Hydroponic, aeroponic and aquaponic: comparison of three technologies

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Contents

Soilless culture and hydroponics

-Floating system; deep water culture

-Nutrient Film Tecnique;

-Aeroponic;

Dr L. Incrocci

Aquaponic

-Advantages and drawbacks

Dr B. Fronte

Soilless cultures

Hydroponics (hydros= water)

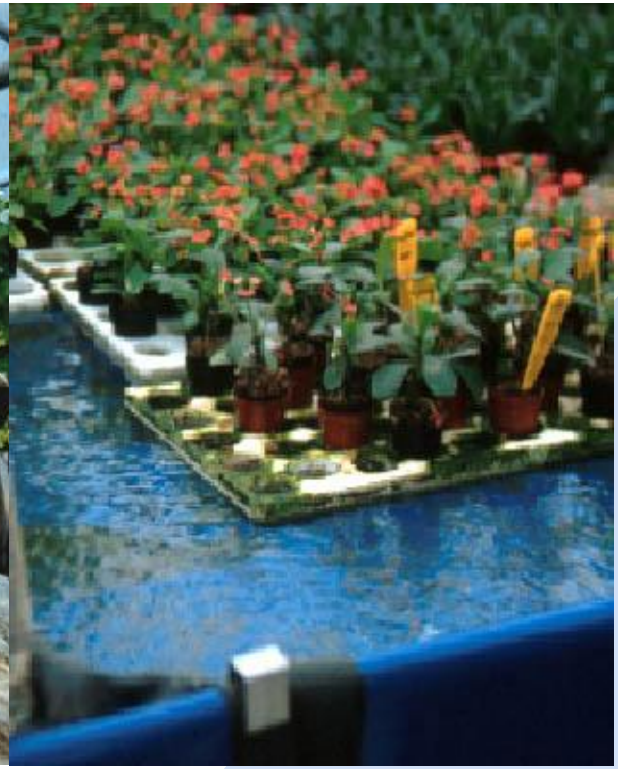
Floating system Deep Water Culture

Nutrient Film Technique

Aeroponic

Soilless cultures

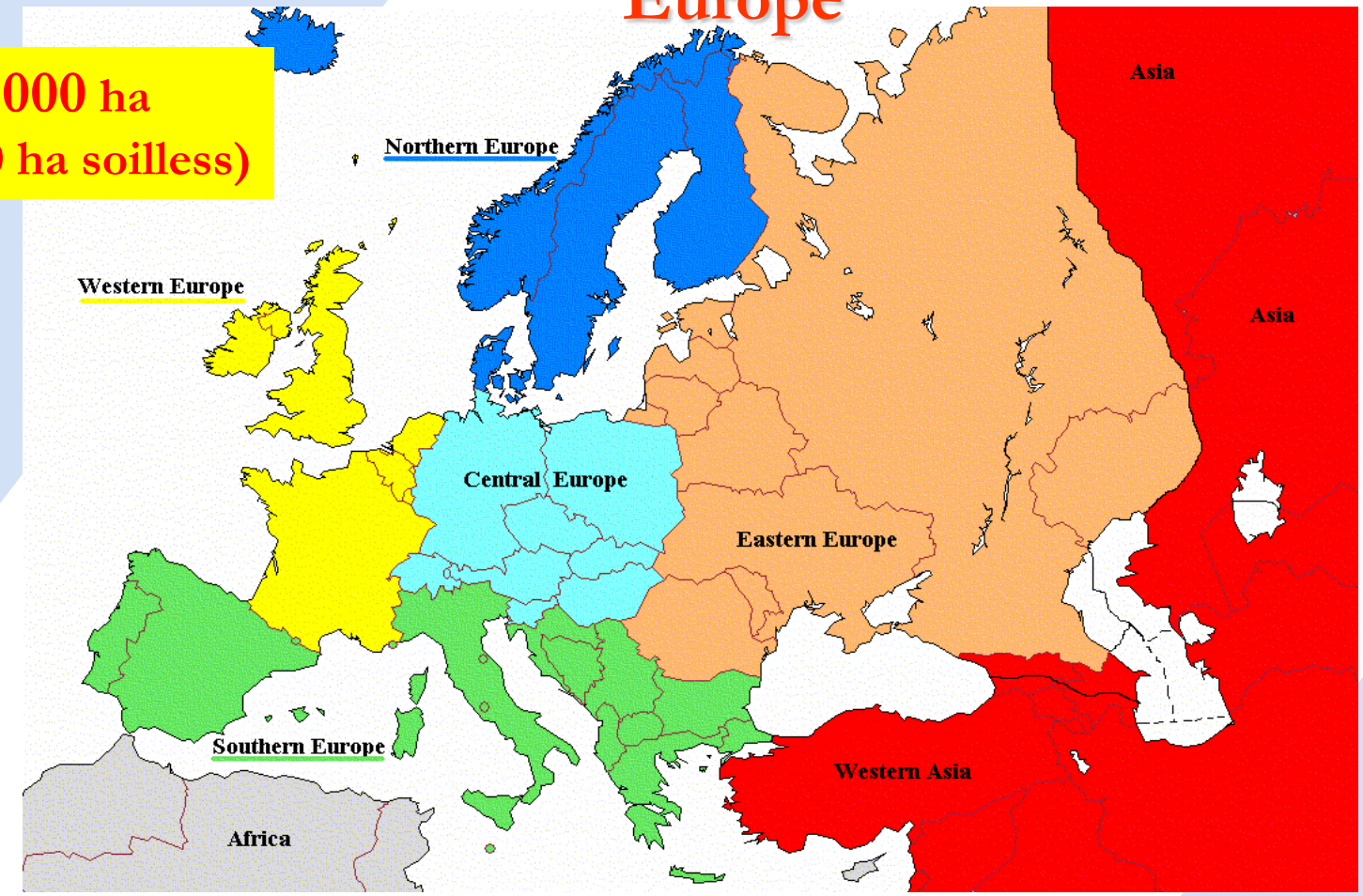
Substrate cultures



Gutter **Bags o pots** **Ebb-and-flow**

Protected cultivation and % of soilless cultures in Europe

~ 200,000 ha
(30.000 ha soilless)



Source: EUROSTAT 2008-09

(x1000 ha)
Holland: 10.2 (>90%)
Poland: 6.3 (>20 %)
Hungary: 2.0 (<10%)

France: 9.2 (<20%)
Spain: 66.0 (>20%)
Italy: 34.6 (<10%)= 2500 ha
Greece: 5.3 (<15%)

Soilless cultures

ADVANTAGES

- To avoid soil-borne diseases;
- Higher yield and extended harvesting time;
- Higher crop quality;
- Optimal for artificial crops, zero-pesticide, cultivation without soil, vertical farming;
- To reduce the water use;
- To control environment pollution (only closed system).

DRAWBACKS

- Higher investment cost;
- Necessity of specialized labour;
- Exhausted substrate and nutrient solution;
- Higher amount of exhausted plastic;
- Possible root hypoxia and anoxia;
- Need of good water quality.

To extend the harvesting time: grape in Sicily in middle May

The harvesting is easier and faster than soil

Drawbacks: exhausted substrates and higher use of plastic

Closed-loop vs Open system

NS input:
pH (5.5-6.0)
EC (1.6-3.0)

Closed-loop system!!

Reuse on soil cultures

Release in the environment

Drainage

Open system!!

Open system vs Closed (tomato with 20 kg/m^2)

- Water run-off= 1,682 m^3/ha
- N= 266 kg/ha N

Floating system

Advantages

No irrigation scheduling: water is every available;

Big water and nutrient buffer (150-200 litre m^{-2});

High tolerance to saline water than substrate and soil culture;

Easy and cheap to build;

Yield higher than soil culture;

The crop is clean, without soil residual.

Drawbacks

Hypoxia or anoxia warning;

Accumulation in the NS of phytotoxic substances ;

High amount of exhausted nutrient solution;

Easy development of algae and some insects(Sciaridae);

Not suitable for long-cycle crops (i.e. vegetable fruit crop)

Floating system: easy to build

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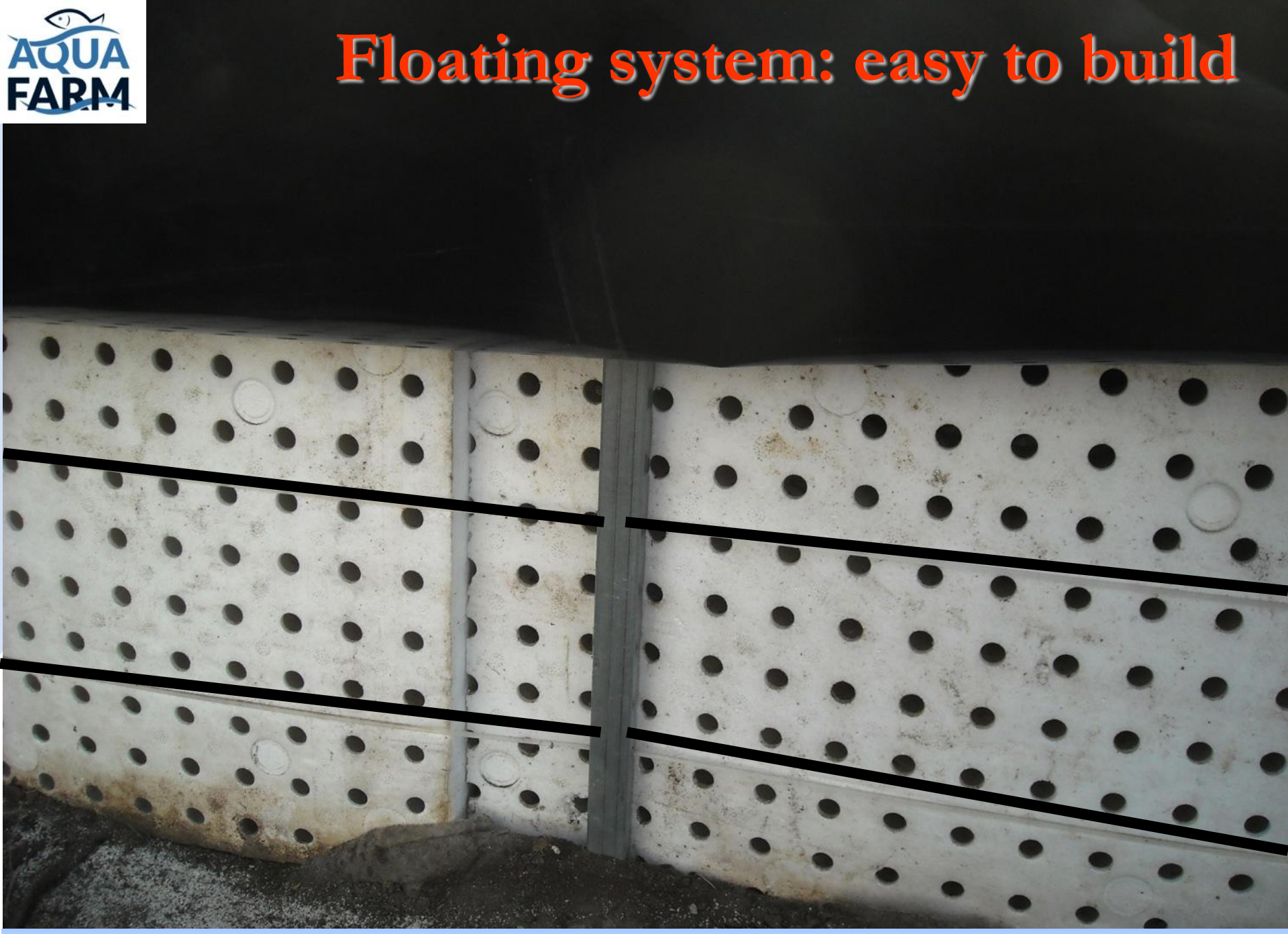
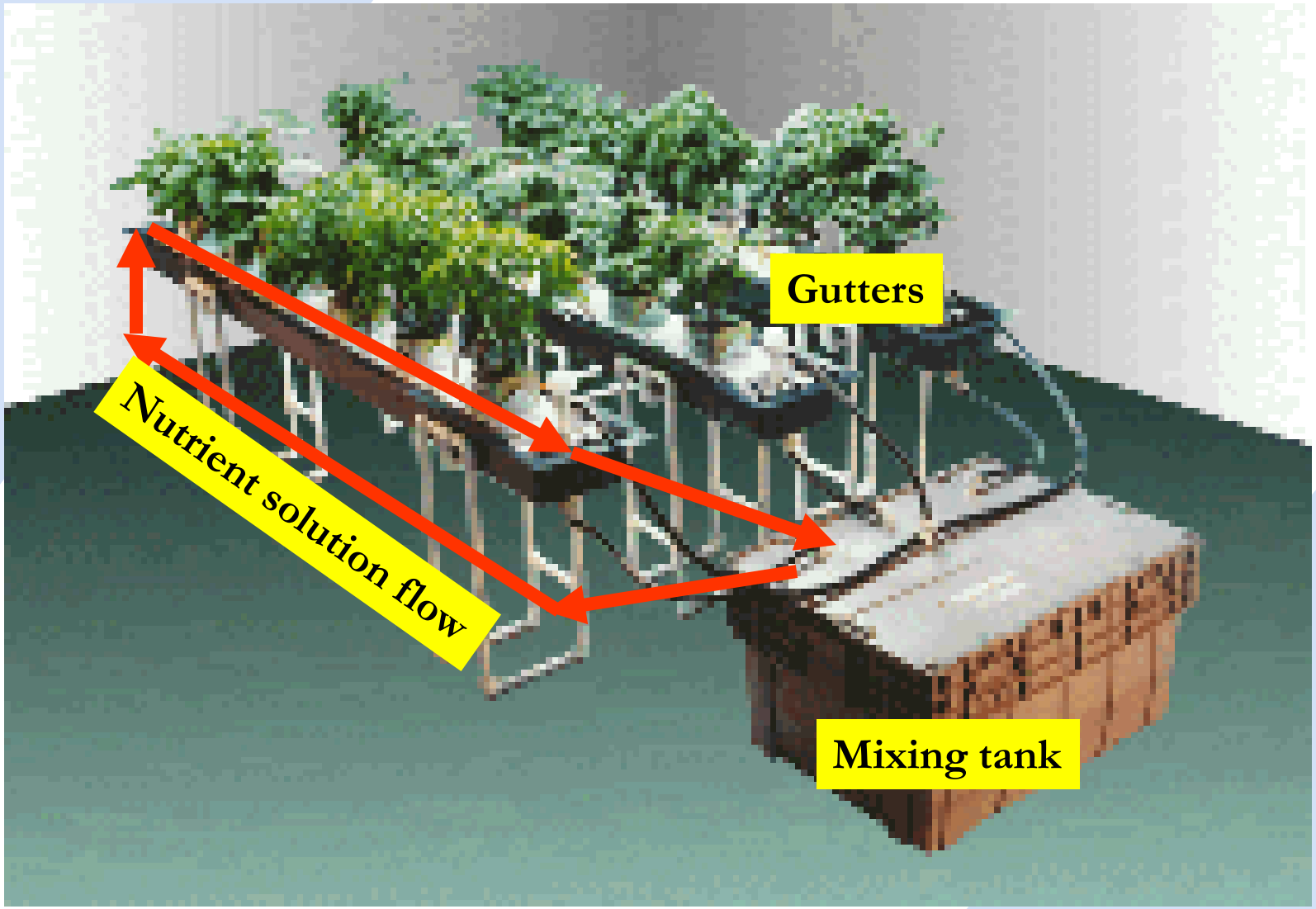


