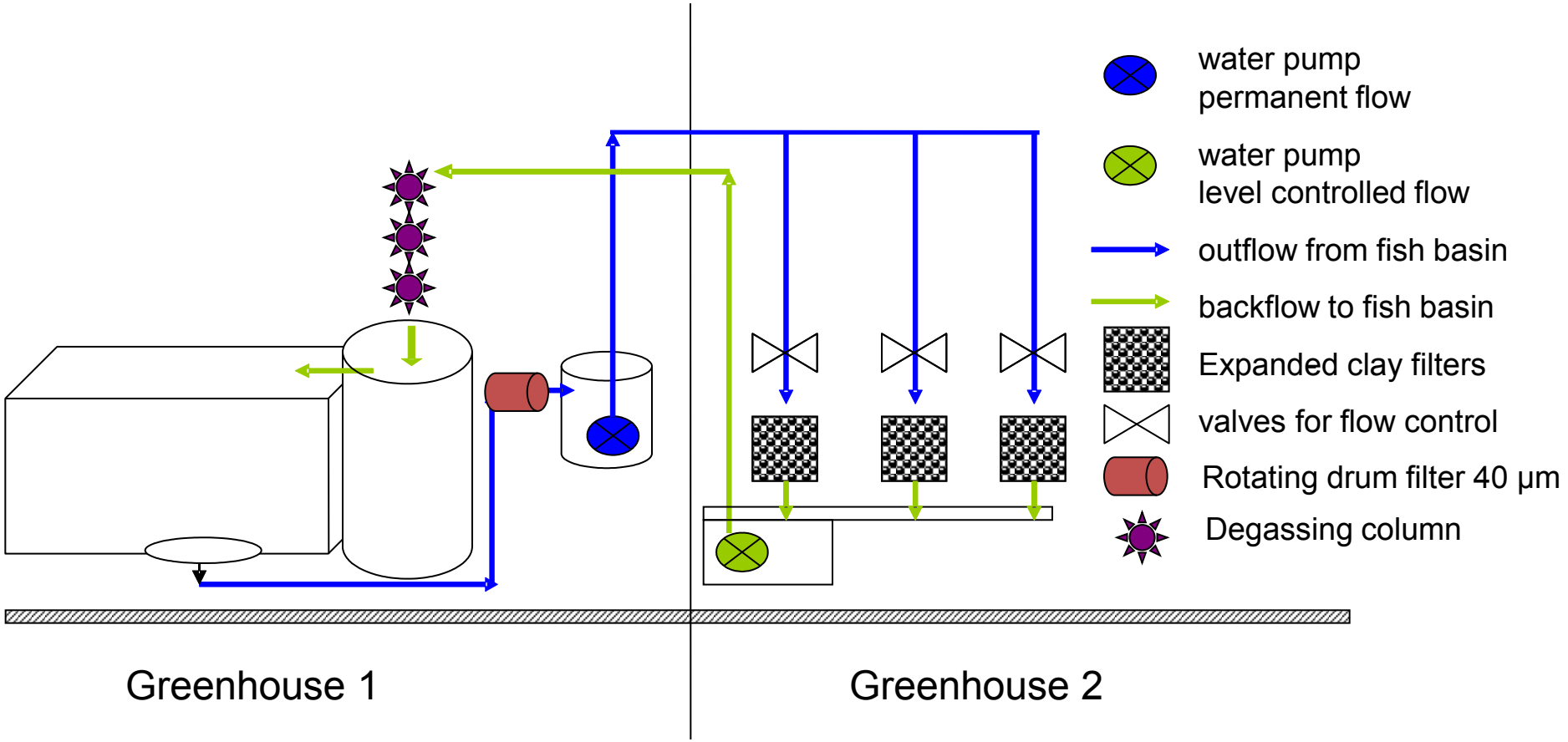
Tilapia *(Oreochromis niloticus)*
Tropenhaus Ruswil, Aquaponic ZHAW
1999 – 2004, 2007 - heute

Bachforelle *(Salmo trutta fario)*
Aquaponic Berggebiet (Wergenstein GR)
2004-2005

Flussbarsch, Egli *(Perca fluviatilis)*
Aquaponic ZHAW
2004 - 2007

Regenbogenforelle *(Oncorhynchus mykiss)*
Aquaponic Berggebiet (Donat GR)
2006-2007

