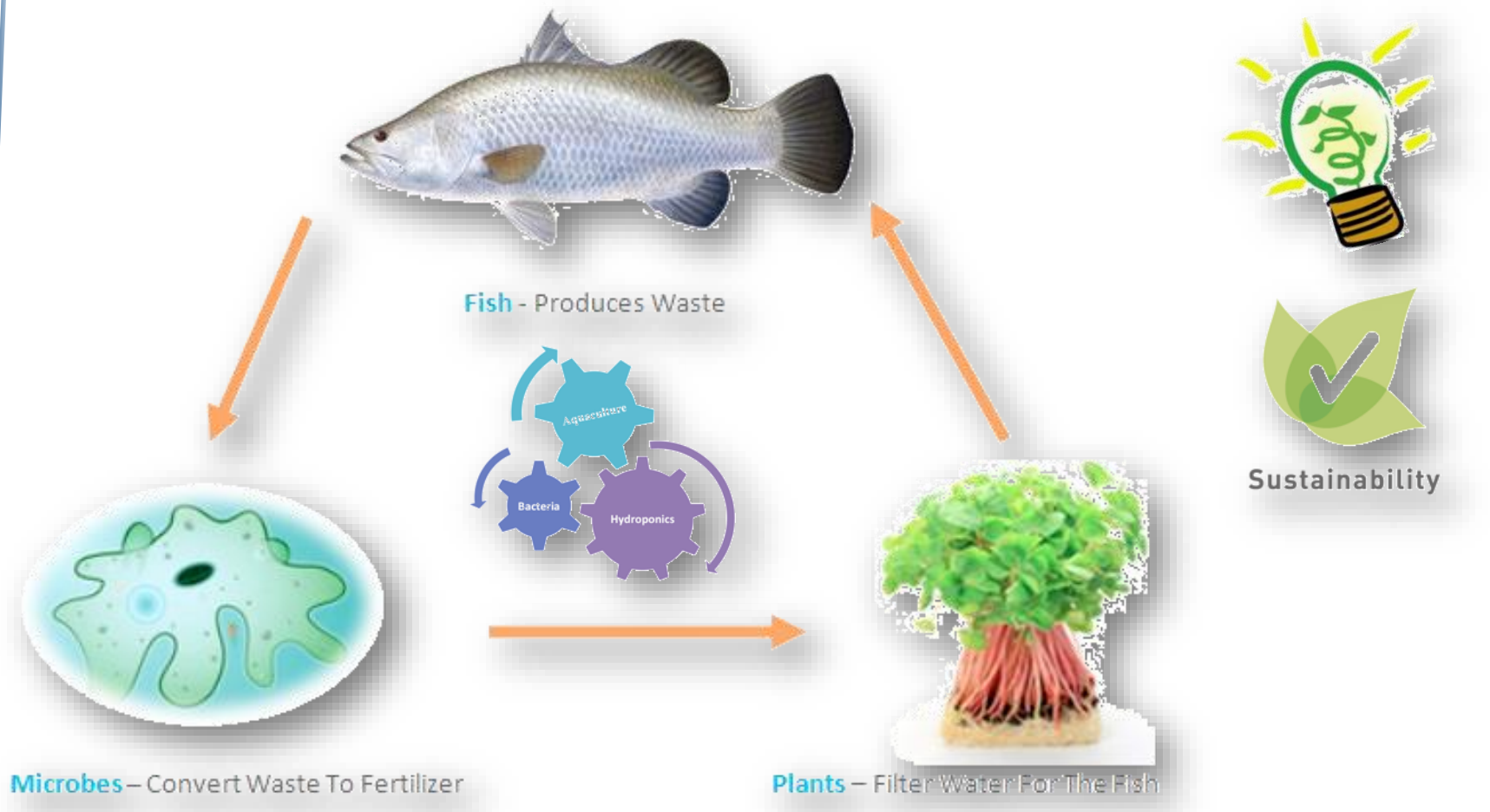
Full integrated aquaponic system for a sustainable local food production

B. Fronte[1], L. Incrocci[2], Y. Galletti[3], A. Pardossi[2], C. Bibbiani[1]

Pordenone fiera, 16 gennaio 2017

AQUAPONIC: LOOKING AHEAD

Technic based on the re-use of aquaculture wastes for greens production



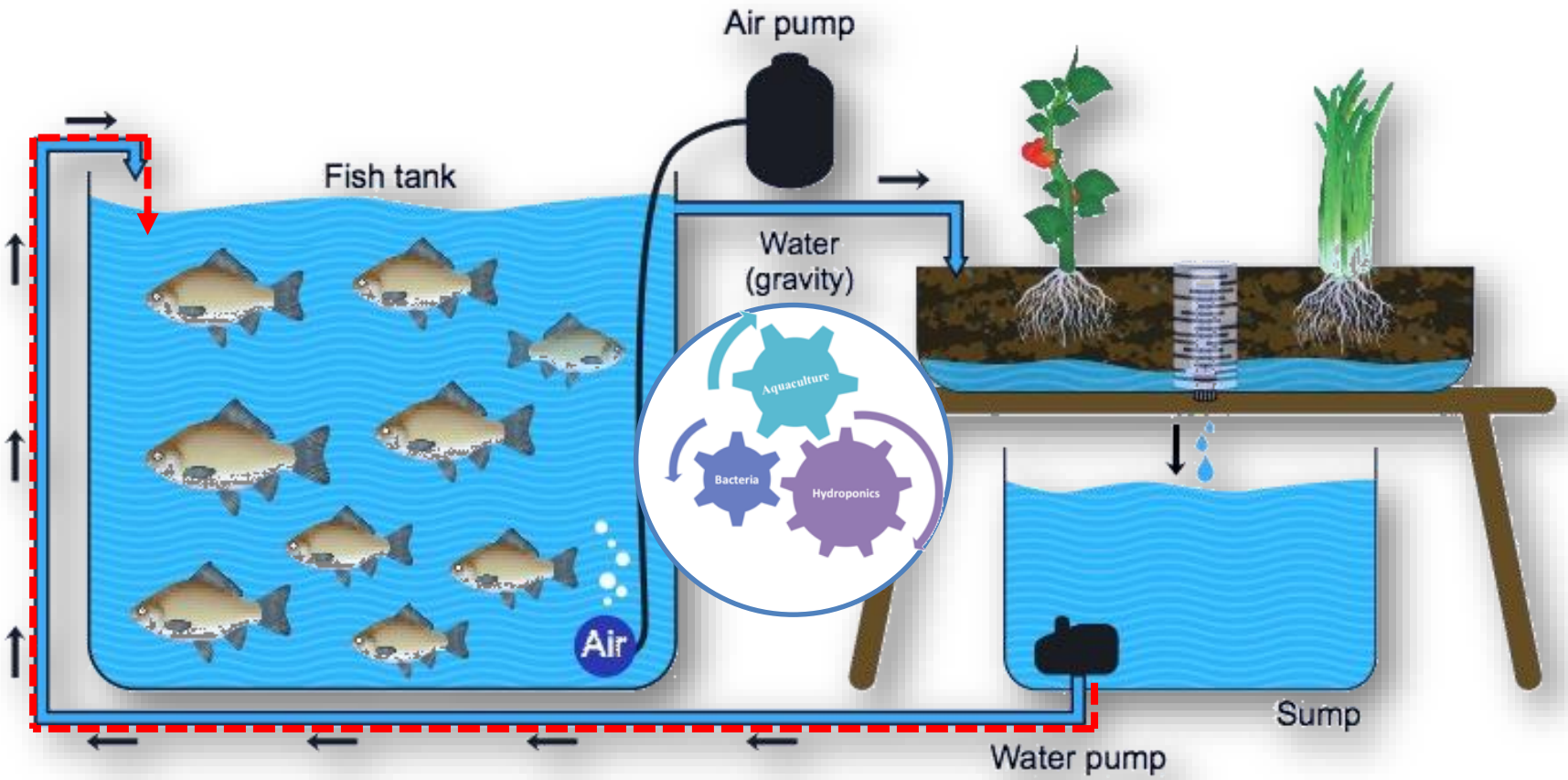
RAS & INTEGRATED AQUACULTURE SYSTEM (IAS)