Floating system: basil

Nutrient Film Technique



NFT system

Advantages

No irrigation scheduling: water is every available;

The crop is clean, without soil residuals;

Absence of exhausted substrates;

Easy sterilization of the system ;

High tolerance to saline water than substrate and soil culture;

Yield higher than soil culture.

Drawbacks

Absence of water and nutrient buffer;

Hypoxia or anoxia warning;

Maximum length of gutters:5-8 m)

Accumulation in the NS of phytotoxic substances;

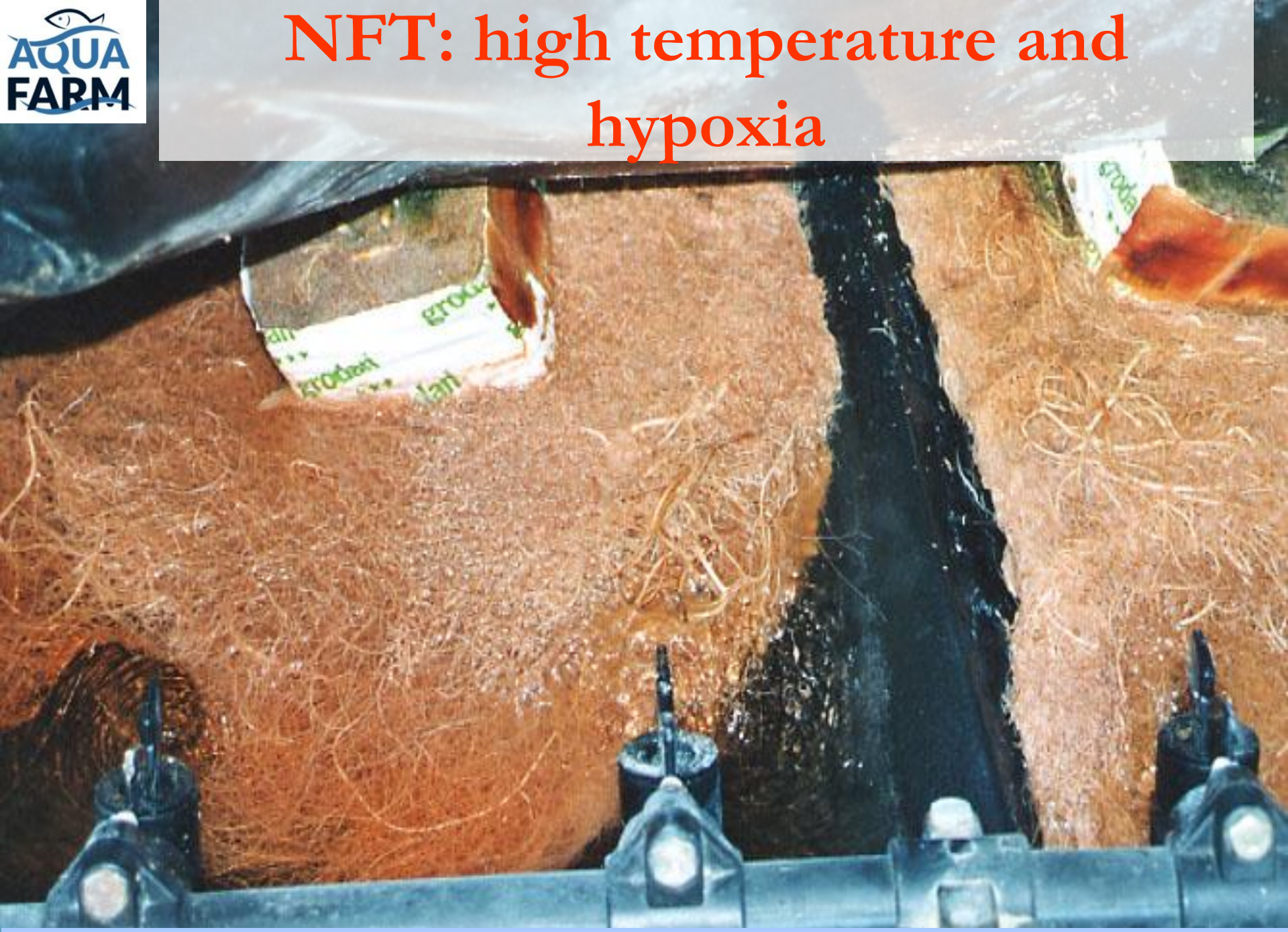
High investment and working cost (electricity for pumps);

Not suitable for long-cycle crops (i.e. vegetable fruit crop);

More sensitive to high greenhouse temperatures.

NFT: tomato

NFT: high temperature and hypoxia



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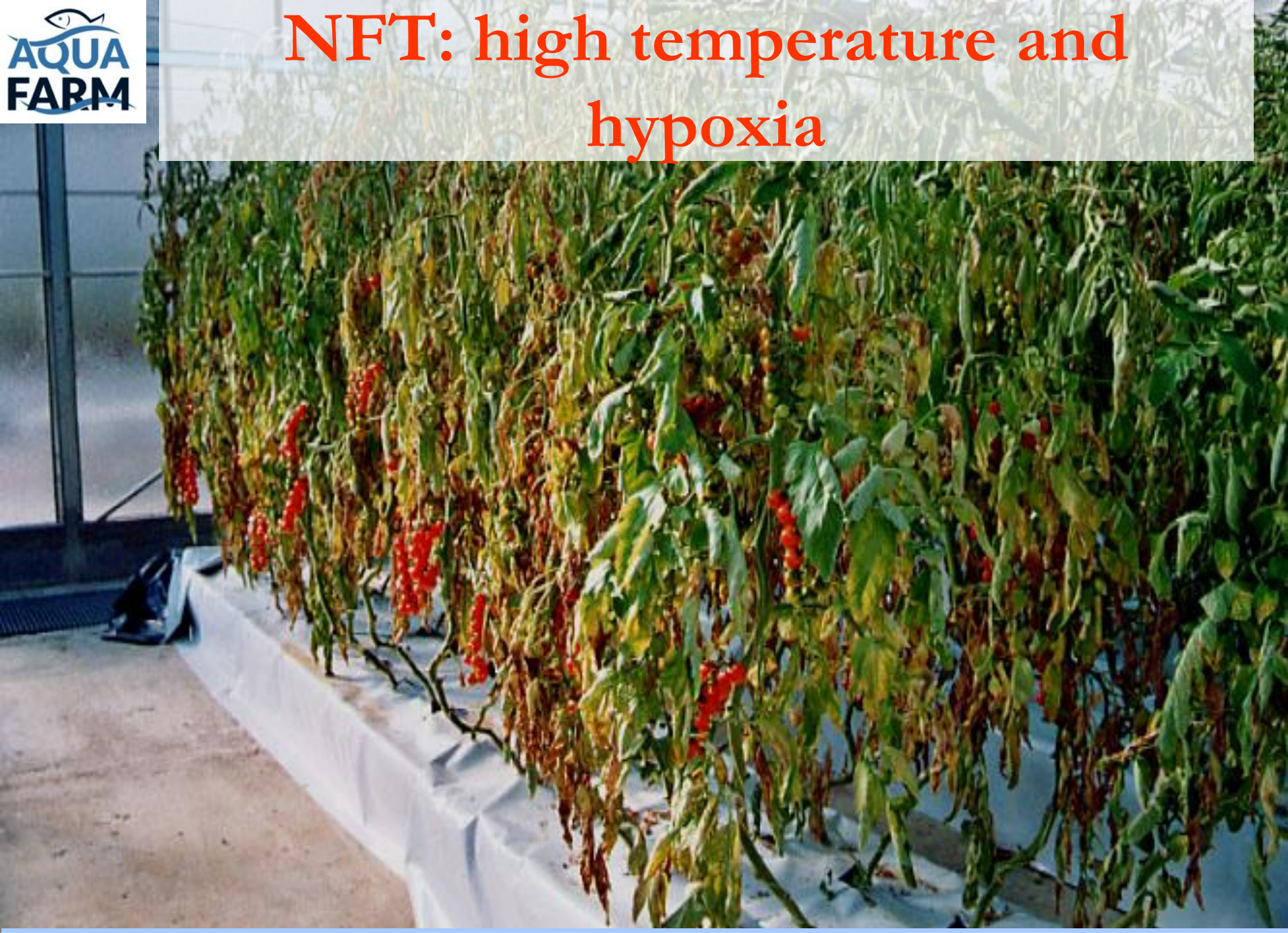
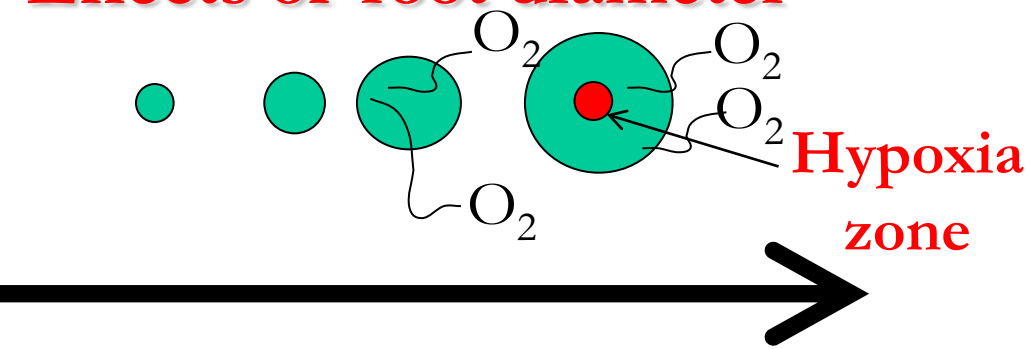


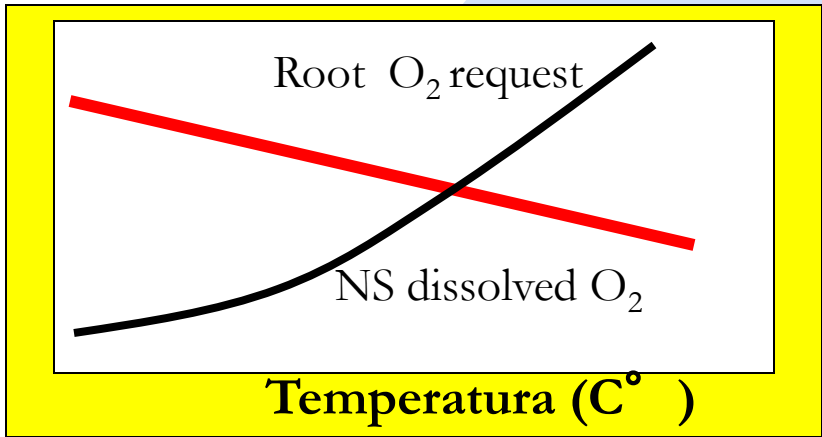
Hydroponic and hypoxia

When the temperature of nutrient solution raises, the plant root O_2 consumption increases, but the maximum O_2 dissolved in the nutrient solution decreases. **Minimum value of dissolved oxygen to avoid hypoxia condition: 3,0-4,0 mg/L di O_2**

Temperature (C°)	Max NS dissolved O_2 (mgL^{-1})	O_2 request ($mg\ gr^{-1}\ h^{-1}$)
10	10,93	0,23
20	8,84	0,46
30	7,53	0,92

Effects of root diameter





Aeroponic

Advantages

The crop is clean, without soil residuals;

The gutter is light and suitable for vertical farm;

Absence of exhausted substrates;

Easy sterilization of the system ;

Medium tolerance to saline water than substrate and soil culture;

Yield higher than soil culture;

No hypoxia problem (if short cycle crops).