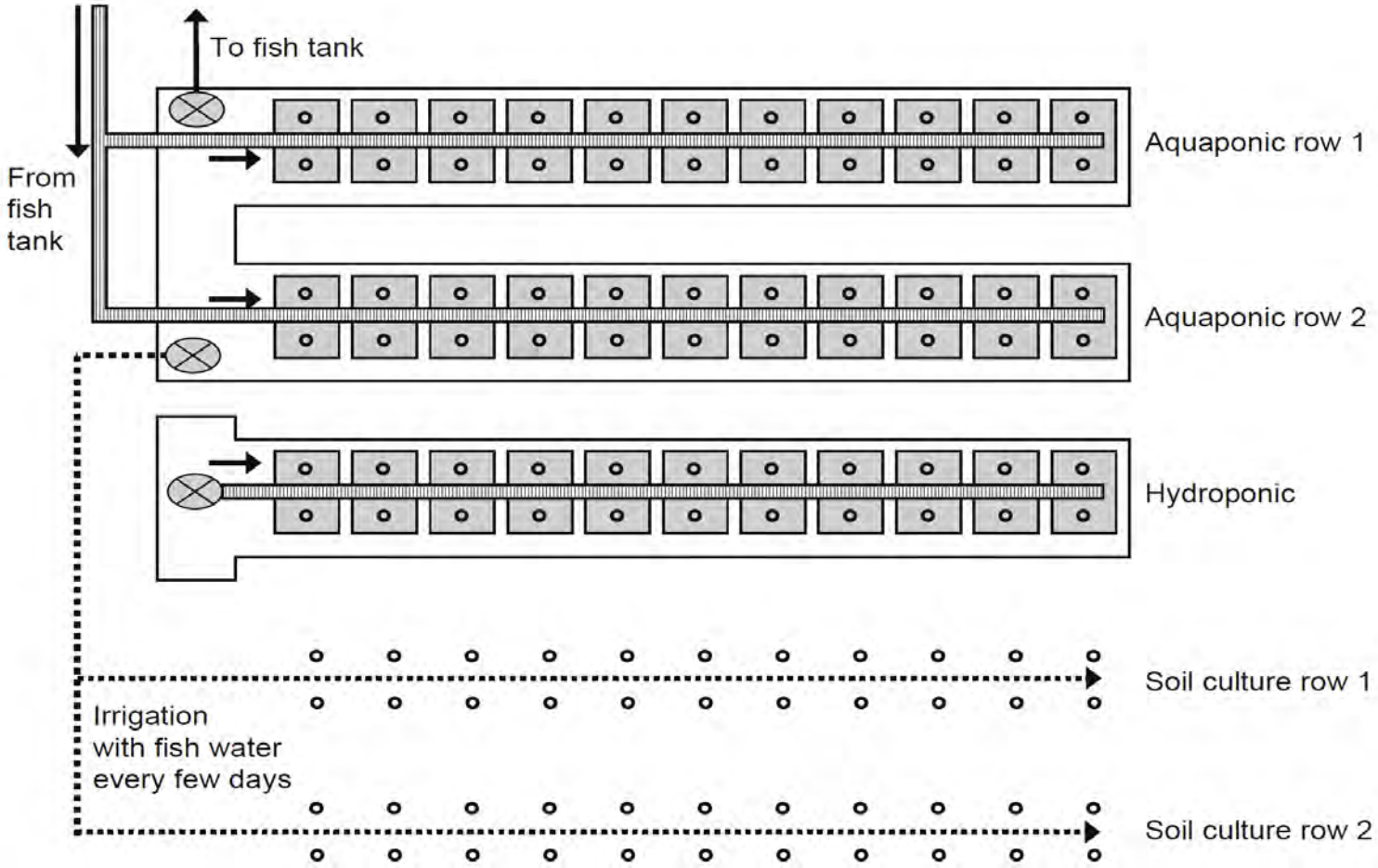
Aquaponic research unit for eurasean perch: side view



Bundesamt für Landwirtschaft
Office fédéral de l'agriculture
Ufficio federale dell'agricoltura
Swiss Federal Office for Agriculture

A. Graber and R. Junge / Desalination 246 (2009) 147–156

Aquaponic research unit for eurasean perch: top view of plant production

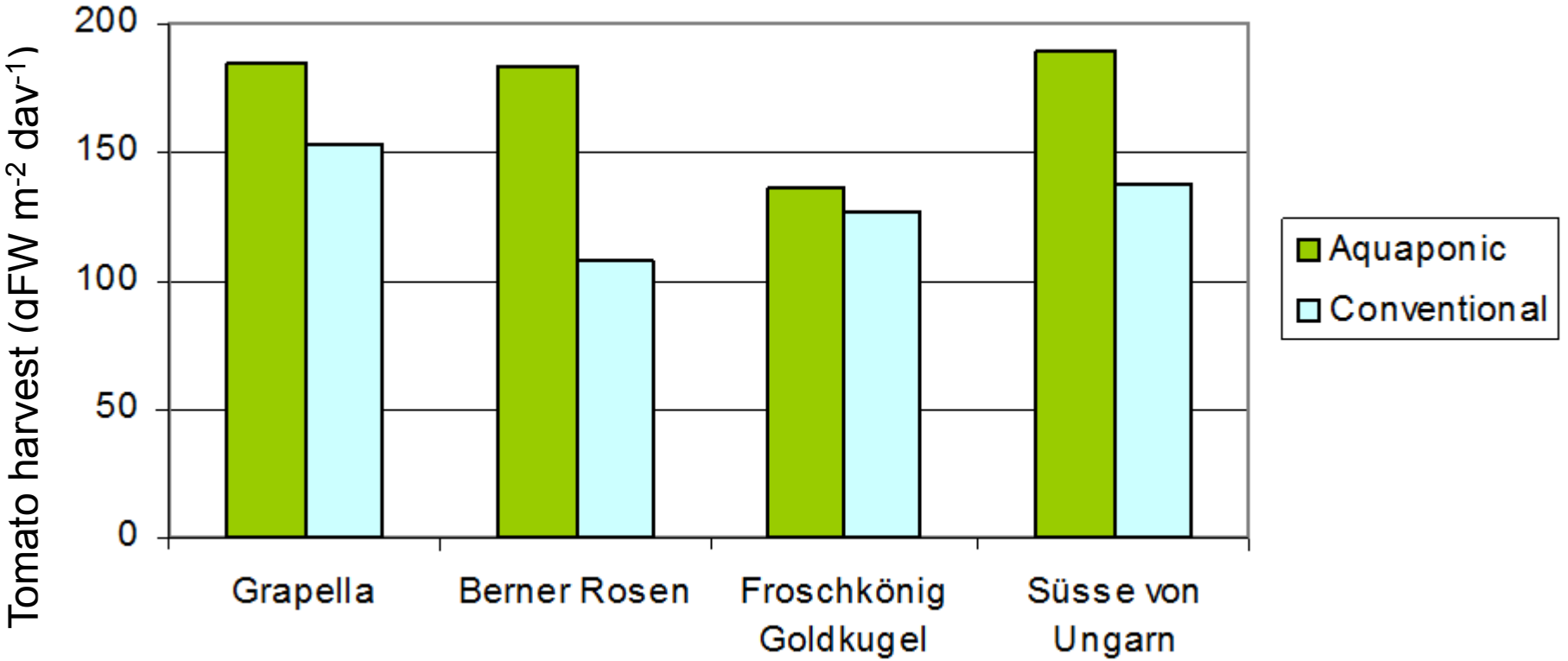


Plant production in top view with expanded clay boxes (□), water pumps (⊗), plant locations (o), water col-sheets underneath (▭) and water flows (continuous ⟶ and on demand ⋯▸).