- RAS + hydroponic system = **Integrated Aquaculture System (IAS)**
- RAS wastewater is **biologically** treated and **entirely** returned to aquaculture
- Hydroponic production "drives" the aquaculture wastewater remediation
- The final result is a double food production: **fish and greens**

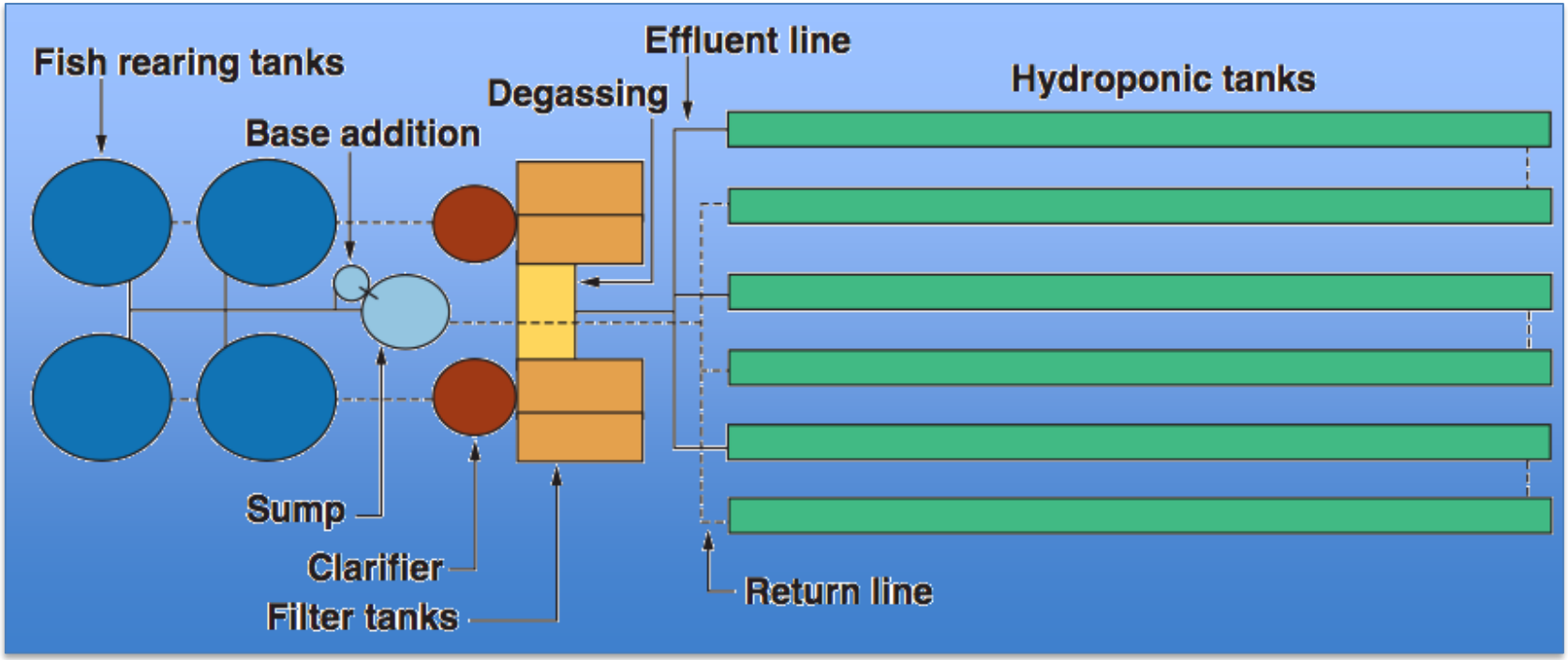
RAS "waste"