Drawbacks

Absence of water and nutrient buffer;

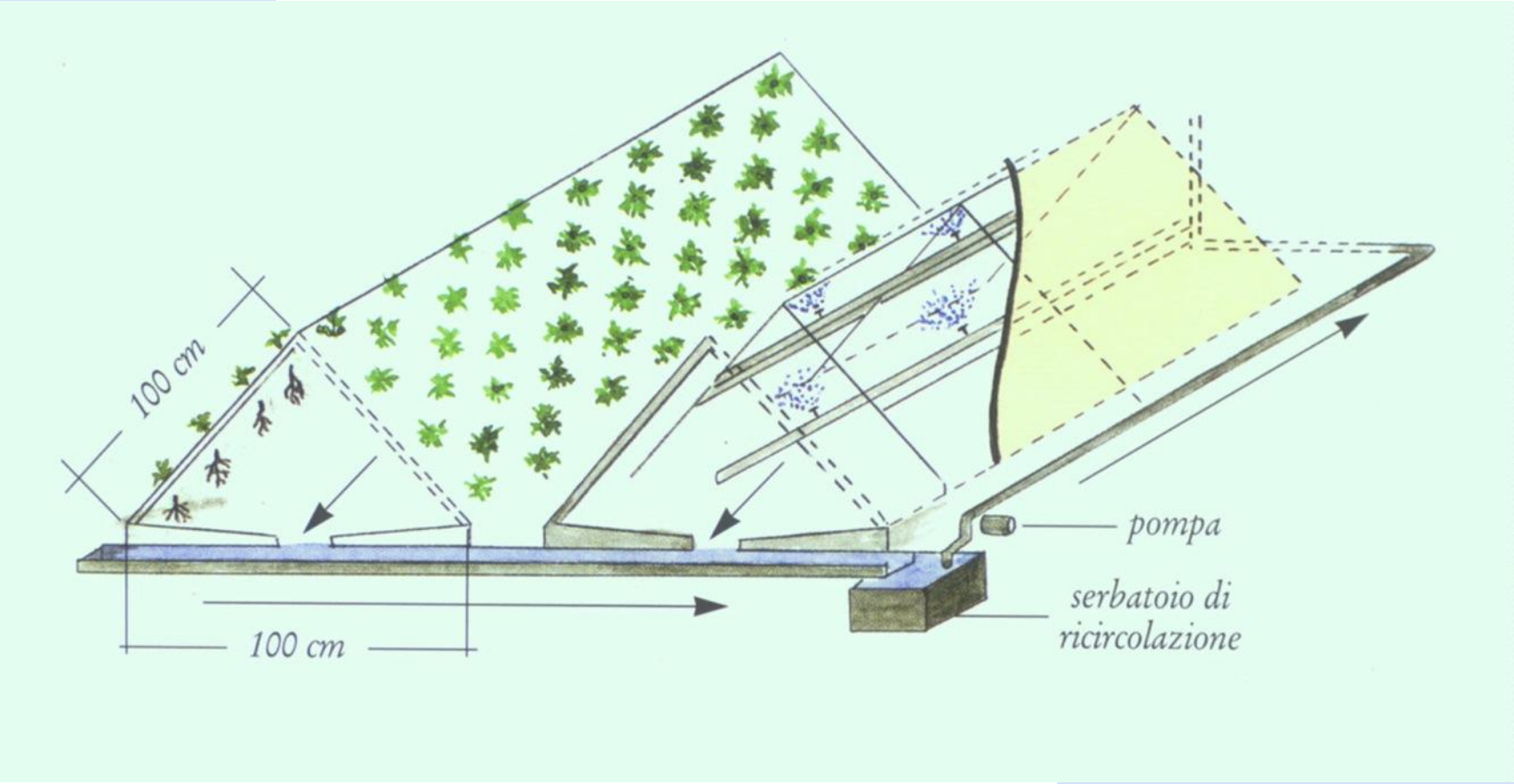
Accumulation in the NS of phytotoxic substances;

High investment and working cost (electricity for pumps);

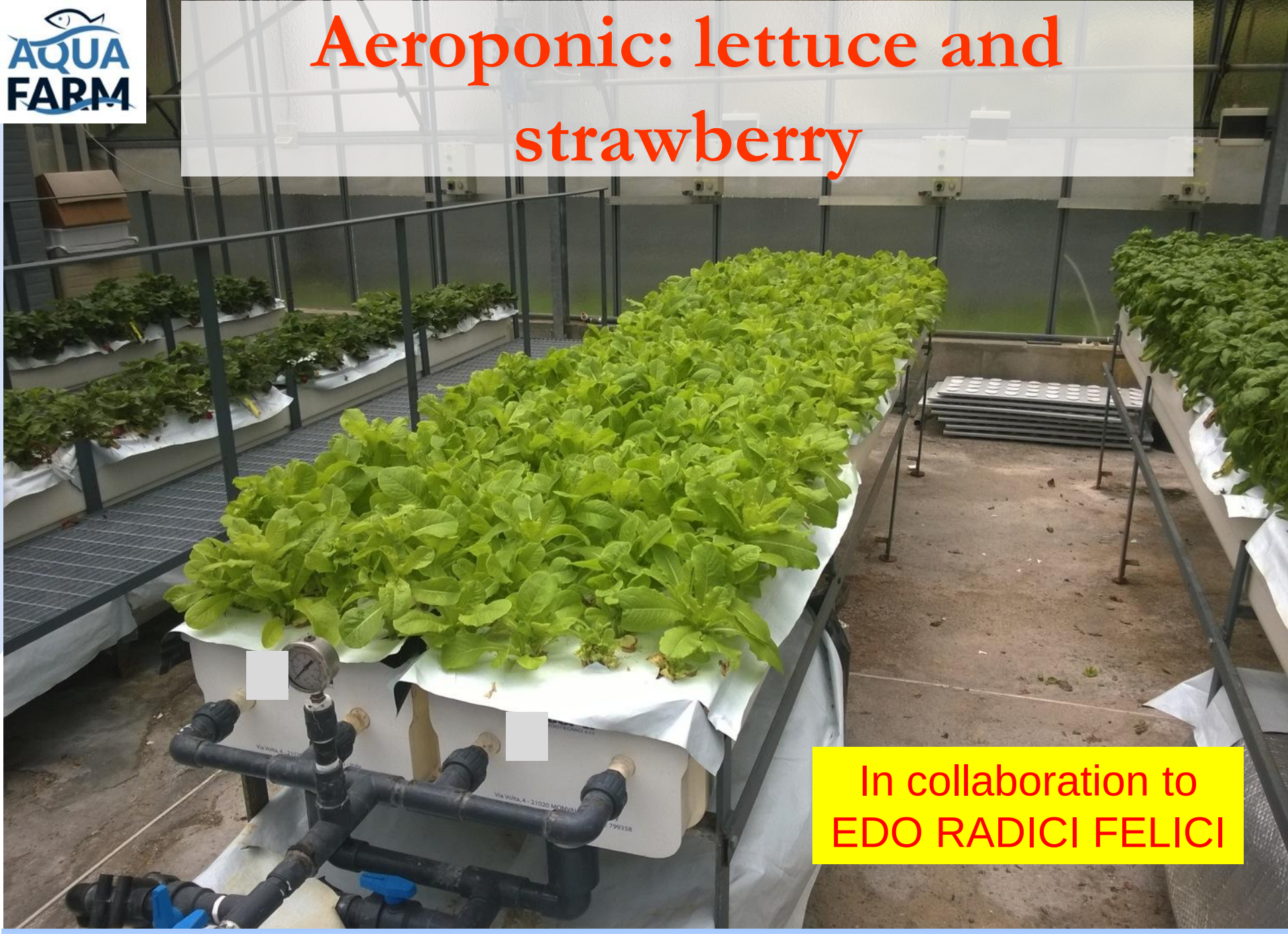
Necessity of pressurized water to sprinkle roots;

Not suitable for long-cycle crops (i.e. for cycle longer than 3-4 months).

Aeroponic



Aeroponic: lettuce and strawberry



In collaboration to
EDO RADICI FELICI

Aeroponic: basil

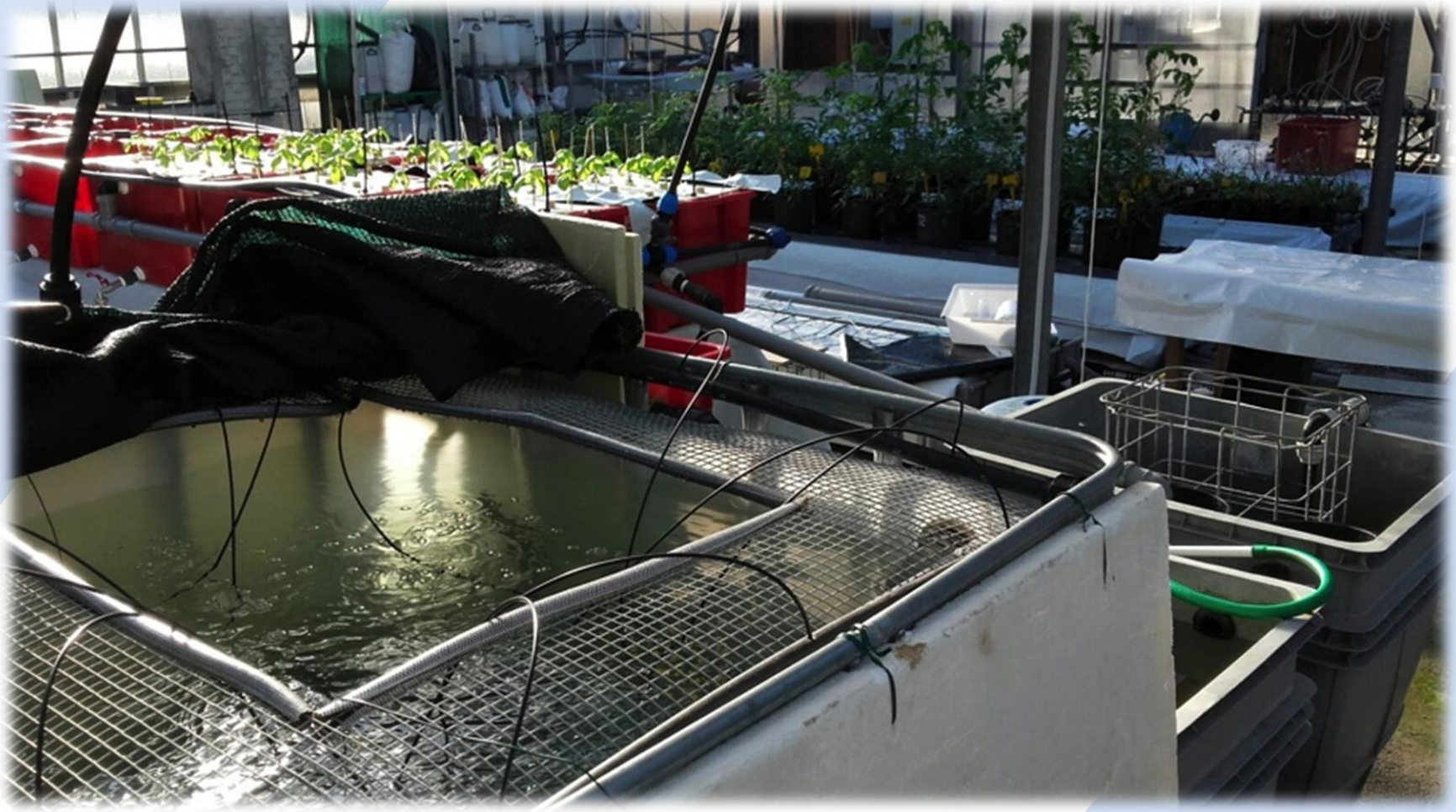
Basil: 31.25 kg m^{-2}; 3 growing cycles/year