Comparison of cultivation in aquaponics with conventional hydroponic

Hirsch 2005, Frei & Nenniger 2005, Wenger 2004

Performance of tomato varieties in conventional hydroponic and aquaponic



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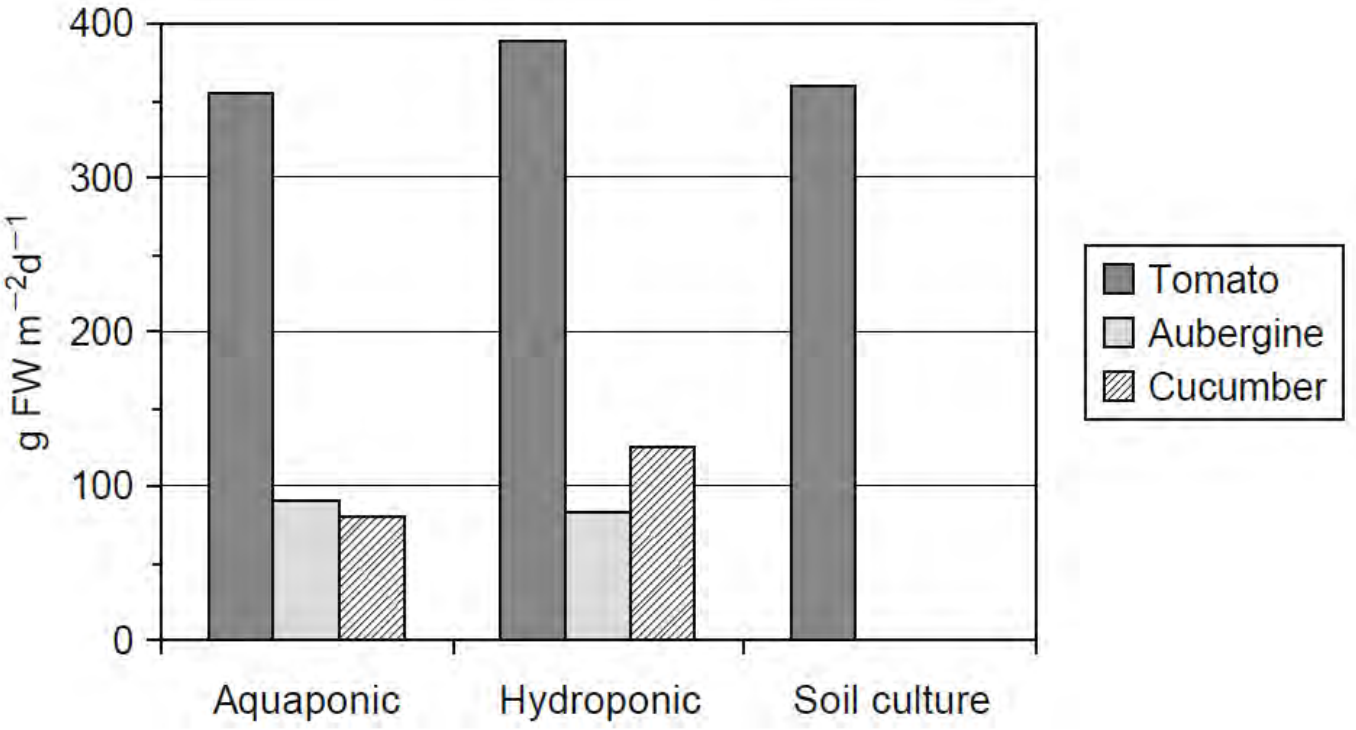
Fruit yields of tomatoes, aubergines and cucumbers



A. Graber and R. Junge / Desalination 246 (2009) 147–156

Aquaponic for alpine regions Experimental plants: Wergenstein & Donat



Products: Flowers, Herbs, Strawberries, Trout





The Present: 2012 - 2015




Main Questions 2012 - 2016

- Pathway to commercialization
- How to build an efficient and stable system with OTC elements?
- Which plant varieties?
- Standardized operation (Safety, SOP)
- Zero waste AP

R & D projects 2012 - 2015

- 2012 – 2014 UF Controller: Aquaponic process control system for urban farming (CTI).
- 2012 – 2014 AQUA-VET. Introducing Aquaponic in VET: Tools, Teaching Units, and Teacher Training (CH. EU-LEONARDO).
- 2012 – 2014 ZEB - ISTIS Zero Emission Buildings - Integrating Sustainable Technologies and Infrastructure Systems (EU-KORANET).
- 2013 – 2014 AQUA-SAFE: Enhancing safety and security of Aquaponics technology for fish and vegetable cultivation (SCIEX-NMS).
- 2014 – 2018 COST FA 1305 The EU Aquaponics Hub - Realising Sustainable Integrated Fish and Vegetable Production for the EU.
- 2015 – 2017 AQUA-ROM: Implementation of aquaponic technology in Romania (Swiss-Romanian Cooperation Programme).
- 2015 – 2018 Development of a recirculating aquaculture system for the production of noble crayfish, grayling and plants (CTI).

2011: ZHAW Spin-Off Urban Farmers

- UrbanFarmers AG is a **clean-tech start-up** & Spin-off from the University of Applied Sciences (ZHAW) in Wädenswil, Switzerland
- UF develop **cost-efficient**, **sustainable** and **reliable** systems to **grow food in the city at large scale**
- The benefit for UF customers is **fresh & healthy food**, produced in a safe environment, **directly at the point of consumption**, eliminating emissions, transportation distances and cost.