Nutrient for plant

RAS + HYDROPONIC = IAS

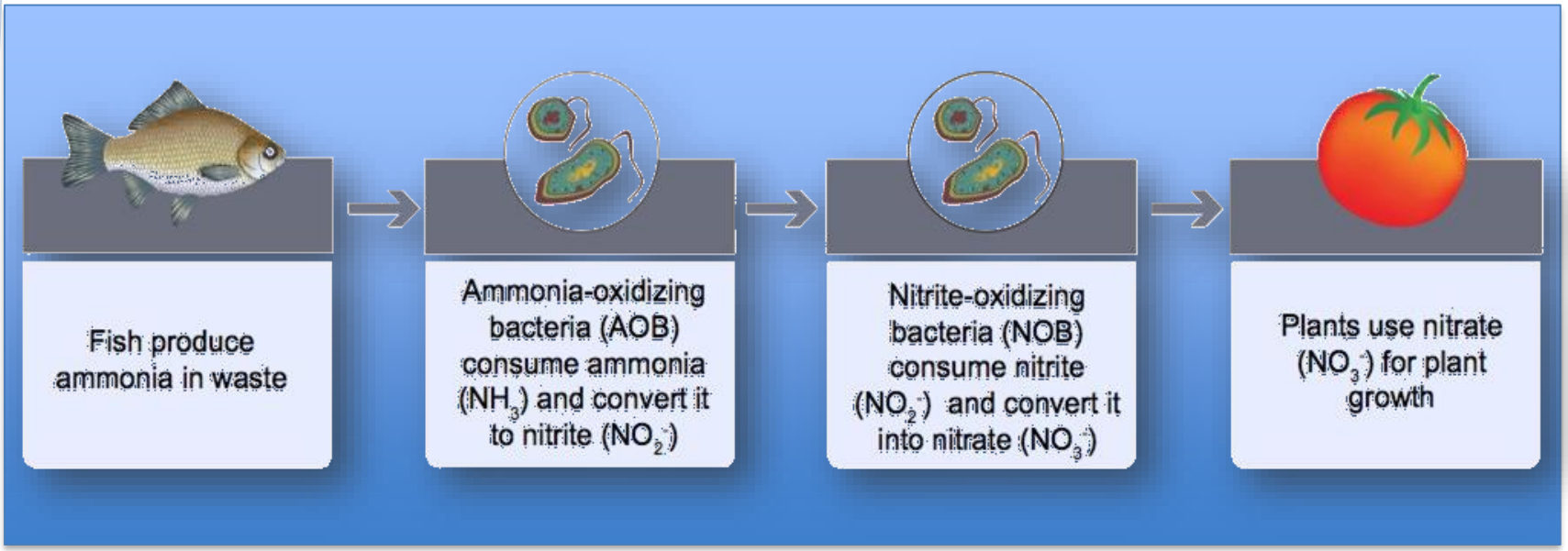


IAS: MAIN COMPONENTS

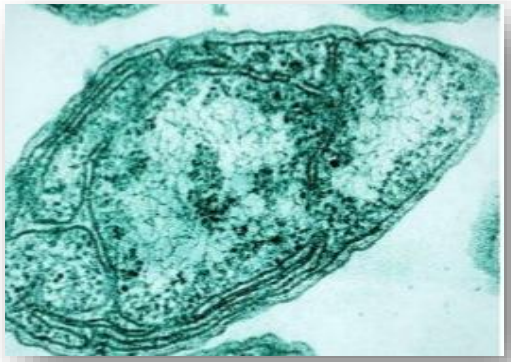


- Plant growing to fish tank surface ratio is normally 7:3
- Larger ratios are needed as solids removal efficiency decreases

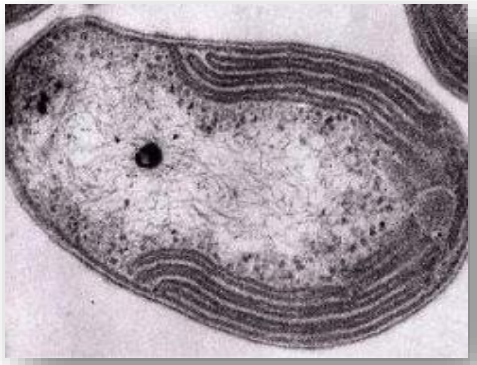
AQUAPONICS: HOW DOES IT WORK?