Aeroponic: basil roots

Aeroponic: squash and cherry tomato

Aeroponic: optimal system for vertical farming

AQUAPONIC



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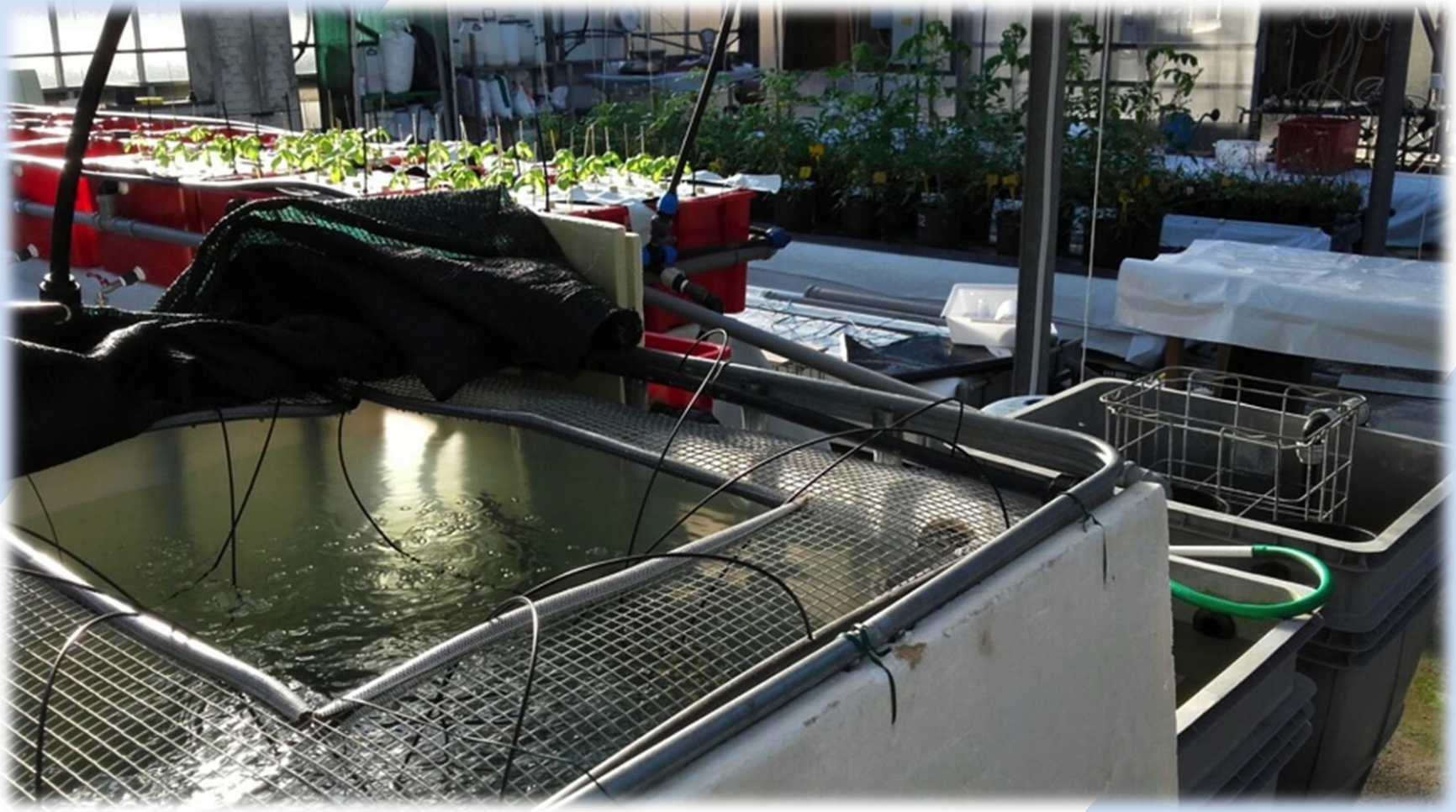
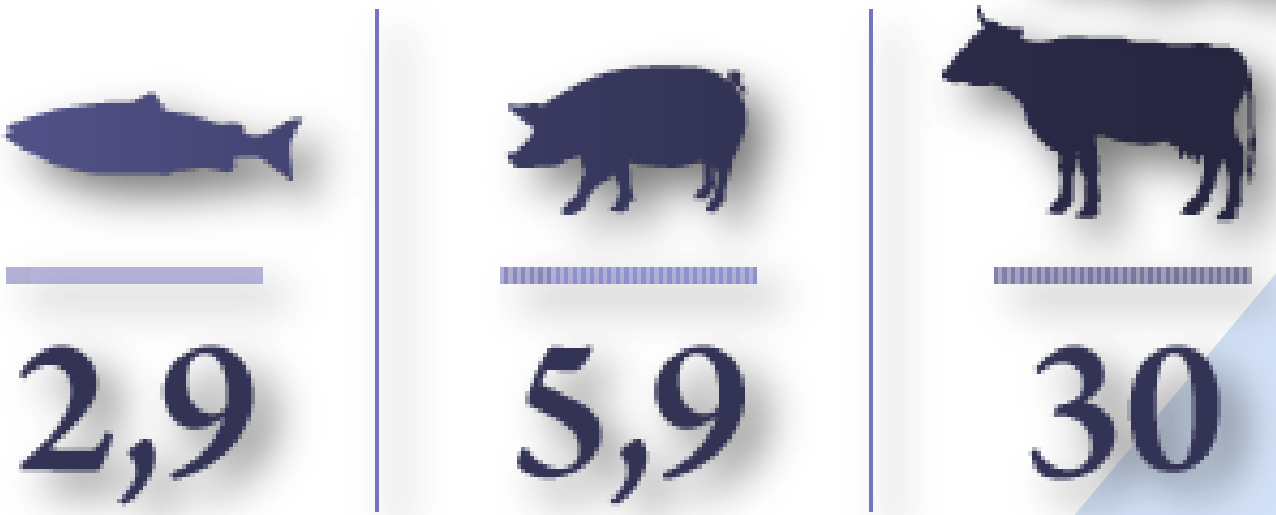


THE AQUACULTURE SUSTAINABILITY

Is Aquaculture fully sustainable and eco-friendly?

Even though its carbon footprint is already favourable in comparison to other animal farming sectors, it should be further improved



AQUACULTURE NEW (& SUSTANAIBLE) STRATEGIES

the Aquaponic system

Sustainability

WHAT DOES HYDROPONIC MEAN?

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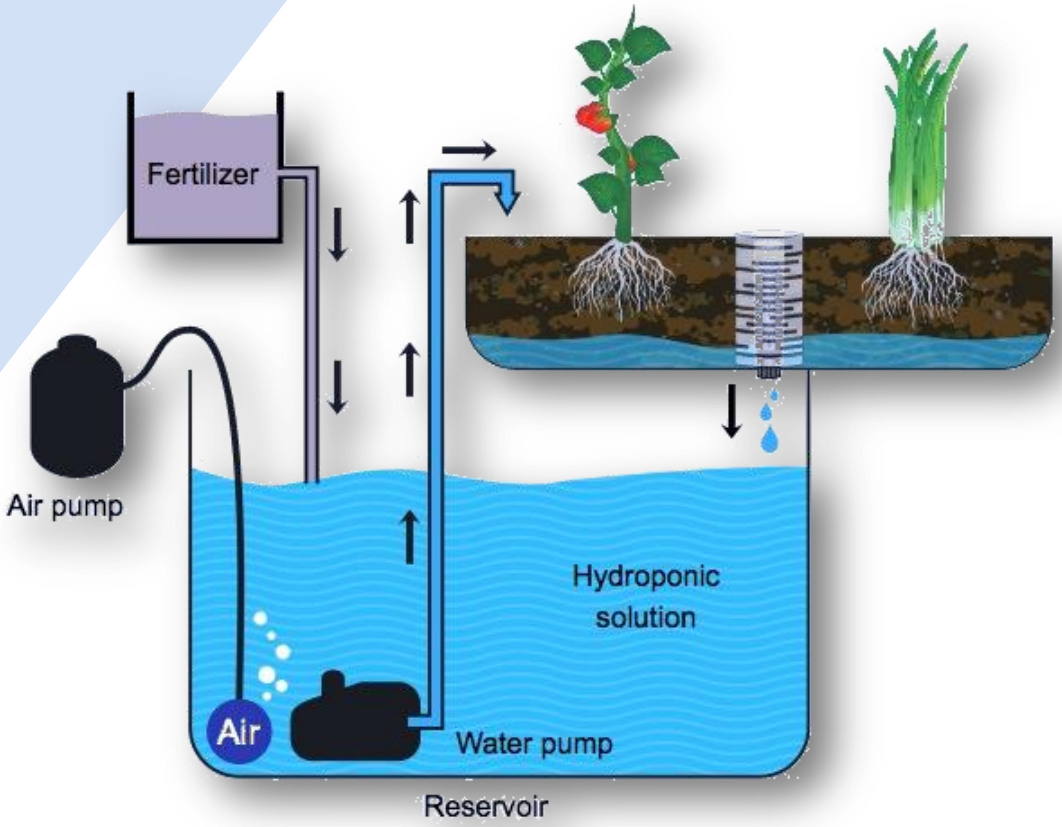


Tips

- reduce pests and soil-borne diseases
- intensive production
- high water and fertilizer-use efficiency
- easy "4 seasons" production
- suitable for arid regions

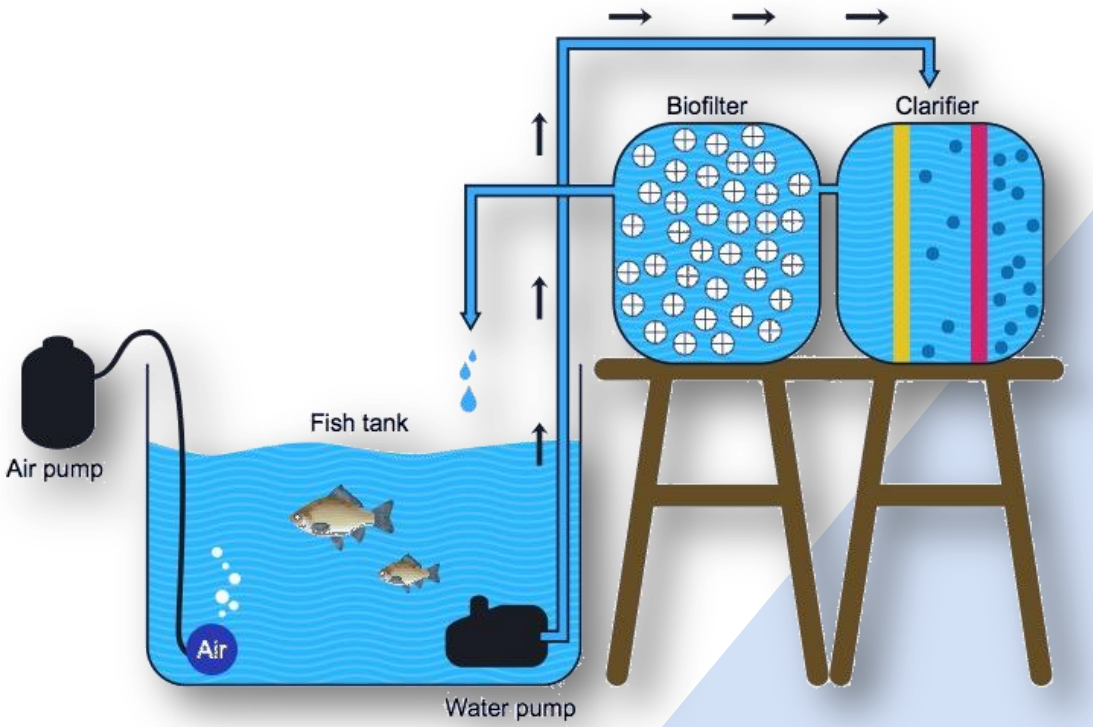
AQUACULTURE

What Aquaculture is?

Captive breeding and production of fish and other aquatic organisms **under controlled conditions**

Aquaculture systems

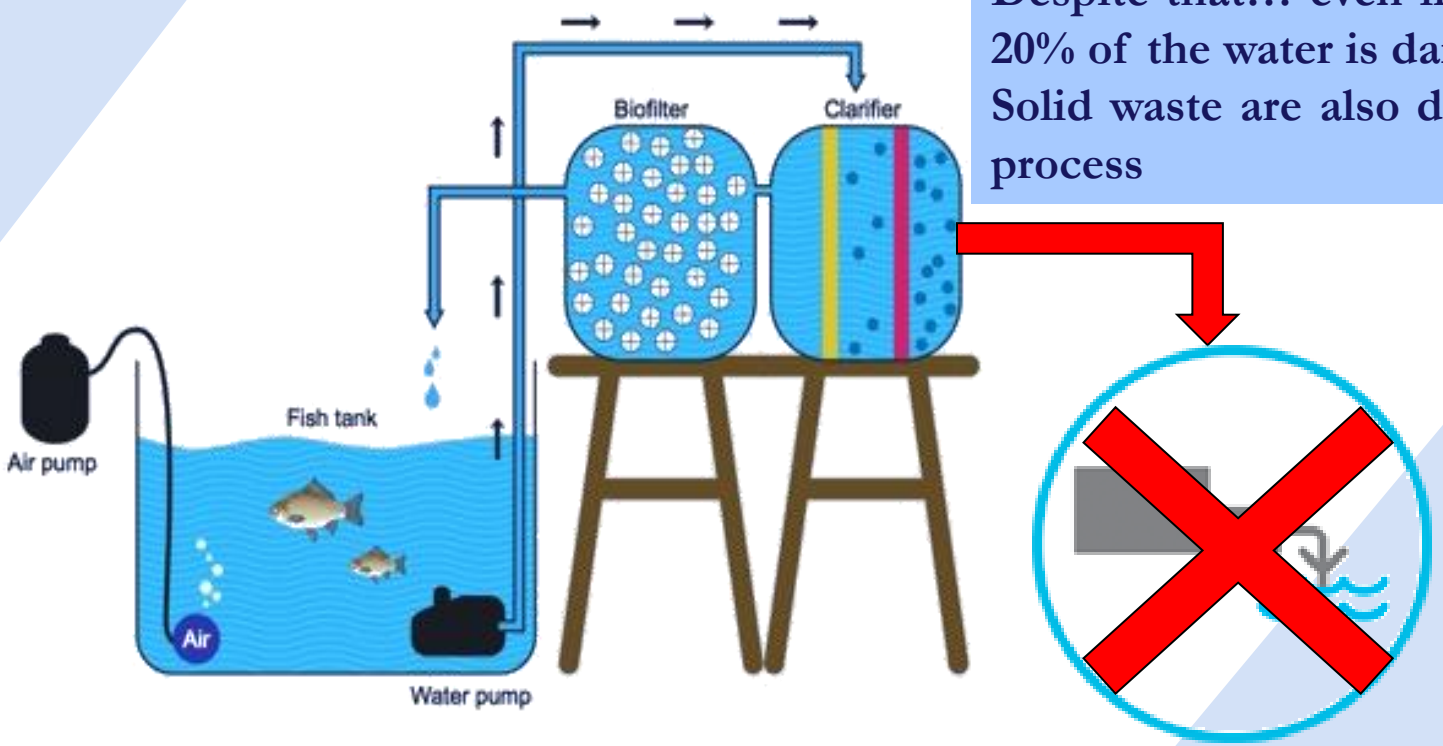
- open water systems (e.g. cages, long-lines)
- pond culture
- flow-through raceways
- **recirculating aquaculture systems (RAS)**