Roman Gaus

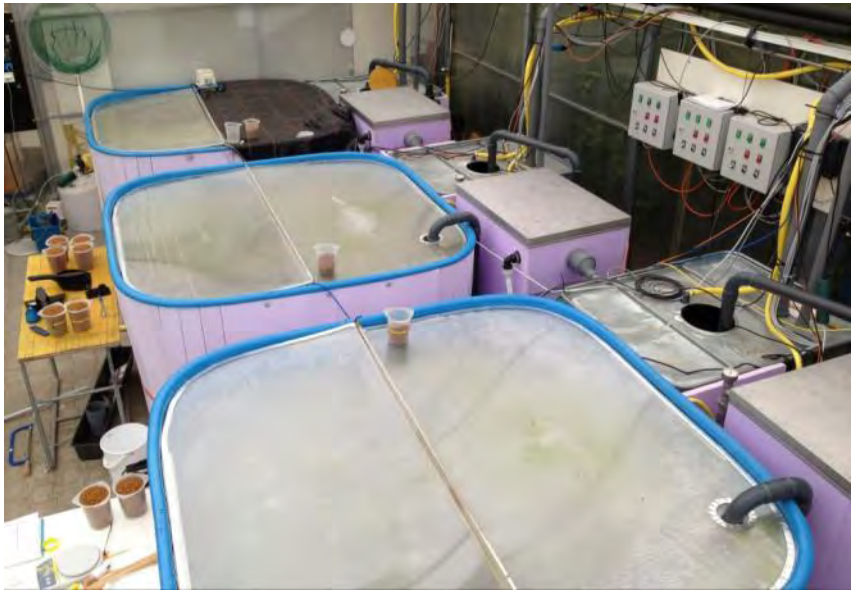
Andreas Graber

Rooftop Aquaponic in the City: “LokDepot-Basel” as 'proof of concept‘

Key figures:

- 250 m^2 of production space
- Construction budget US$ 900’000
- Start of operations: 01.12.2012
- Capacity of 5 t of vegetables, 800 kg fish = Supply for 80-100 people

Aquaponics Lab2 at ZHAW: established 2013

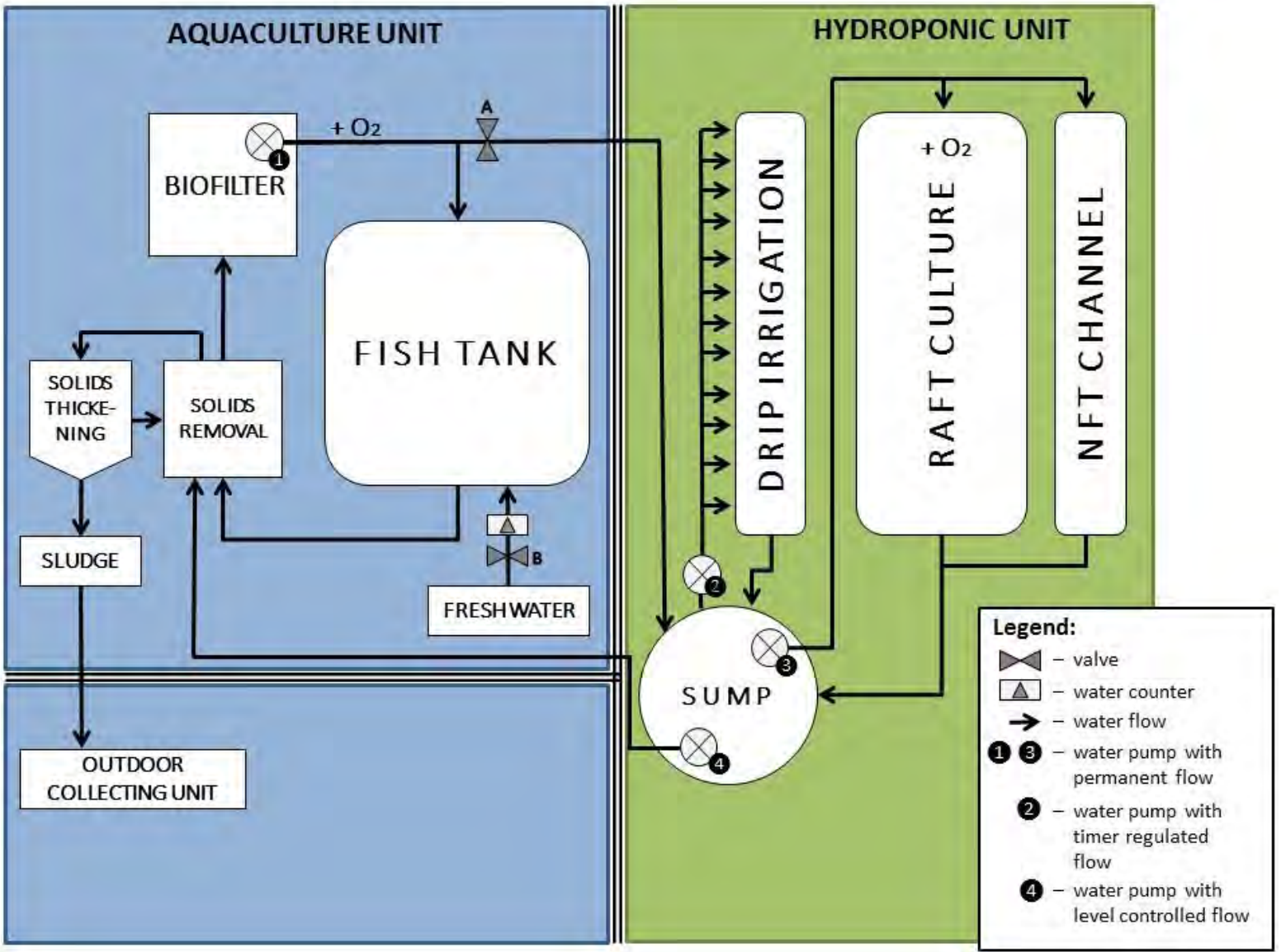


3 separate RAS systems of 4 m^3 each

3 separate Hydroponic systems (can be modified according to experimental setup)

Extra: 9 mesocosm aquaponic units

Design of “Waedenswil” aquaponic system



2014: Tomato production in aquaponic system: mass balance and nutrient recycling

Zala Schmautz* [1], Andreas Graber [1,3], Alex Mathis [1], Tjaša Griessler Bulc [2] and Ranka Junge [1]

[1] ZHAW, Institute Natural Resource Sciences, Wädenswil (Switzerland)

[2] University of Ljubljana, Faculty of Health Sciences, Ljubljana (Slovenia)

[3] Urban Farmers AG, Zurich (Switzerland)

Objective: To **examine the distribution and possible losses** of nutrients within the aquaponic system by determining the mass balance for particular **macronutrients** (C, N, P, K, Ca, and Mg) and **micronutrients** (Fe, Mn, Zn, and Cu).