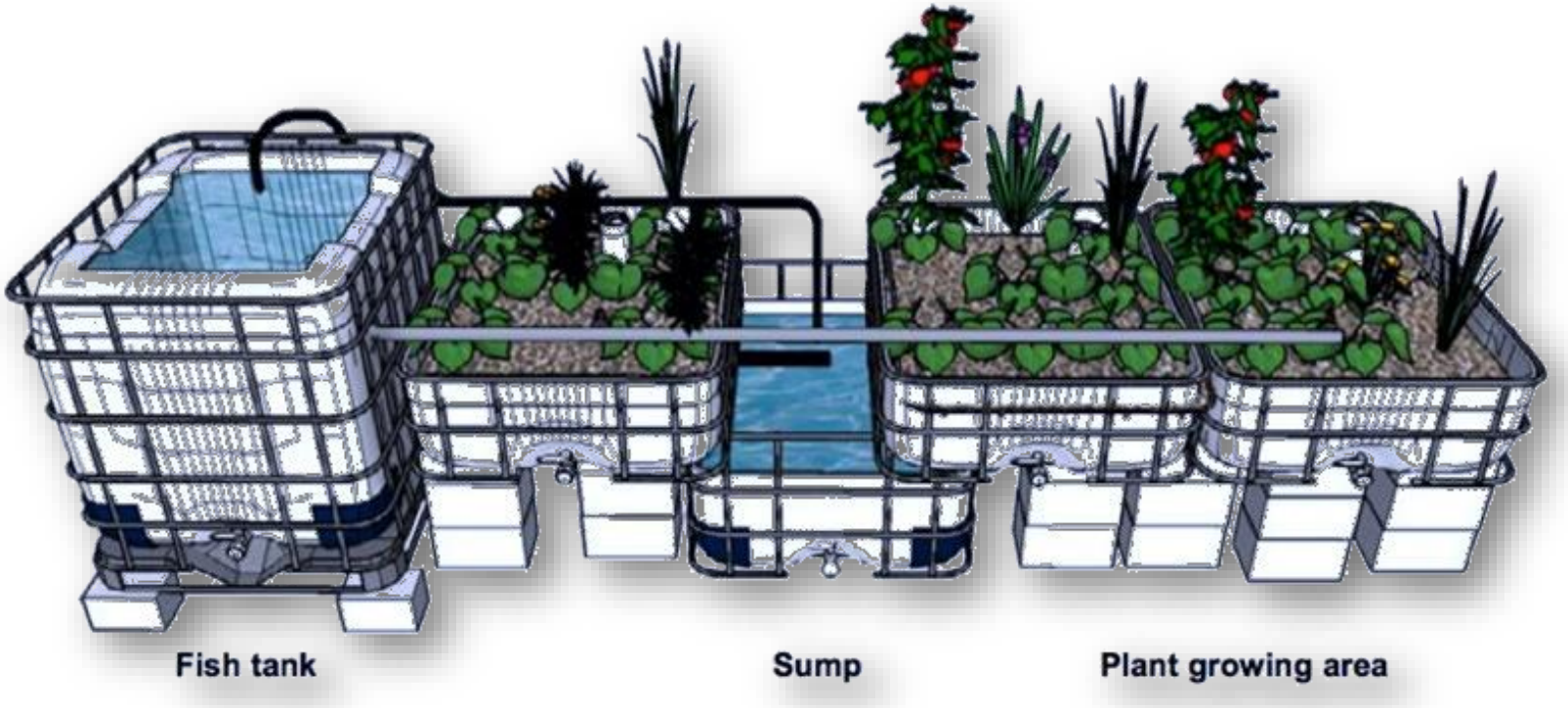
Nitrosomonas spp



Nitrobacter spp



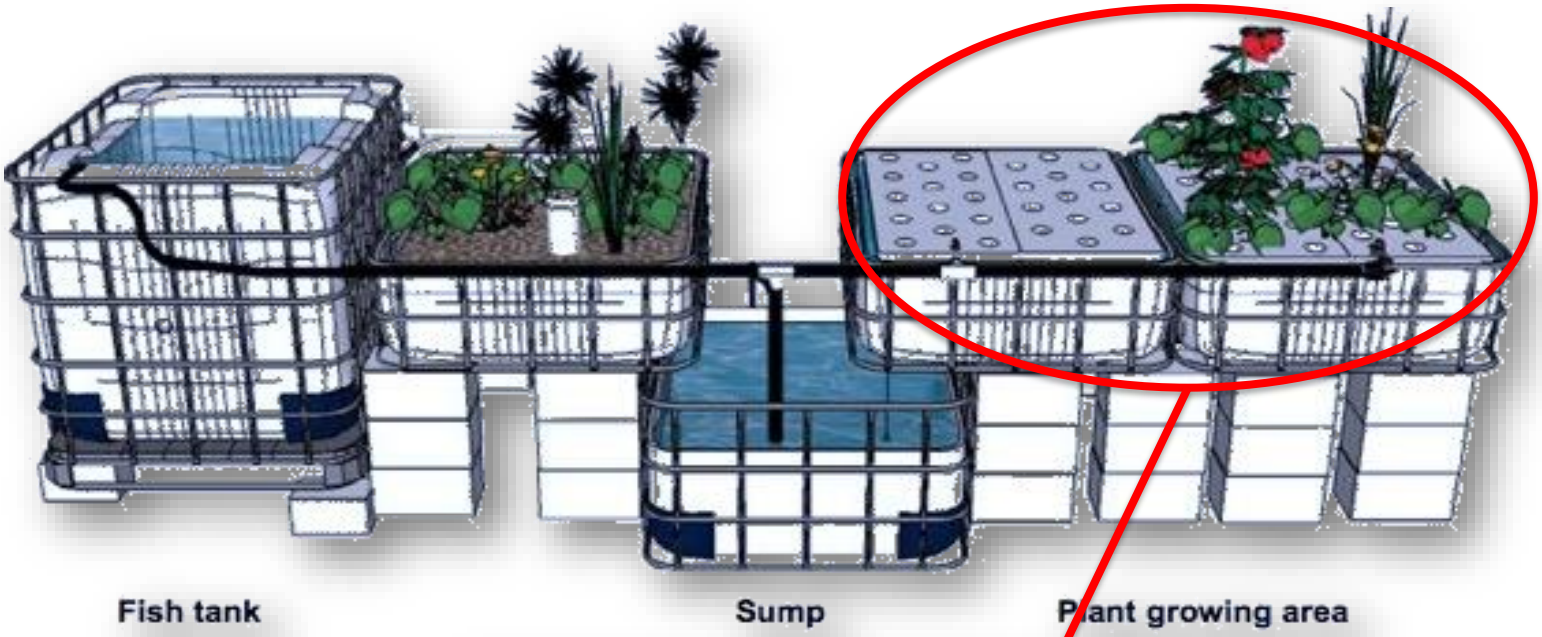
AQUAPONIC SYSTEMS: GROW BEDS (MEDIA BED)



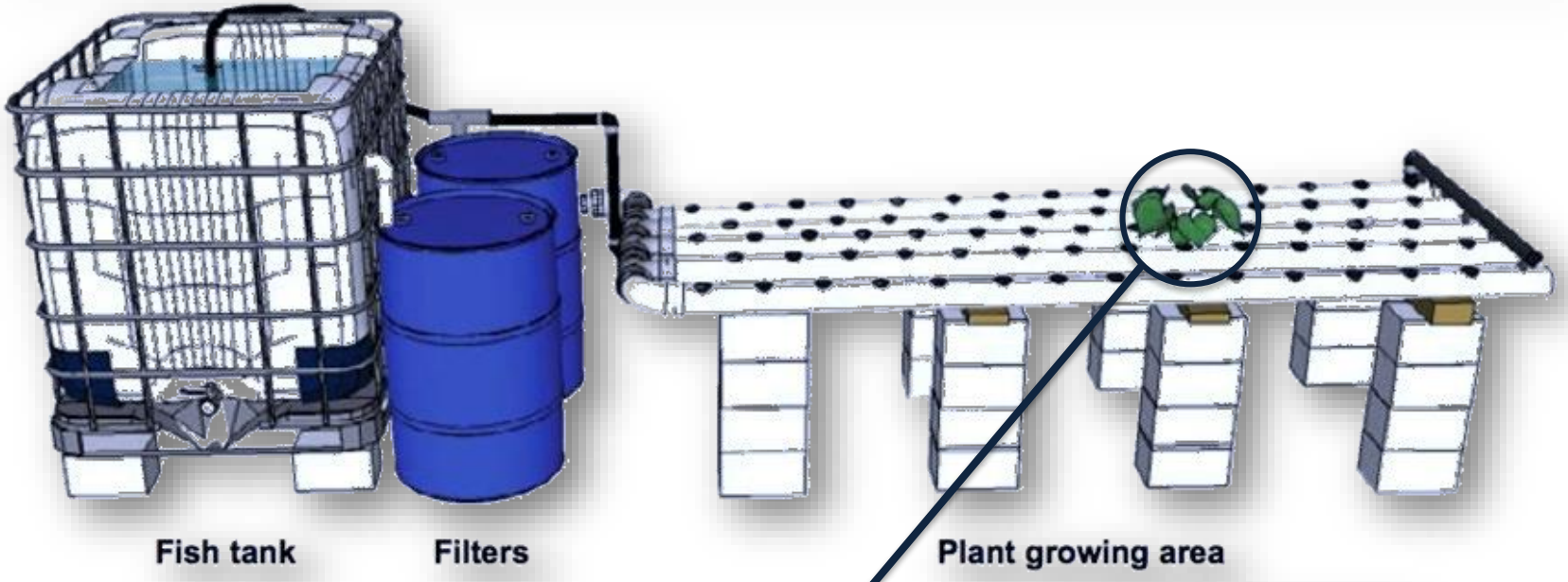
The medium characteristics:
Permeable for water and air, inert, not dusty, and non-toxic, neutral pH

Most common substrate:
volcanic gravel (a), limestone (b), light expanded clay aggregate (c), coconut fiber (d)

AQUAPONIC SYSTEMS: DEEP WATER CULTURE (DWC)



AQUAPONIC SYSTEMS: FILM NUTRIENT TECHNIC (FNT)



AQUAPONICS: HOW DOES IT WORK?