RECIRCULATION AQUACULTURE SYSTEM (RAS)

RAS TIPS:

- water is partially reused after cleaning and filtration
- it can considerably increase productivity
- most efficient water-saving technology
- higher investment, energy and management costs



Despite that… even in a RAS, about 20% of the water is daily discharged Solid waste are also dispersed in the process

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- When we combine a RAS together to an hydroponic system we "create" an Integrated Aquaculture System (IAS)
- IAS is a type of RAS where wastewater is **"biologically"** treated and **entirely** returned to the fish tanks
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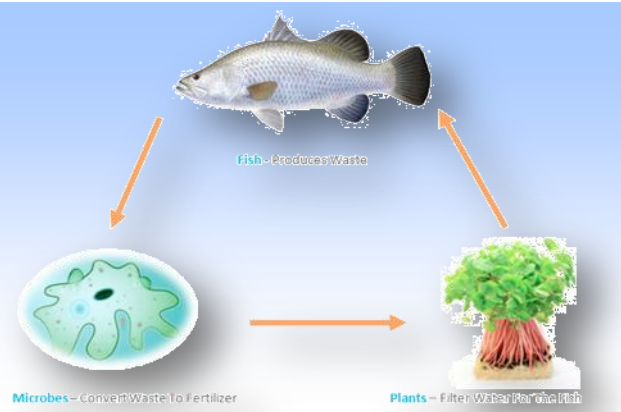
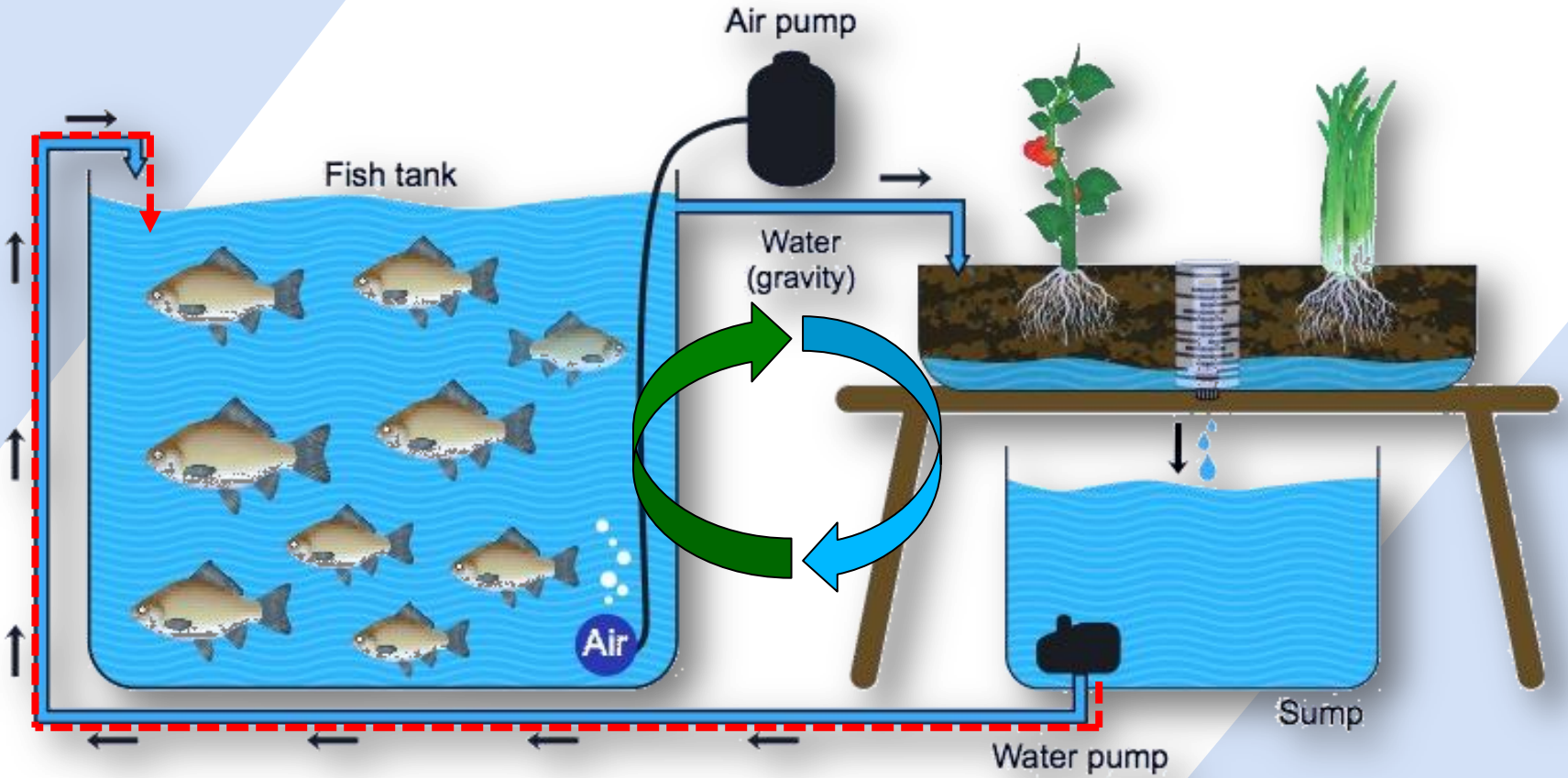
Wastes of RAS



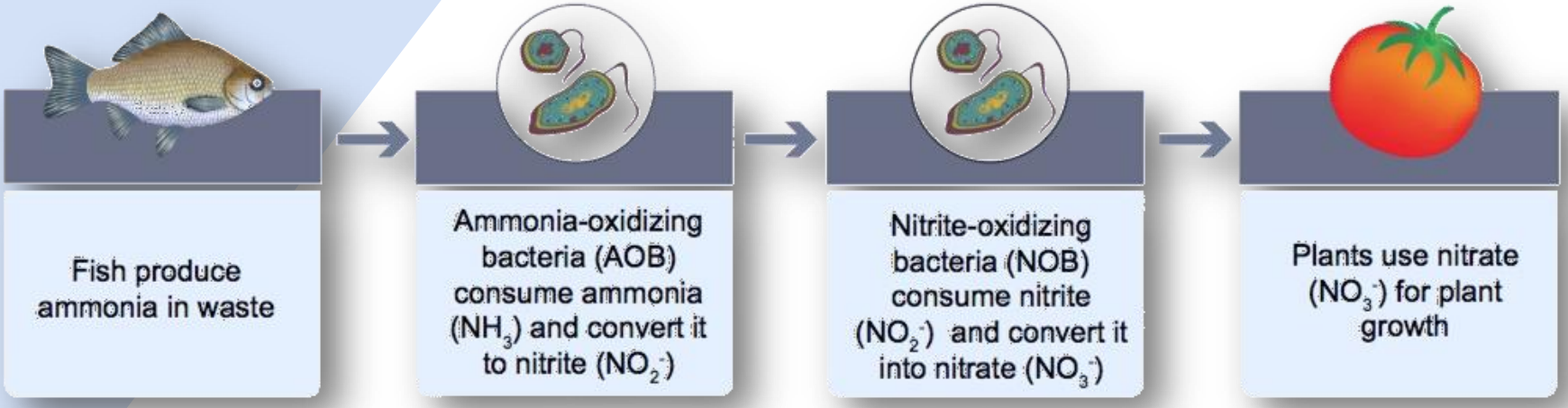
Nutrient for plant

RAS + HYDROPONIC = AQUAPONIC

Integrated Aquaculture System



AQUAPONICS: HOW DOES IT WORK
the "engine"



- Specific Surface Area (SSA) is a ratio defining the surface area exposed from a given volume of media (m^2/m^3)
- In general, the smaller and more porous the particles of the media are:
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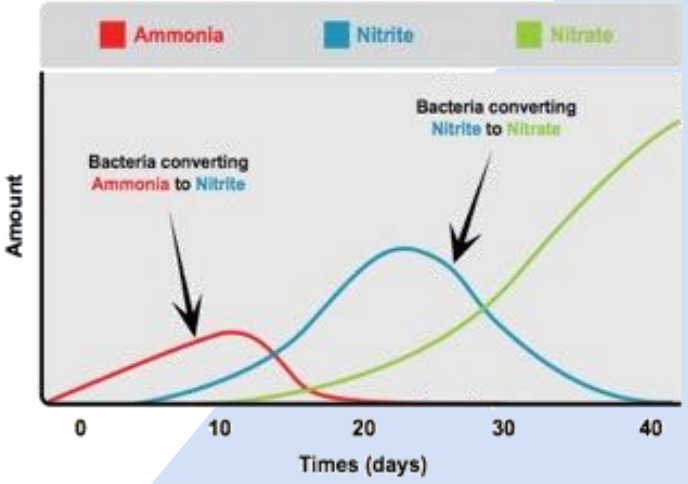
  - the faster and more efficient is the nitrification process

Levels of ammonia, nitrite and nitrate during the first few weeks in a recirculating aquaculture system



AQUAPONIC SYSTEMS
Grow Beds or Media Bed

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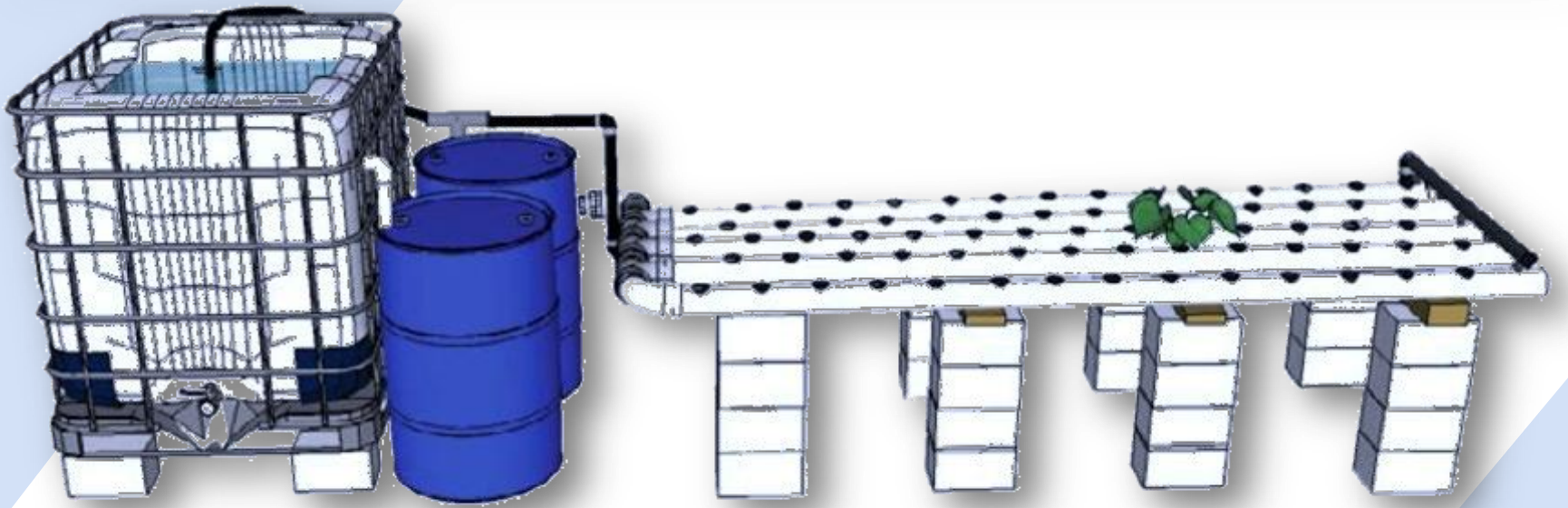
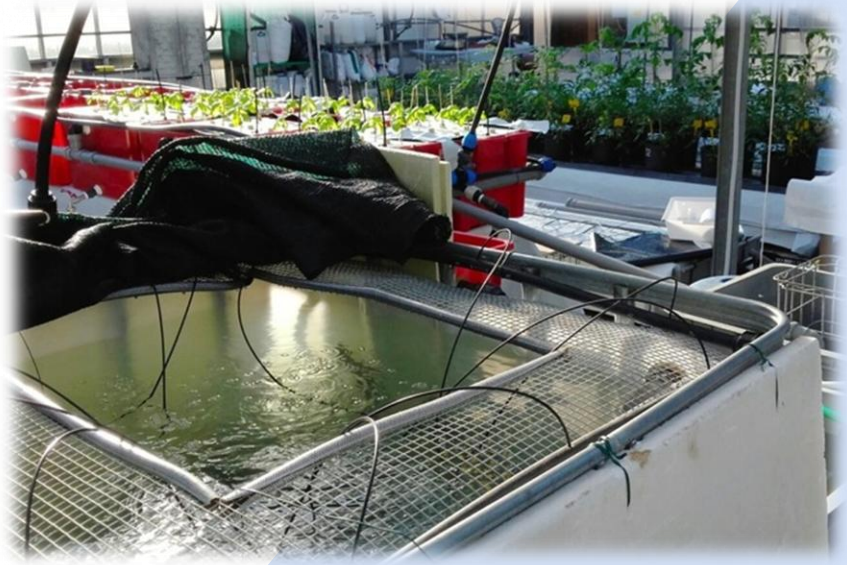