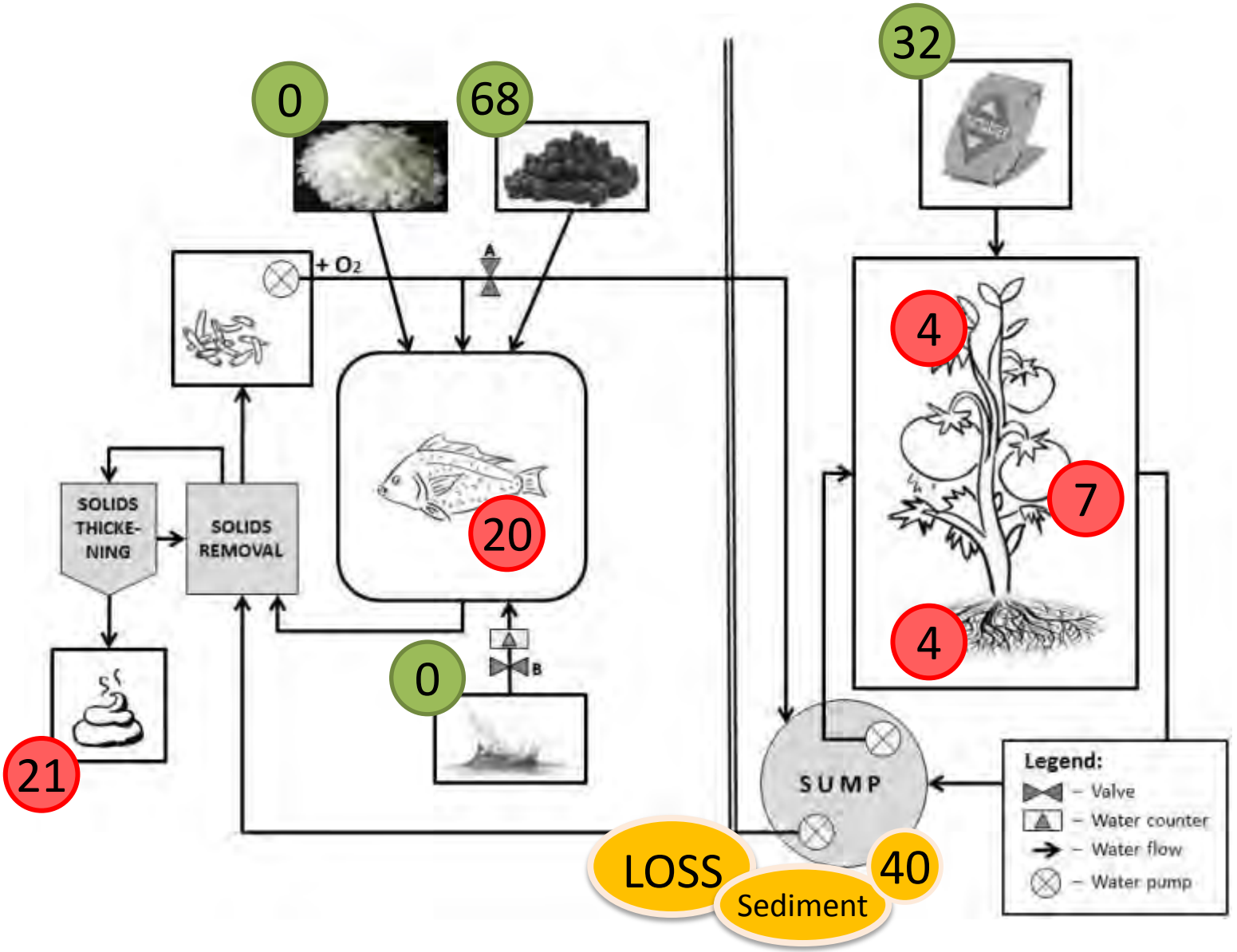
Comparison of three HP methods

DRIP IRRIGATION

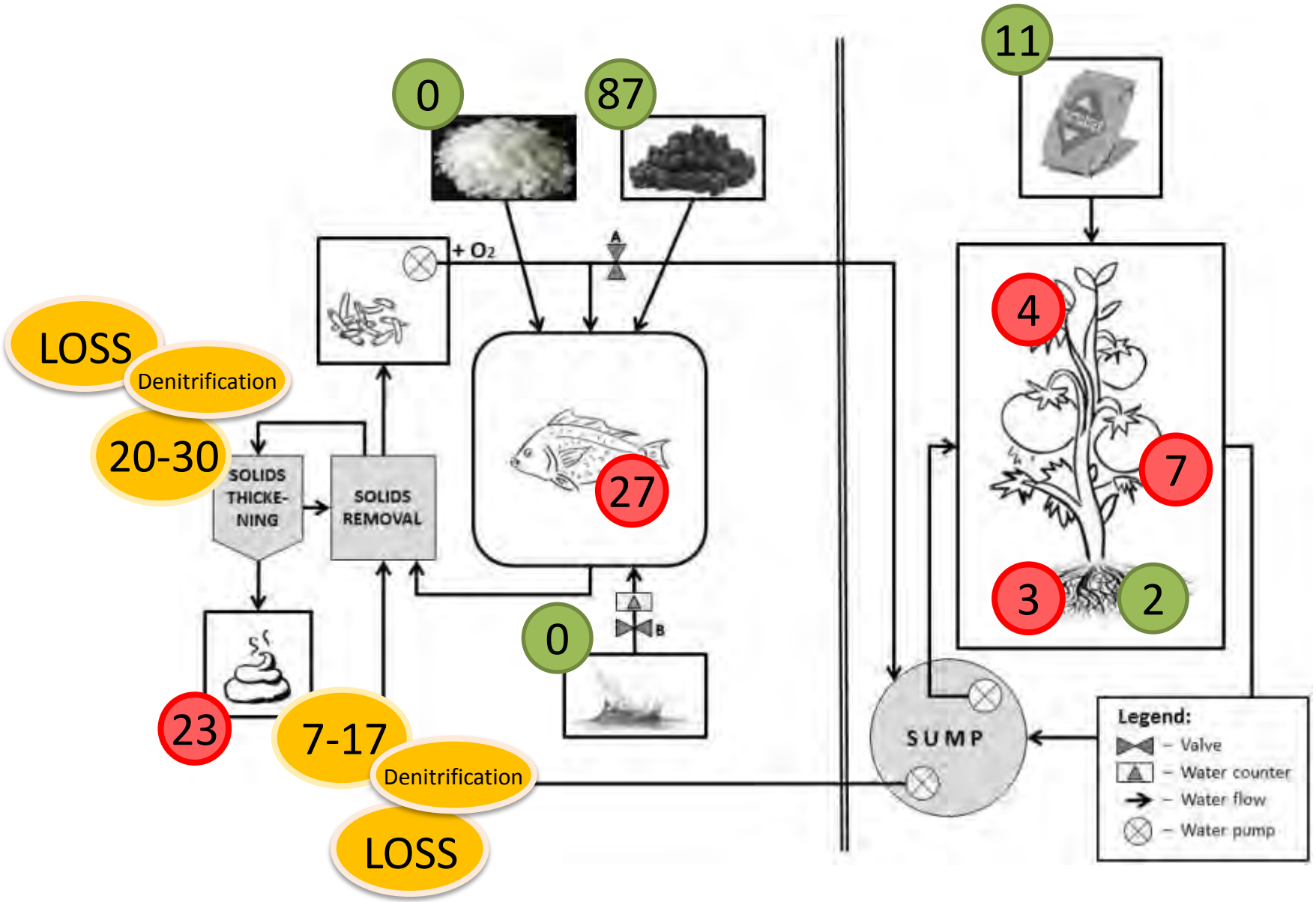
RAFT CULTURE

NFT CHANNEL

Phosphorus


0
68
32
+ O2
A
4
SOLIDS THICKE-NING
SOLIDS REMOVAL
20
7
4
0
B
21
SUMP
Legend:
– Valve
– Water counter
– Water flow
– Water pump
LOSS
40
Sediment

Nitrogen


0
87
11
+ O2
A
LOSS
Denitrification
20-30
SOLIDS THICKE-NING
SOLIDS REMOVAL
27
4
7
3
2
0
B
23
7-17
Denitrification
LOSS
SUMP
Legend:
– Valve
– Water counter
– Water flow
– Water pump

2012-2013: AQUA-SAFE: enhancing safety of aquaponics technology for fish and vegetable cultivation

Ivaylo N. Sirakov, Matthias Lutz, Andreas Graber, Alex Mathis, Yordan Staykov, Ranka Junge (in preparation)