Biofilter:

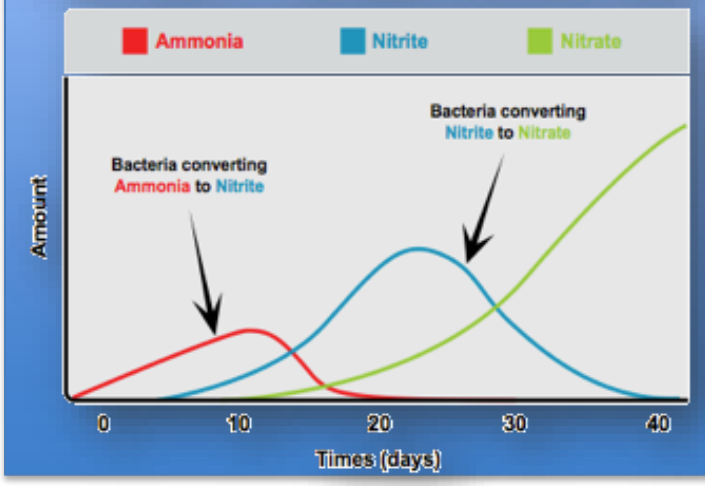
- Specific Surface Area (SSA – surface / volume - m^2/m^3)
- Lower SSA means:
  - higher surface available for bacteria colonization
  - more efficient and fast nitrification process

Suitable compromise for fish & plants:

- pH 6-7
- Temperature 17-34 °C
- DO: 4-8 mg/L (<2 nitrification decrease and denitrification starts)
- no UV until bacteria population is established

Nitrifying bacteria	Optimal pH
Nitrosomonas spp.	7.2–7.8
Nitrobacter spp.	7.2–8.2

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



AQUAPONICS SYSTEMS: SIZING METHOD

Feed rate ratio (FFR - feed / m^2 plants growing area)

- The FRR is a summation of the three most important variables:
  - the daily amount of fish feed in grams per day,
  - the plant type (vegetative vs. fruiting)
  - and the plant growing space in square metres.
- By using the amount of feed, it is then possible to calculate how many fish can be raised based on their average daily feed intake

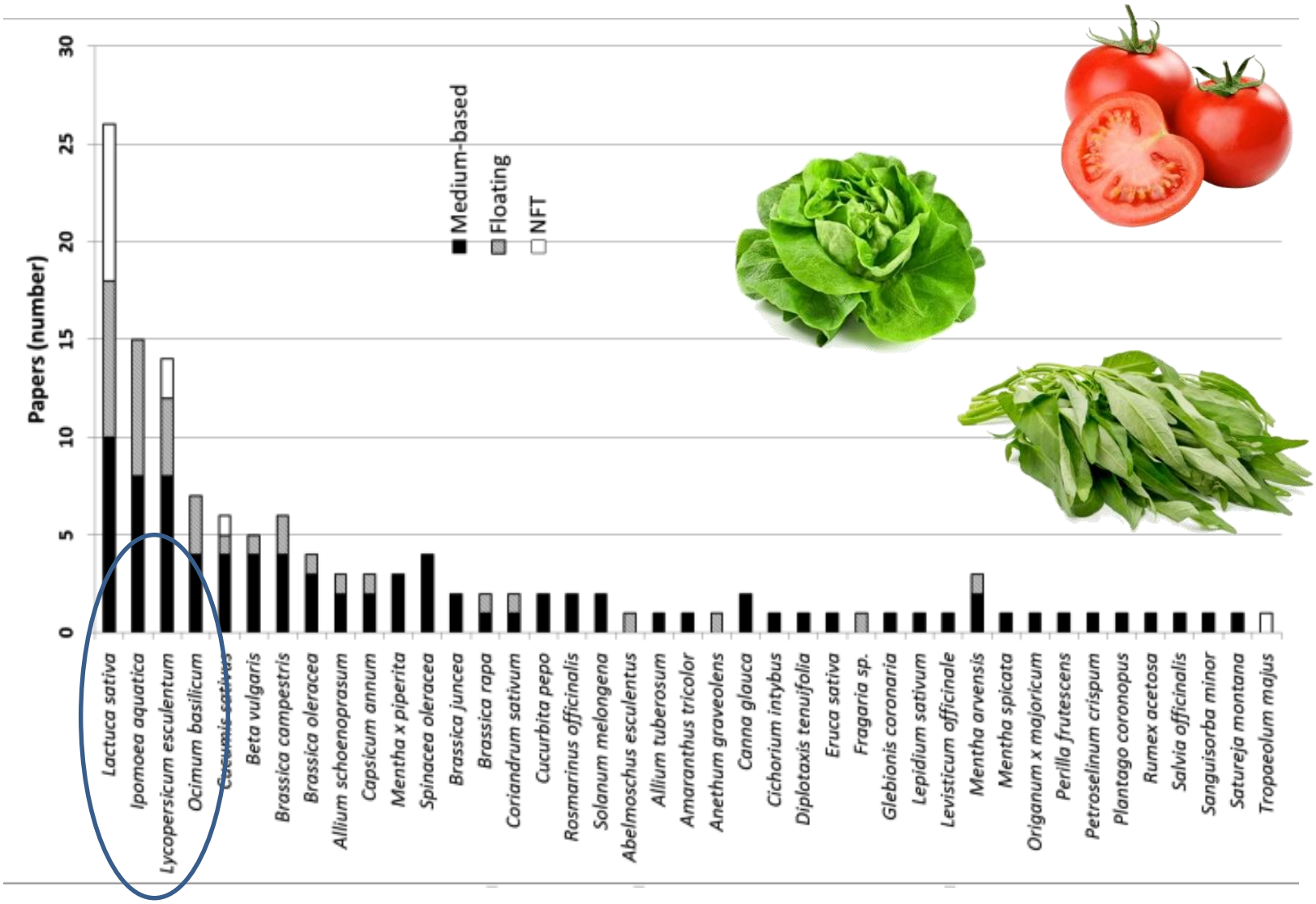
Recommended daily fish feed rates:

- Leafy green vegetables: 40-50 g/m^2
- Fruting vegetables: 50-80 g/m^2

Suggested plant density:

- Leafy green plants: 20-25 per m^2
- Fruting plants: 4-8 per m^2

MOST STUDIED VEGETABLE CULTIVATIONS



AQUAPONIC: FRESHWATER FISH

Carp

Order: Cypriniformes

Family: Cyprnidae

Genus: Cyprinus

Species: C. carpio

Trout

Order: Salmoniformes

Family: Salmonidae

Genus: Salmo

Species: S. trutta

Tilapia

Order: Perciformes

Family: Cichlidae

Genus: Tilapia

Species: Oreochromis spp

AQUAPONIC: FRESHWATER FISH

African catfish

Order: Siluriformes

Family: Clariidae

Genus: Clarias

Species: C. gariepinus

AQUAPONIC: MARINE FISH

European sea bass

Order: Perciformes

Family: Moronidae

Genus: Dicentrarchus

Species: D. labrax

AQUAPONIC: MARINE FISH

Ghilthead sea bream

Order: Perciformes

Family: Sciaenidae

Genus: Sparus

Species: S. aurata

White Seabream

Order: Perciformes

Family: Sparidae

Genus: Diplodus

Species: D. sagrus

Red Porgy

Order: Perciformes

Family: Sparidae

Genus: Pagrus

Species: P. pagrus

AQUAPONIC: MARINE FISH

Shi drum

Order: Perciformes

Family: Sciaenidae

Genus: Umbrina

Species: U. cirrosa

Red drum

Order: Perciformes

Family: Sciaenidae

Genus: Sciaenops

Species: S. ocellatus

Florida Pompano

Order: Perciformes

Family: Carangidae

Genus: Trachinotus

Species: T. carolinus

SO FAR… NOTHING REALLY NEW, RIGHT?

Well, now the questions are:

a. Do we get to an end point?
b. May we improve further aquaculture and IAS sustainability?
c. How we can do?

First of all we have to consider that:

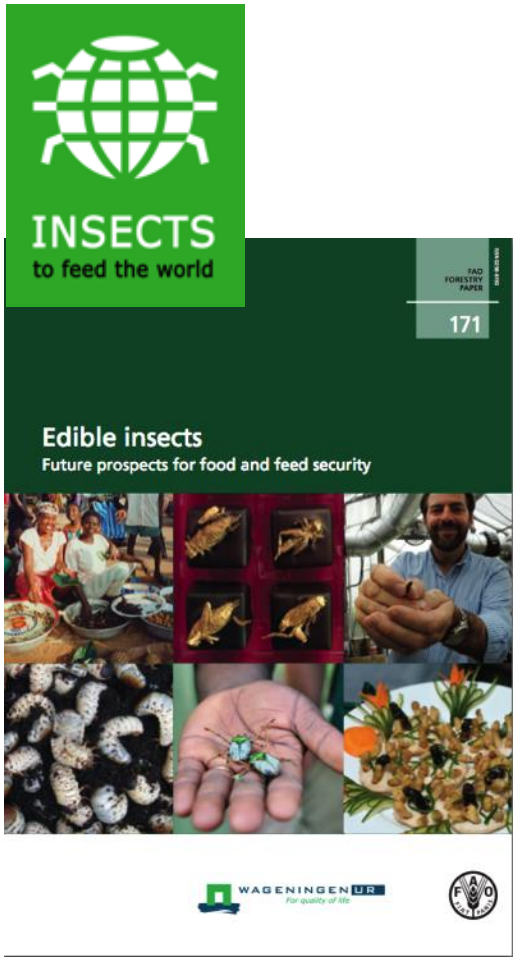
1. the main input in a IAS is the feed
2. input such as water, fertilizers and "drugs/pesticides" are neglectable

Therfore:

- improving feed sustainability is the priority
- Insects represent the right step toward a fully sustainable IAS

Novel foods and novel feeds: *Insects*

- Interesting nutritional characteristics
- Sustainable production:
  - High productivity per surface unit
  - Low water input
  - Short life cycle
  - Poor technology



Why Insects?

High content in:

- Crude Protein: 42-63%
- Lipids: up to 36%
- Unsaturated FA: 60-70%

Low content in:

- Methionine & lysine (excepted for silk worms)
- Calcium

For every kg of beef we consume 15 thousand liters of water, for a kg of insects we need only 100 (www.waterfootprint.org)

Why Insects?

- Expanding population growth
- Increasing demand for fish
- Increased awareness of the health benefits of seafood
- Sustainable breeding strategies in response to the Paris objectives and the fight against climate change

Insects production: the scientific literature

Los Angeles, London, New Delhi
and Singapore
http://www.sagepub.com

ISSN 0734-242X
Waste Management & Research
2009; 27: 603-610
DOI: 10.1177/0734242X09103838

Conversion of organic material by black soldier fly larvae: establishing optimal feeding rates

Stefan Diener, Christian Zurbrügg, Klement Tockner*
Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland

Contents lists available at ScienceDirect
Aquaculture
journal homepage: www.elsevier.com/locate/aqua-online

The potential of various insect species for use as food for fish

Fernando G. Barroso [a,*], Carolina de Haro [a], María-José Sánchez-Muros [a], Elena Venegas [b], Anabel Martínez-Sánchez [c], Celeste Pérez-Bañón [c]

[a] Department of Applied Biology, University of Almería, Almería, Spain
[b] Food Technology Division, University of Almería, Almería, Spain
[c] Instituto Universitario CIBIO, University of Alicante, Alicante, Spain

Contents lists available at ScienceDirect
Journal of Cleaner Production
journal homepage: www.elsevier.com/locate/jclepro

Review

Insect meal as renewable source of food for animal feeding: a review

María-José Sánchez-Muros [a], Fernando G. Barroso [a], Francisco Manzano-Agugliaro [b,c,*]

Waste Biomass Valor (2011) 2:357–363
DOI 10.1007/s12649-011-9079-1

ORIGINAL PAPER

Biological Treatment of Municipal Organic Waste using Black Soldier Fly Larvae

Stefan Diener · Nandayure M. Studt Solano · Floria Roa Gutiérrez · Christian Zurbrügg · Klement Tockner

Comp. Biochem. Physiol. Vol. 114B, No. 2, pp. 161–170, 1996

ISSN 0305-0491/96/$15.00
PII S0305-0491(96)00019-3

Polyunsaturated Fatty Acids in Neutral Lipids and Phospholipids of Some Freshwater Insects

C. Ghioni, J. G. Bell and J. R. Sargent
NERC Unit of Aquatic Biochemistry, University of Stirling, Stirling, FK9 4LA, Scotland, U.K.