AQUAPONIC & VERTICAL FARMING

a natural "marriage"



AQUAPONICS: DISEASES AND TREATMENTS

AQUAPONICS: DISEASES AND TREATMENTS
just some tips

- Maintaining optimal water quality conditions is a priority
- "Soil-less" culture drastically reduce plant & fish disease incidence
- Antibacterial and antiparasites treatments have detrimental effects on the system, starting from the biofilter
- Pest control: repellents, soft-chemicals, plant-derived insecticides and salt bath; mainly soft-chemical alternatives to industrial pesticides can be applied to deter pests (essential oils, plant extracts, beneficial insects, inorganic chemicals, etc.).
- Sound fish management practices are a priority to secure a healthy stock

AQUAPONIC & SOCIAL FARMING

WHERE CAN AN AQUAPONIC SYSTEM FIT?

Improve "food security" worldwide:

- "producing more with less"
- producing food everywhere
    - Home (backyard agriculture to enhance self-efficiency)
    - Schools (educational programmes to promote "green" culture in youth)
    - Communities (to enhance communities' resilience)
    - Urban areas (urban/peri-urban agriculture to regenerate or reclaim disused buildings and promote 0 miles food market)
    - Hospital and prisons (social benefits, human wellbeing)

WHERE CAN AN AQUAPONIC SYSTEM FIT?

Small scale system can be easily implemented into "social activity" tanks to:

a. pretty low technologies
b. limited educational requirements
c. relatively limited financial investments
d. simple management (maintenance procedures)

For this reasons, aquaponics is being used as a vehicle for:

- enhancing agriculture sustainability
- including congruent sustainable activities (such as rainwater harvesting, nutrient recycling, organic food production, insect meal production, etc.)

Moreover, aquaponics is an efficient tool for hands-on learning experience for a wide-ranging topics such as:

1. anatomy and physiology
2. biology
3. botany
4. physics and chemistry
5. general sustainability studies

Aquaponic is an effective tool for promoting sustainable & local food production, as well as empowering communities by diversifying income generation

CAWR (UK) & UNIV. PISA (I) PROJECT

First Progress Report on the Aquaponic Unit at KCCA - KYANJA AGRICULTURAL RESOURCE CENTRE

- 38 Sex reversed male tilapia
- Initial BW 15 g
- 48th day BW 115 g (2.1 g/day)
- Baby leaf 48th day production 50.000 UGX (12.8 €)
- Energy costs 700 UGX/day (0.18 €cent/day)

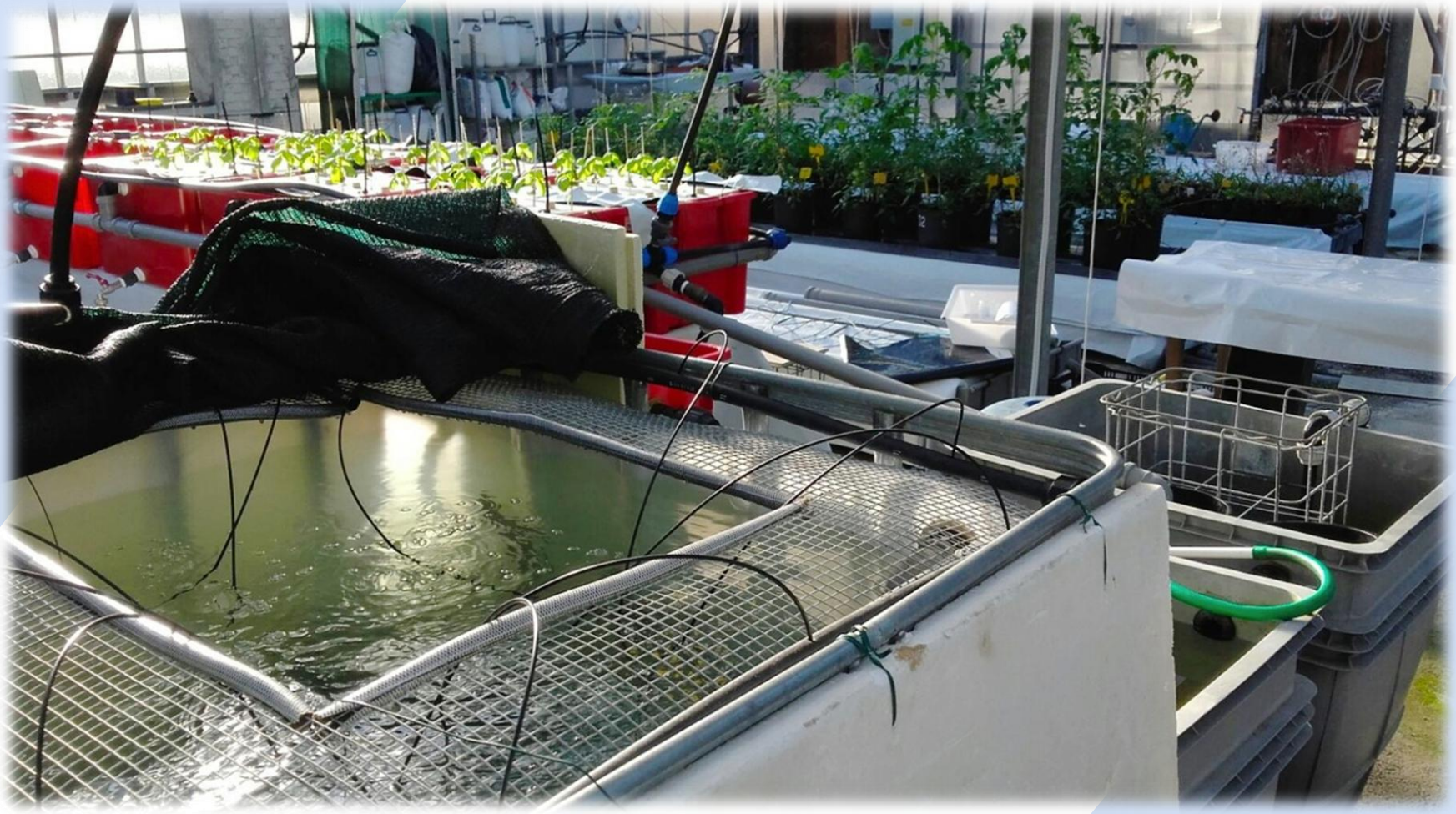
OUR IAS & PROJECT IN PISA
Eel production for wildlife restocking

- 50 Eel (Pit-tagged)
- Initial BW 133±68.4
- Initial BL 42.8±4.60
- Crop production: basil
- Aquaponic vs hydroponic trial

WHAT ABOUT MARINE AQUAPONIC?

- More economically valuable fish species (higher income)
- Larger market size in the Mediterranean area
- Advanced expertise in marine fish farming
- Avoiding seawater pollution
- Avoiding competition for relevant sites (aquaculture vs tourism)

CONCLUSIONS: WHY AQUAPONIC?



CONCLUSIONS: WHY AQUAPONIC?

Summarizing:

a. **Water use**: limited and efficient (two "crops" from one input)
b. **Productivity**: comparable to traditional agriculture and farming
c. **Nearly zero pollution**: no nutrient-rich waste-water discharge
d. **Location**: facilities may be located very close to the end users (e.g. restaurants, green grocers, food manufacturers, public)
e. **Land use**: use of saline, arid or marginal lands (greening the deserts)
f. **Chemical inputs**: pesticides & herbicides cannot be used to treat the plants, as these would affect fish (no harmful chemical residues)
g. **Social aspects**: suitable for enhancing social and educational programs or activities

CONCLUSIONS: WHY AQUAPONIC?

However:
A more comprehensive

- **optimization of the technics** used
- **evaluation of costs**
- **evaluation of social aspects** (where considered)

should be further studied to enable Aquaponics developing on "commercial scale" worldwide

Thank you for your attention

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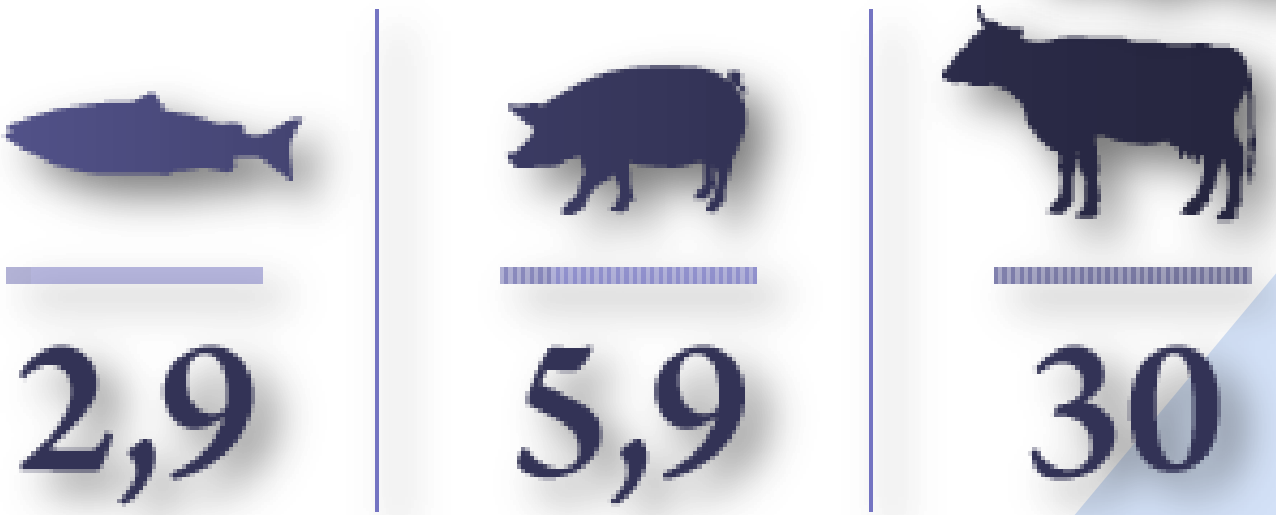

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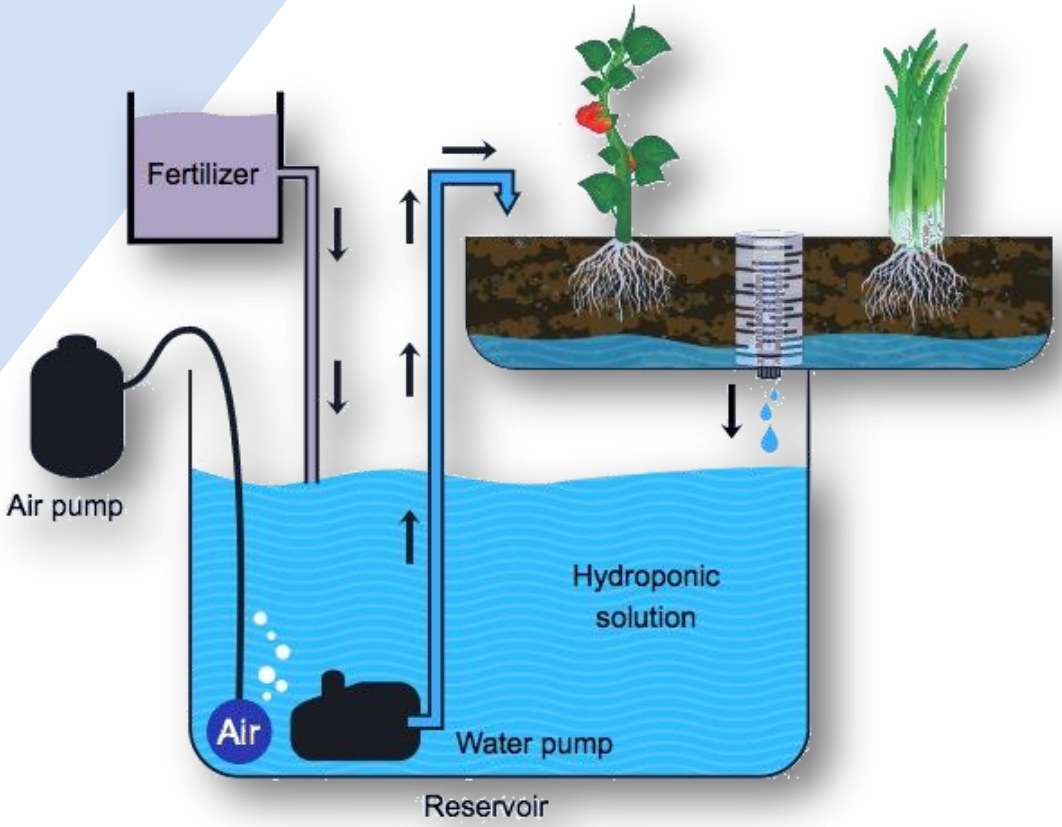