The study present the results of the first ever search for beneficial bacteria that exert simultaneous biological control of both plant and fish pathogens. 1365 isolates were sampled from different parts of Aquaponic System .

In vitro tests revealed that 1.27% of these isolates exerted simultaneous suppressive effects on plant (*Pythium ultimum* etc.), and on fish (*Saprolegnia parasitica*) pathogens.

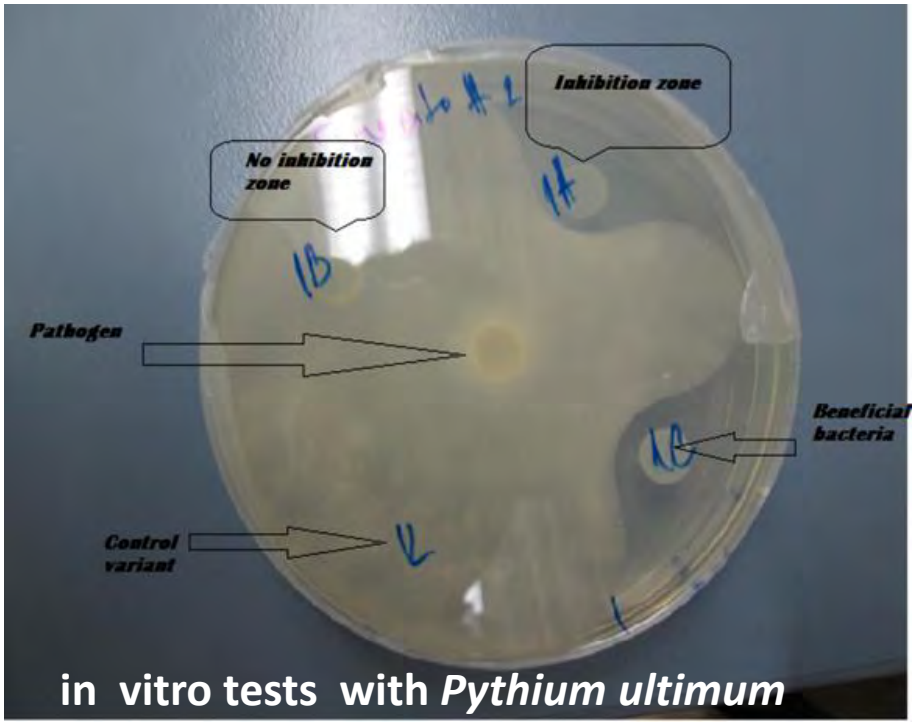
These findings open new options for the implementation of biological disease control in aquaponics, where plants and fish are cultivated simultaneously in the same water recirculating system.