Contents lists available at ScienceDirect
Animal Feed Science and Technology
journal homepage: www.elsevier.com/locate/anifeedsci

Review

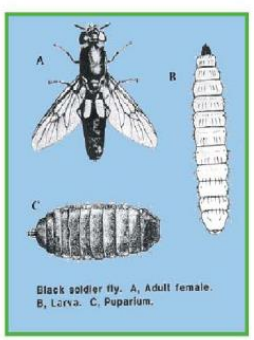
Review on the use of insects in the diet of farmed fish: Past and future

M. Henry [a,*], L. Gasco [b], G. Piccolo [c], E. Fountoulaki [a]

BSF: AN EXAMPLE TO GO FROM WASTE TO VALUABLE PROTEIN

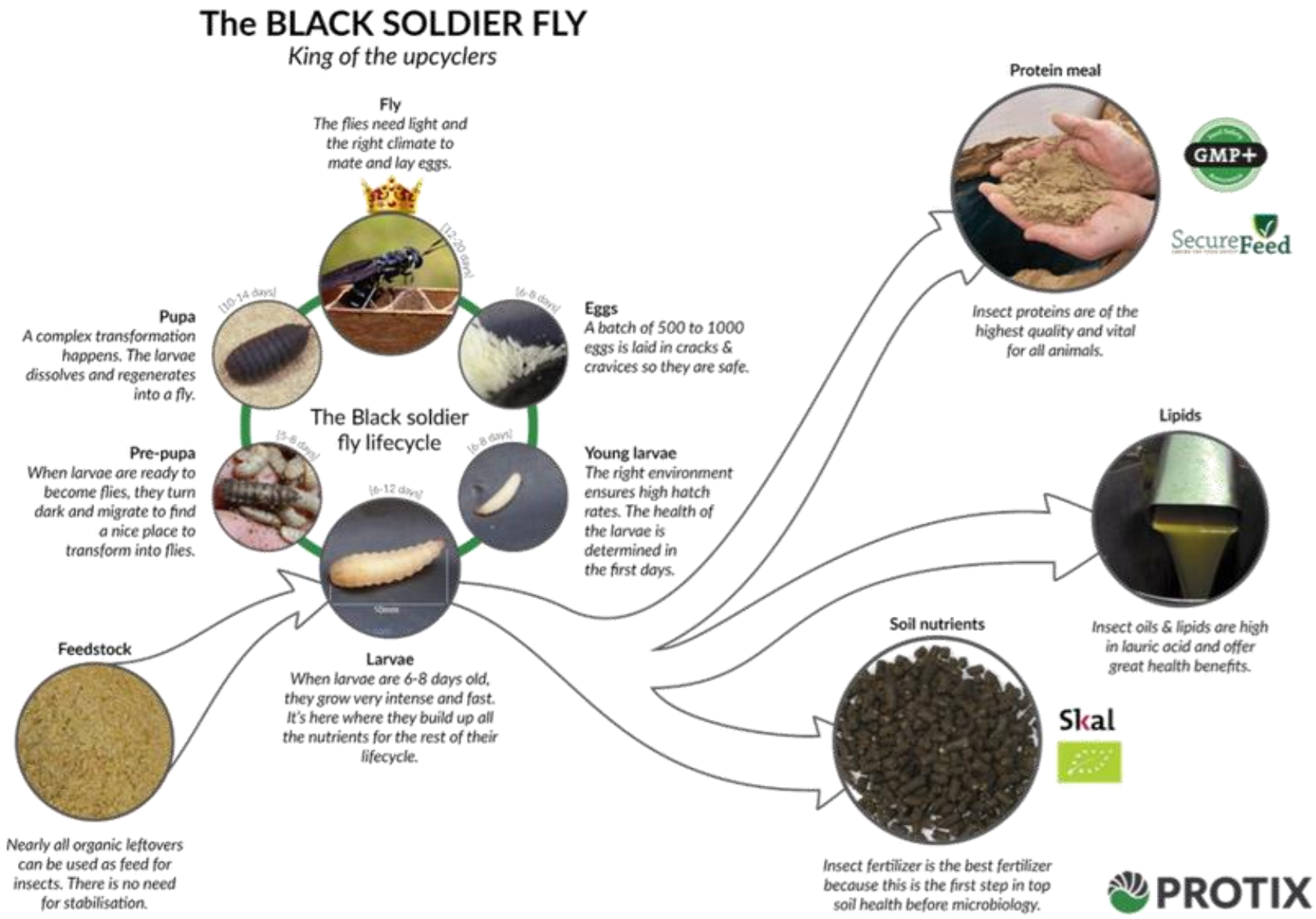
Black soldier fly (*Hermetia illucens*)

- ~24 days to develop into pupae on poultry manure
- 20 days for adult to emerge
- Adults survive ~2 wks



- Reduce waste
  - Up to 50% reduction in mass
  - Between 20 and 50% reduction in phosphorus and nitrogen in remaining material
- Pupae by-product is a suitable animal grade foodstuff
  - ~40% protein
  - ~30% fat

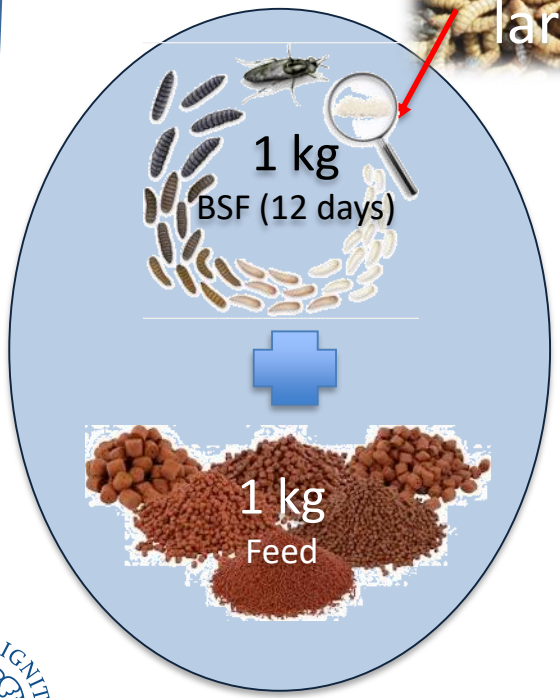
Insects production: the international context