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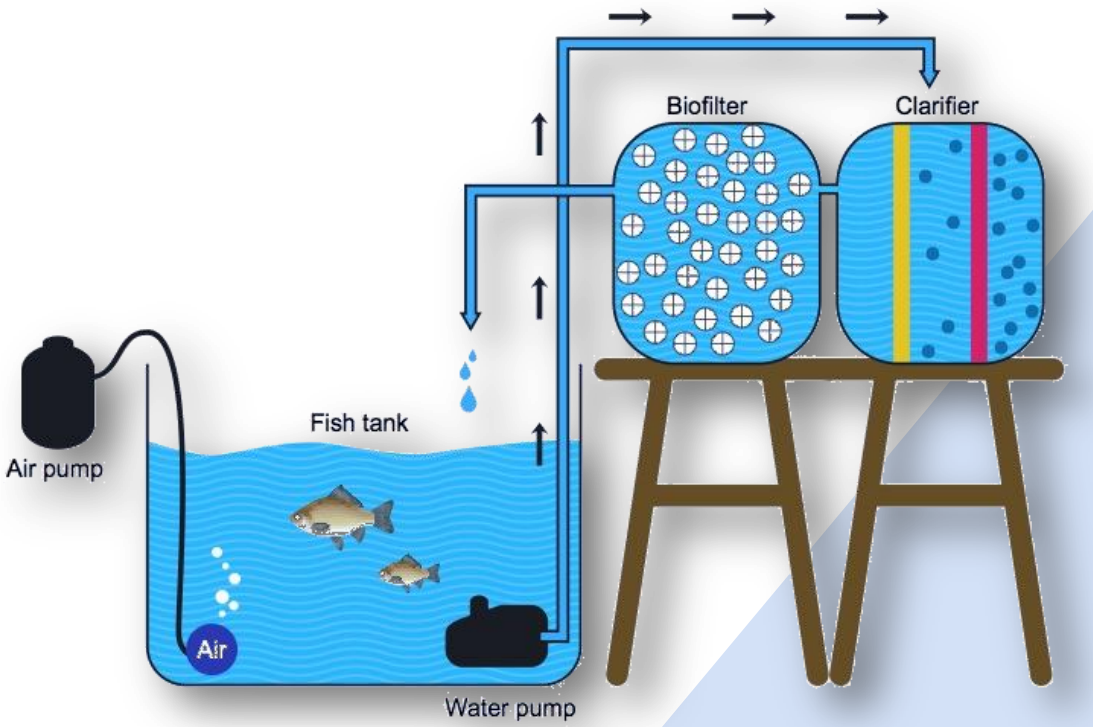

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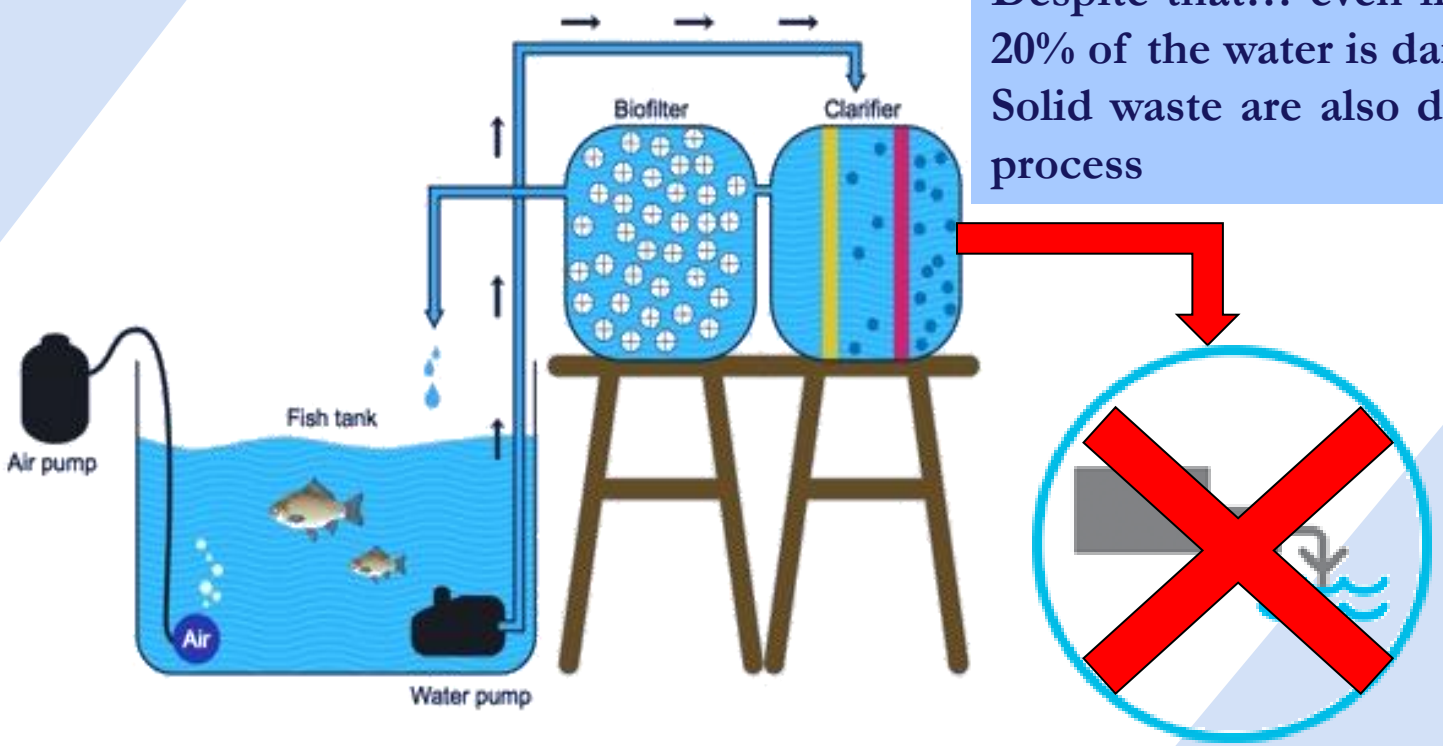

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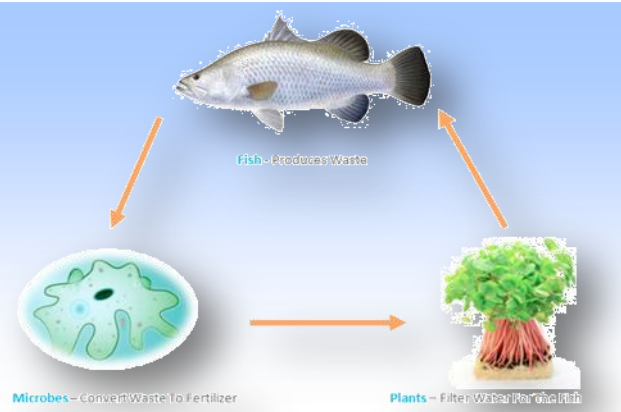

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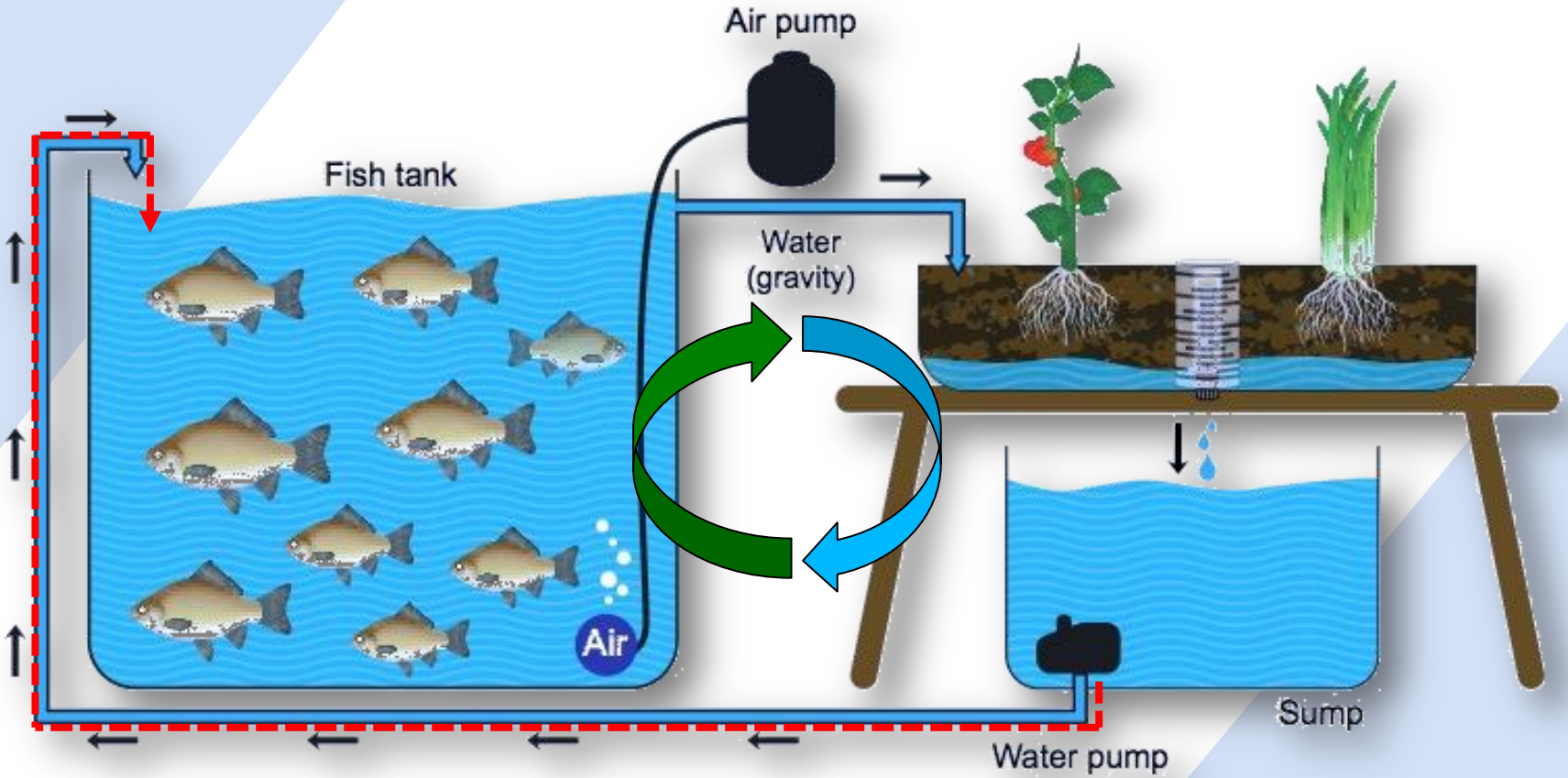

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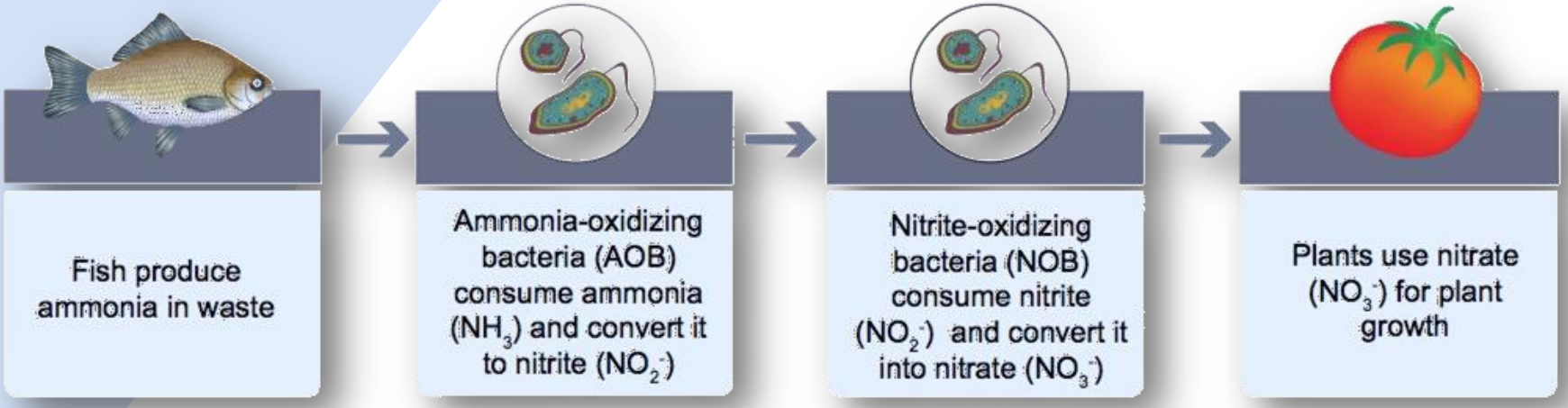