Isolates & *in-vitro* tests

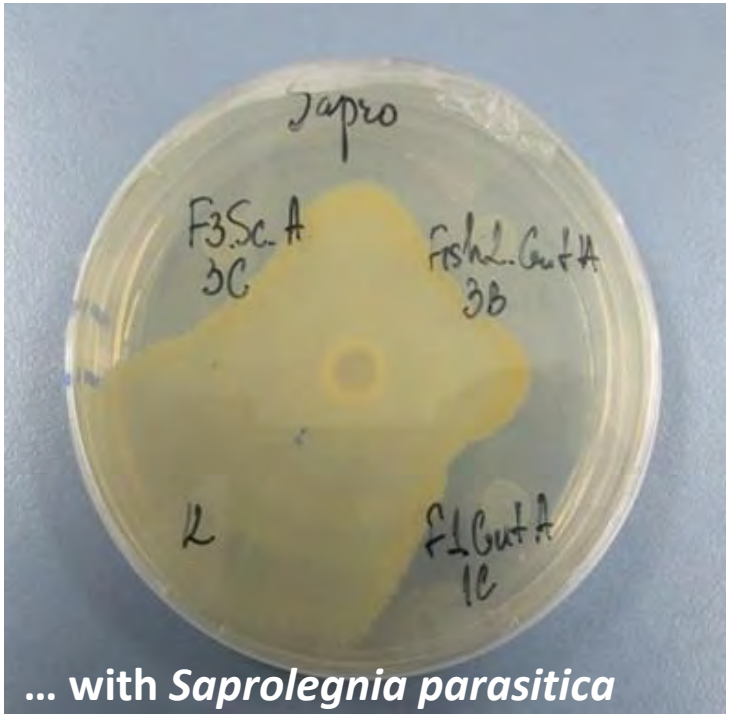
1365 isolates from different parts of the aquaponic system, plants and fish were samples.

The separate colonies were enriched and used in challenging tests with pathogens (*Pythium ultimum* and *Saprolegnia parasitica*).

The tests with the best 50 strains, which had antagonistic effects against *Pythium ultimum* showed that 30 of them also had an inhibition effect of >50% against *Saprolegnia parasitica* .

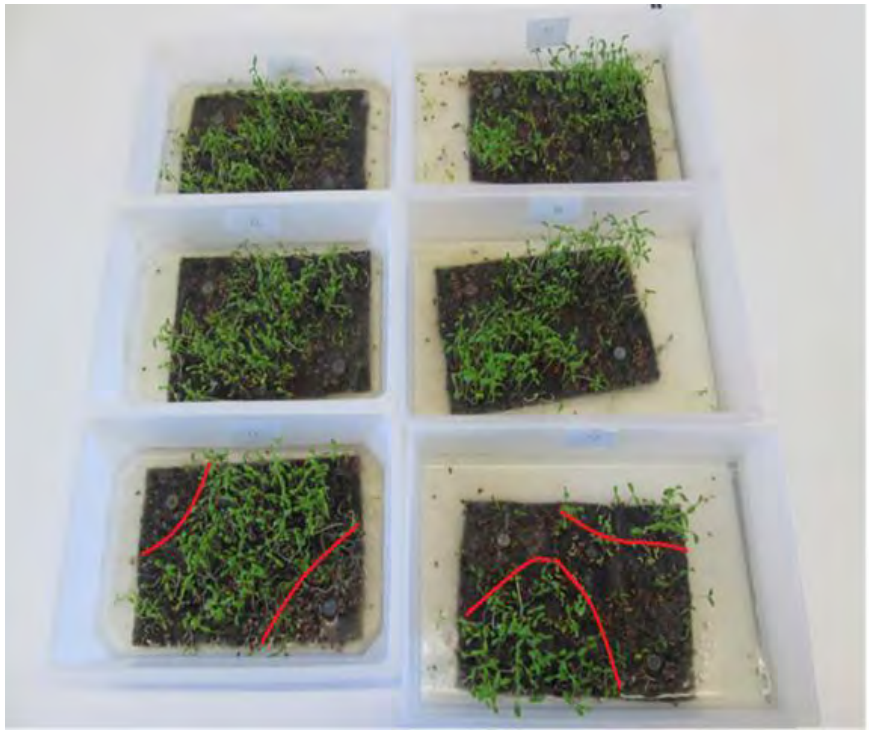


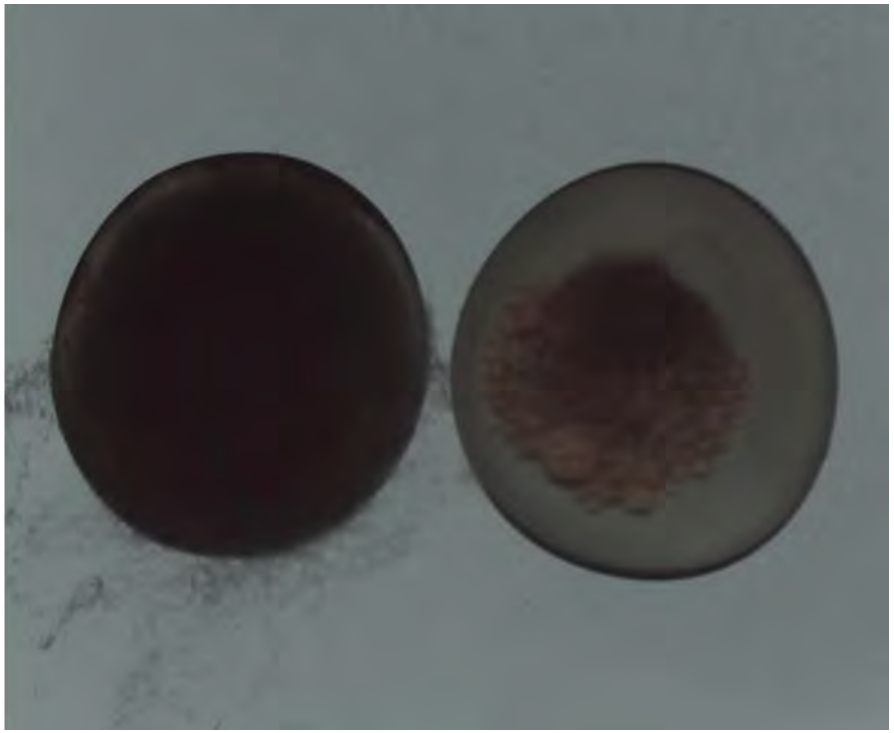
in vitro tests with *Pythium ultimum*



… with *Saprolegnia parasitica*

The *in vivo* tests with plants and fish eggs



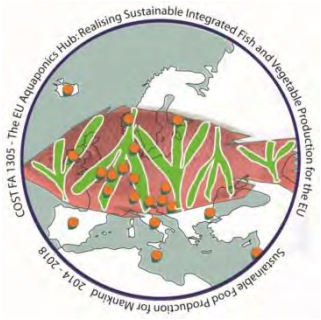


PROGRAMUL DE COOPERARE ELVEȚIANO-ROMÂN
SWISS-ROMANIAN COOPERATION PROGRAMME

2012-2017 Implementation of aquaponic technology in Romania to benefit health and sustainable livelihood in deprived areas