Insects production: our breeding

10 kg/year Fresh water Fish consumption

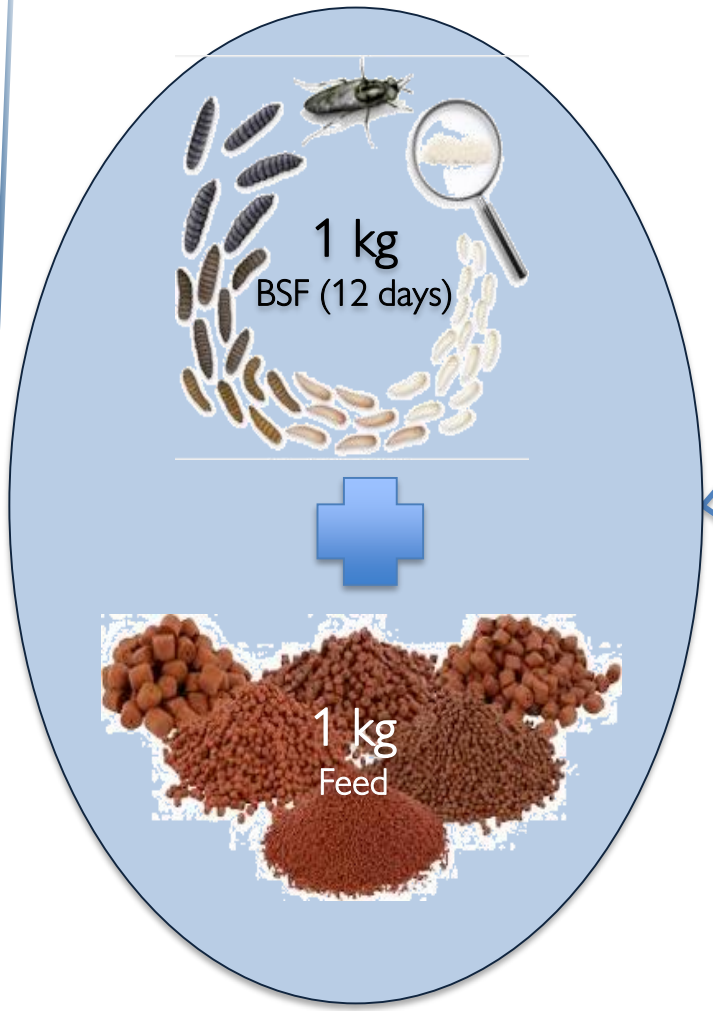
6 months x
2 cycles



Average
100 kg
Fish

10 m^3
Fish tank

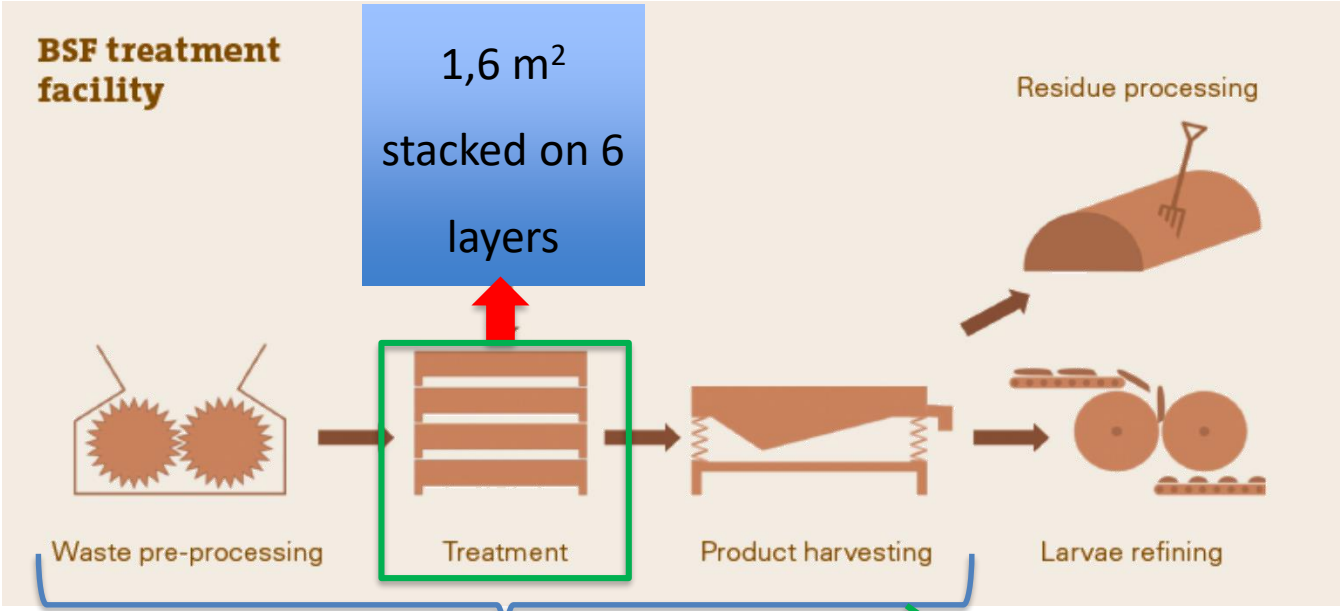
Insects production: our breeding



50% input
- high nutritional value
- renewable source (sustainable)
- from waste to high quality feed

50% input
- Commercial feed (NO FISHMEAL)
- increased sustainability

Insects production: our breeding



Where? Metropolis, cities, quarters

Waste from supermarket

Waste from canteen

Waste from residence

Insect production unit

Aquaponics

FISH

VEGETABLE

consumers

How? Finding sponsors

naturasi
bio per vocazione

UNIVERSITÀ DI PAVIA

Milano
Comune di Milano

INTESA SANPAOLO

fondazione cariplo

TEAM

Idea and experimentation

CAMBIAMO
DIPINGERE INSIEME IL NOSTRO FUTURO

Communication and disclosure

irci
IMPIANTI ED ENERGIA

The system

PROTIX

The larvae

Expected results

- Development of an efficient aquaponic system.
- Development of a unit for the transformation of organic waste to insects for fish feeding.
- Creation of a *new product at Km 0*, with high environmental sustainability.
- Development of a cooperative, sustainable and resilient local culture, in response to the decarbonisation goals set by the European Union and the Paris agreement on climate.

Conclusions/1

- Aquaponics presents an opportunity to rethink the indoor fish farming by using the resources more efficiently
- Aquaponic allows to combine fish and crop production, enabling a virtuosos production circle
- Food production turn into a more sustainable approach
- Under-exploited lands and buildings are profitably used
- Food can be produced locally and:
  - the Food chain is shortened
  - transportation and related pollution can be drastically reduced
  - food can be freshly consumed (direct harvesting)
  - farm profitability can be increased (direct sales)

Conclusions/2

Moreover:

- the IAS integration with a "insect production unit", will strikingly improve the system sustainability
- contemporaneously, the system will facilitate the waste management at municipality level and, as a consequence, at country level

References

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6. Somerville C., Cohen M., Pantanella E., Stankus A., Lovatelli A., 2014. Small-scale aquaponic food production. Integrated fish and plant farming. FAO Fisheriers and Aquaculture Technichal Paper No 589. Roma.

Grazie per l’attenzione.