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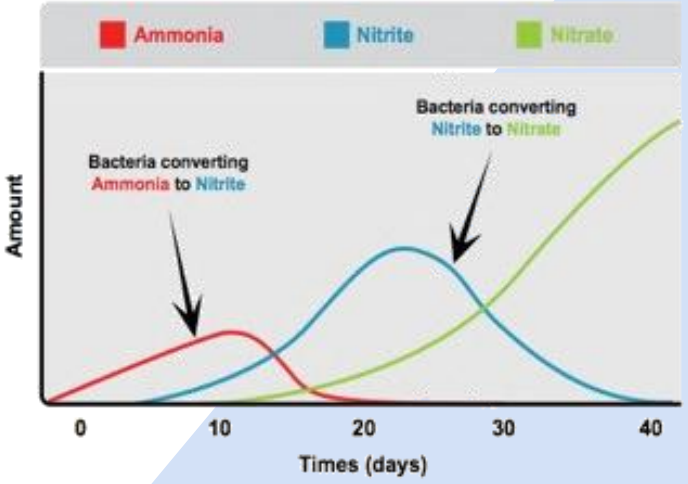

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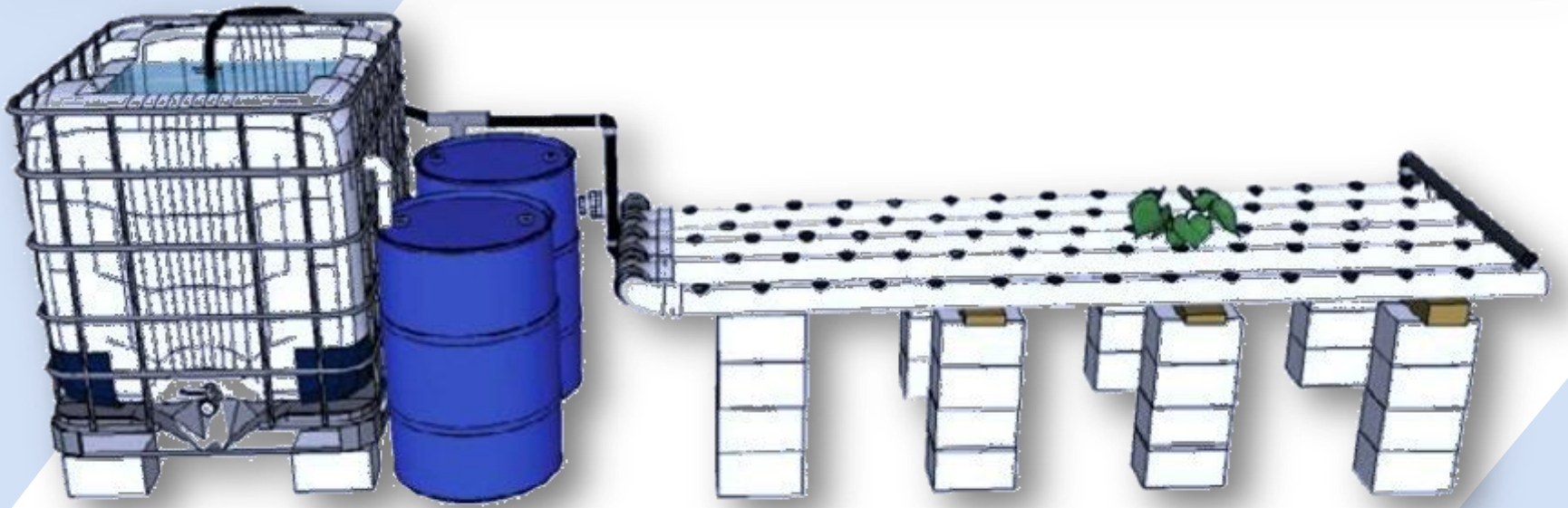

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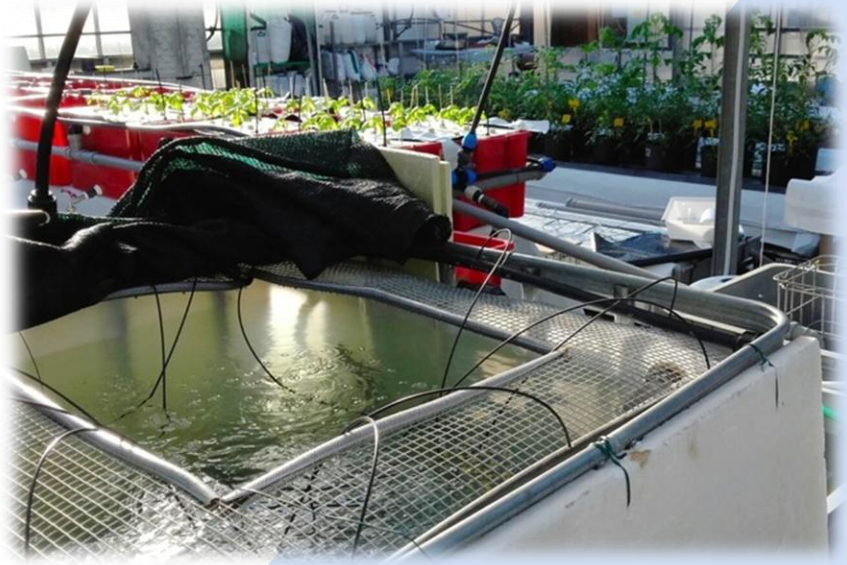

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- Maintaining optimal water quality conditions is a priority
- "Soil-less" culture drastically reduce plant & fish disease incidence
- Antibacterial and antiparasites treatments have detrimental effects on the system, starting from the biofilter
- Pest control: repellents, soft-chemicals, plant-derived insecticides and salt bath; mainly soft-chemical alternatives to industrial pesticides can be applied to deter pests (essential oils, plant extracts, beneficial insects, inorganic chemicals, etc.).
- Sound fish management practices are a priority to secure a healthy stock

AQUAPONIC & SOCIAL FARMING

WHERE CAN AN AQUAPONIC SYSTEM FIT?

Improve "food security" worldwide:

- "producing more with less"
- producing food everywhere
    - Home (backyard agriculture to enhance self-efficiency)
    - Schools (educational programmes to promote "green" culture in youth)
    - Communities (to enhance communities' resilience)
    - Urban areas (urban/peri-urban agriculture to regenerate or reclaim disused buildings and promote 0 miles food market)
    - Hospital and prisons (social benefits, human wellbeing)

WHERE CAN AN AQUAPONIC SYSTEM FIT?

Small scale system can be easily implemented into "social activity" tanks to:

a. pretty low technologies
b. limited educational requirements
c. relatively limited financial investments
d. simple management (maintenance procedures)

For this reasons, aquaponics is being used as a vehicle for:

- enhancing agriculture sustainability
- including congruent sustainable activities (such as rainwater harvesting, nutrient recycling, organic food production, insect meal production, etc.)

Moreover, aquaponics is an efficient tool for hands-on learning experience for a wide-ranging topics such as:

1. anatomy and physiology
2. biology
3. botany
4. physics and chemistry
5. general sustainability studies

Aquaponic is an effective tool for promoting sustainable & local food production, as well as empowering communities by diversifying income generation

CAWR (UK) & UNIV. PISA (I) PROJECT

First Progress Report on the Aquaponic Unit at KCCA - KYANJA AGRICULTURAL RESOURCE CENTRE

- 38 Sex reversed male tilapia
- Initial BW 15 g
- 48th day BW 115 g (2.1 g/day)
- Baby leaf 48th day production 50.000 UGX (12.8 €)
- Energy costs 700 UGX/day (0.18 €cent/day)

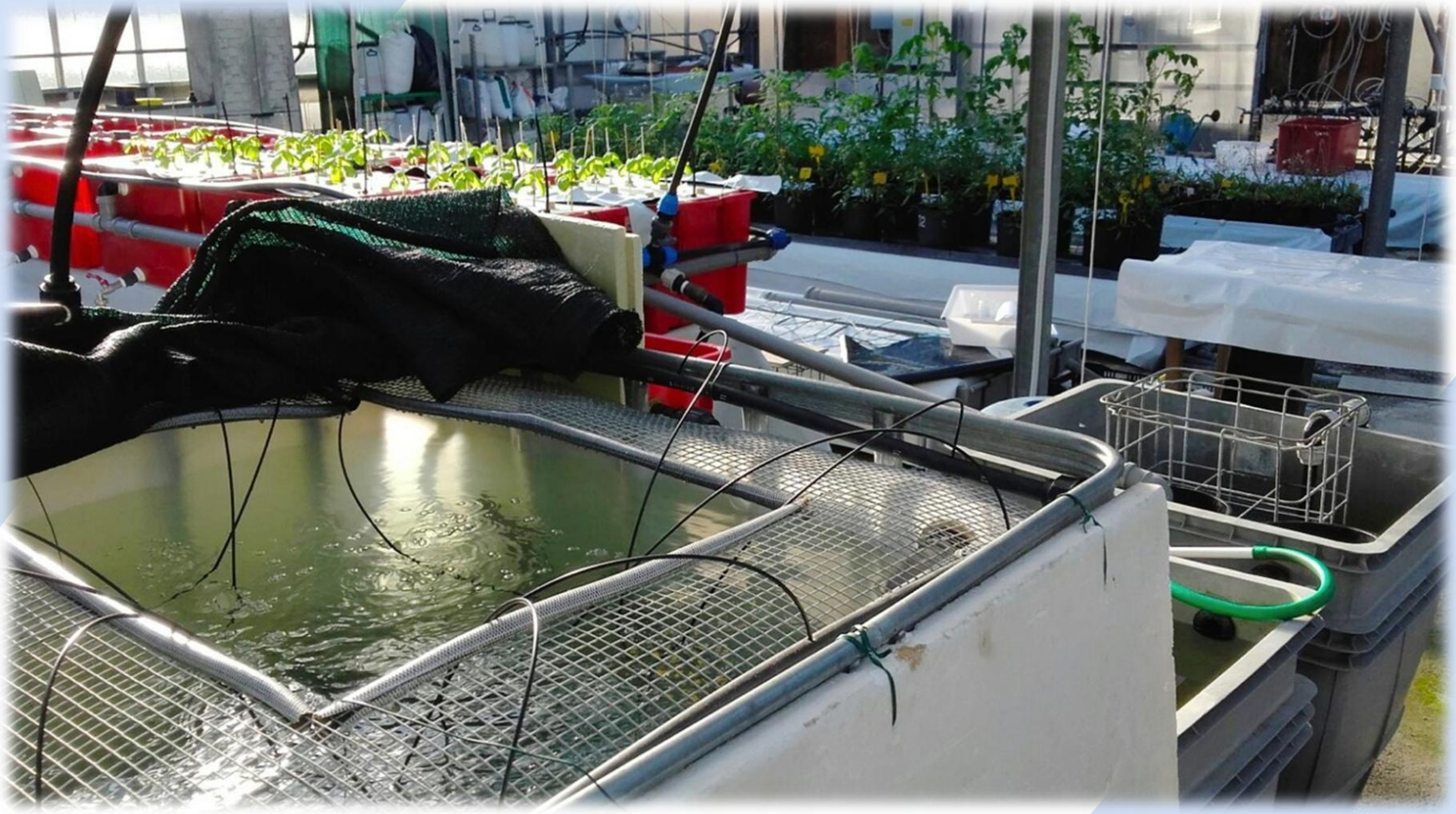
OUR IAS & PROJECT IN PISA
Eel production for wildlife restocking

- 50 Eel (Pit-tagged)
- Initial BW 133±68.4
- Initial BL 42.8±4.60
- Crop production: basil
- Aquaponic vs hydroponic trial

WHAT ABOUT MARINE AQUAPONIC?

- More economically valuable fish species (higher income)
- Larger market size in the Mediterranean area
- Advanced expertise in marine fish farming
- Avoiding seawater pollution
- Avoiding competition for relevant sites (aquaculture vs tourism)

CONCLUSIONS: WHY AQUAPONIC?



CONCLUSIONS: WHY AQUAPONIC?

Summarizing:

a. **Water use**: limited and efficient (two "crops" from one input)
b. **Productivity**: comparable to traditional agriculture and farming
c. **Nearly zero pollution**: no nutrient-rich waste-water discharge
d. **Location**: facilities may be located very close to the end users (e.g. restaurants, green grocers, food manufacturers, public)
e. **Land use**: use of saline, arid or marginal lands (greening the deserts)
f. **Chemical inputs**: pesticides & herbicides cannot be used to treat the plants, as these would affect fish (no harmful chemical residues)
g. **Social aspects**: suitable for enhancing social and educational programs or activities

CONCLUSIONS: WHY AQUAPONIC?

However:
A more comprehensive

- **optimization of the technics** used
- **evaluation of costs**
- **evaluation of social aspects** (where considered)

should be further studied to enable Aquaponics developing on "commercial scale" worldwide

Thank you for your attention