A joint project by HORTING, AQUATERRA & ZHAW

- **Establish** a long-term partnership between Romanian (HORTING, AQUATERRA) and Swiss (ZHAW) Institutions in order to contribute to poverty reduction in deprived areas and promote the principles of healthy diets based on Aquaponic systems.
- **Develop** and promote Aquaponic Technology as sustainable, resource efficient technology in urban and rural areas of Romania.
- **Set up** appropriate channels for promoting, training programmes and consulting system for interested farmers, students, policy makers and business people.



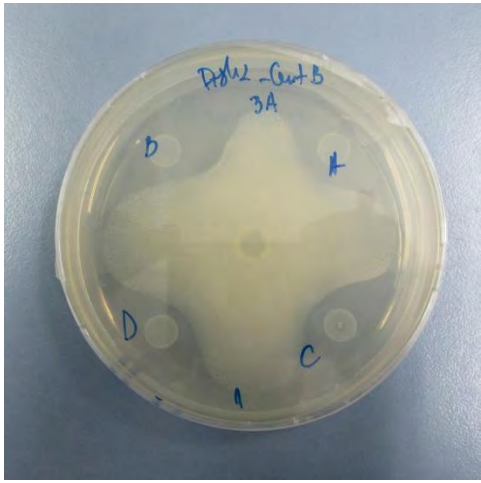
2015: COST STSMs

Boris Delaide: Experiment of aerobic sludge mineralisation

Valentina Nozzi: Comparison of different nutrient management in hydroponic and freshwater aquaponics systems: effects on lettuce, mint and mushroom plants

Simon Goddek: Influence of different fertilization regimes on the quality and quantity of lettuce in aquaponic systems



The Future: 2016 - .....



What interests us in 2016 - and beyond....

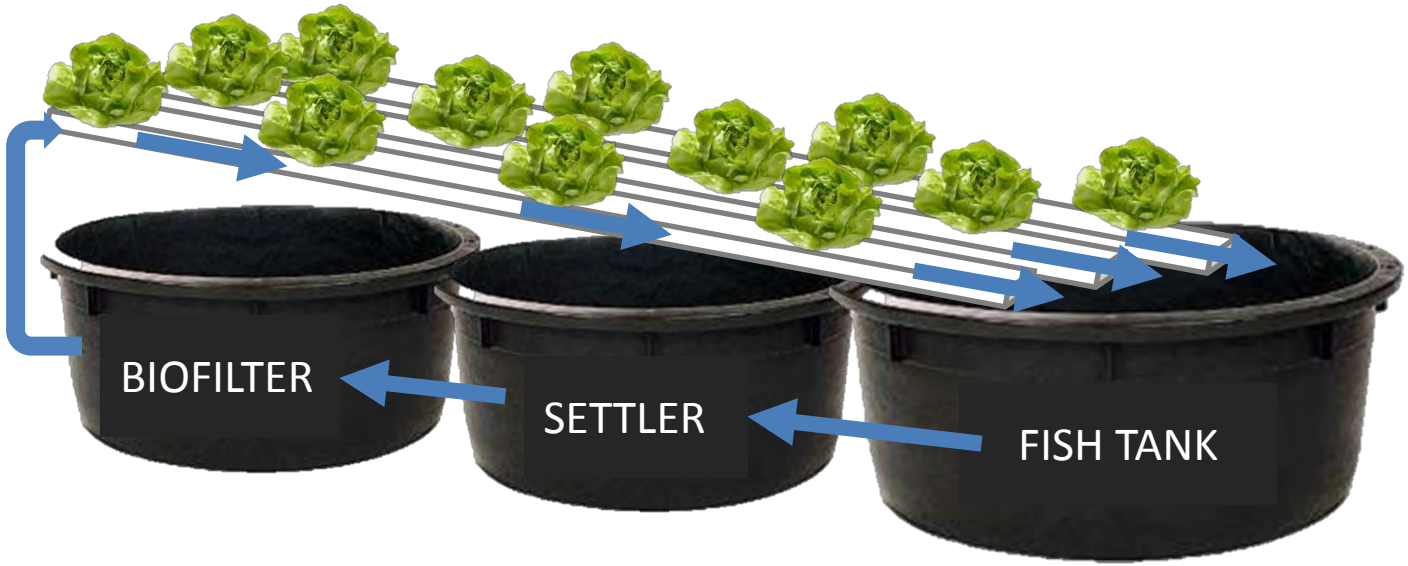
- Nutrient cycling in closed loop AP: precise fate of nutrients, microbial processes
- Pest and disease control
- Optimal nutrition for fish (algae, non-toxic, vegetarian, ...)
- Efficiency of low-tech systems
- New varieties of vegetables, and fish

Renovation & upgrade of 3 full scale systems

- New control system (LINN)
- New drum filters (option for salt water culture)
- Options for bypass
- Renovation tables for raft cultures
- New irrigation system
- New/additional pumps
- Electrical installations
- O2 emergency supply
- SMS Alarm

Renovation & upgrade of 9 mesocoms scale systems

- New/additional pumps
- New heaters
- Electrical installations



PhD Zala Schmautz: Mass balance, nutrient recycling, and microbial communities in Aquaponics

The dynamics and spatial variation of the microbial community structure in AP systems is not known. A comprehensive study of community structure over time and in different compartments will be performed to gain understanding of the bacterial community and allow the detailed interpretation of system performance data.