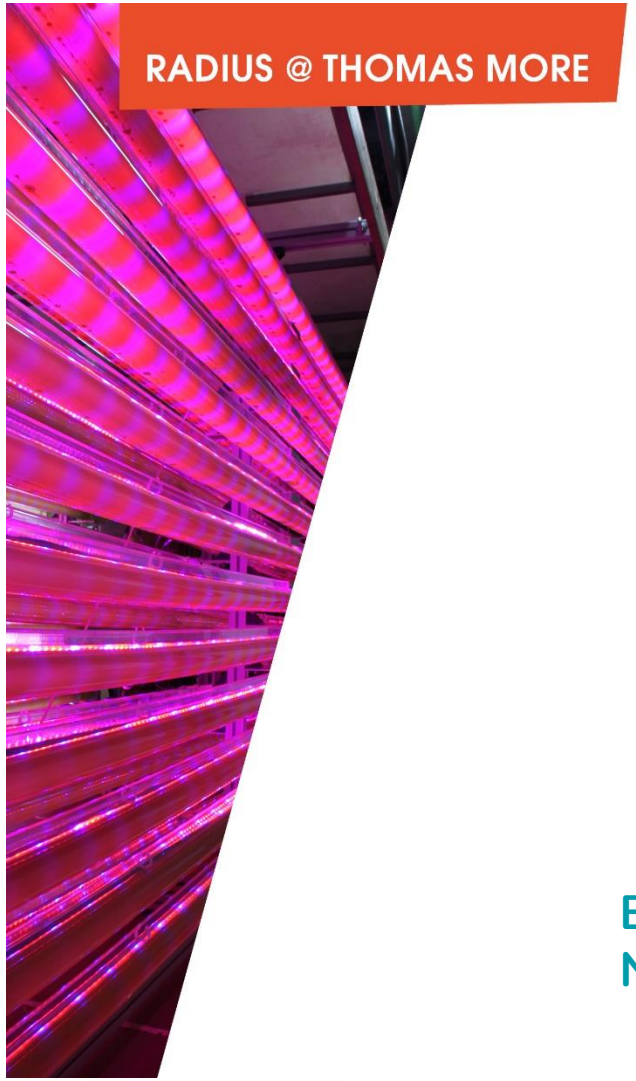


Maestro

DEPARTEMENT LANDBOUW & VISSERIJ

Willy Verstraete

UGent

Elfde Vlaams Aquacultuursymposium: Nieuwe eiwitten voor de aquacultuur

Vlaams Aqua cultuur platform

THOMAS MORE University of Applied Sciences

Single Cell Protein (SCP) for Aquaculture

GHENT UNIVERSITY

KWR Watercycle Research Institute

Willy Verstraete

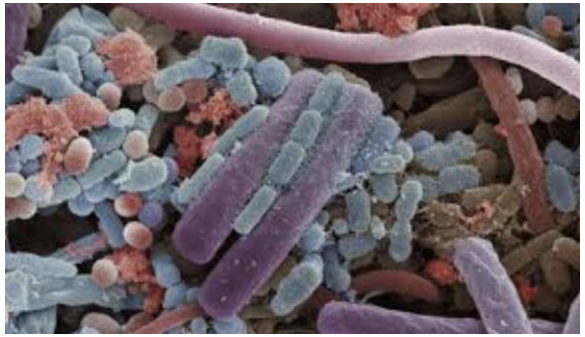
Basic Microbiology for Single Cell Protein

- Single cell = cells on their own / not making large tissues

- **Bacteria** 1 um / some can fix nitrogen

a) Organotrophs : they eat low value organic matter / using oxygen they burn half of the input to CO_2 and the other half becomes their body mass (70% protein)

Yield : 1,0 g organic matter gives 0,5 g dry matter SCP



b) Phototrophs : they use 'weak' light as energy source and take organic matter to make body mass (70% protien + pigments) ;

Yield : 1,0 g organic matter gives 1,0 g dry matter SCP

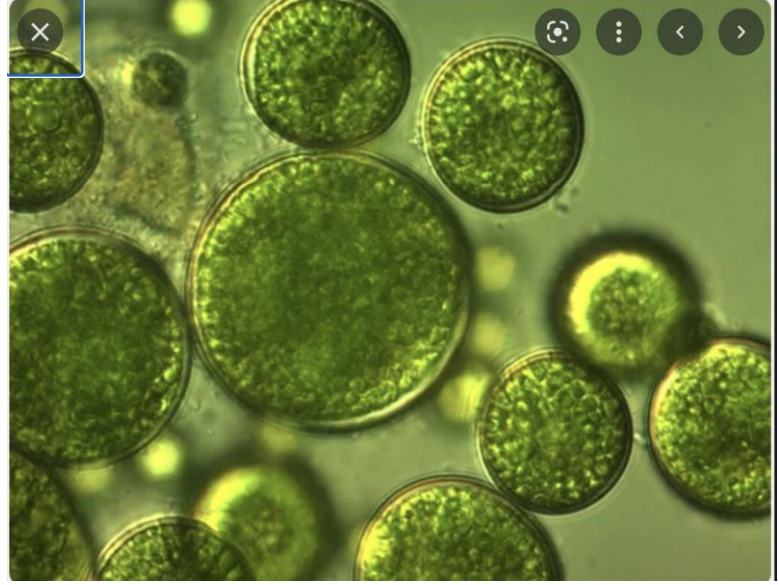
Basic Microbiology for Single Cell Protein

- **Yeast / Fungi** : 10 um

They are organotrophs ; they can not fix nitrogen

They take high value carbohydrates / using oxygen they burn 60% tot CO_2 and the rest becomes their body mass (50% protein) ; Yield : 0,4

Basic Microbiology



- **Algae** 10um

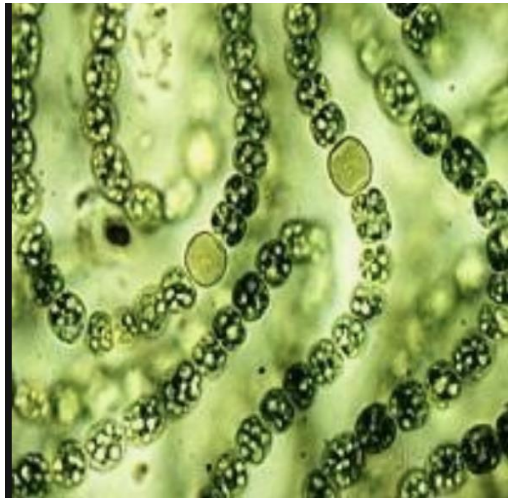
They use <u>strong light</u> + minerals + CO2

to produce cell biomass (50% protein) . Yield : compare with higher plants = some 10 tons dry matter per ha per year

Note : “Blue green algae” are smaller

than regular algae , but they can fix nitrogen

(Nostoc , Anabaena , …)



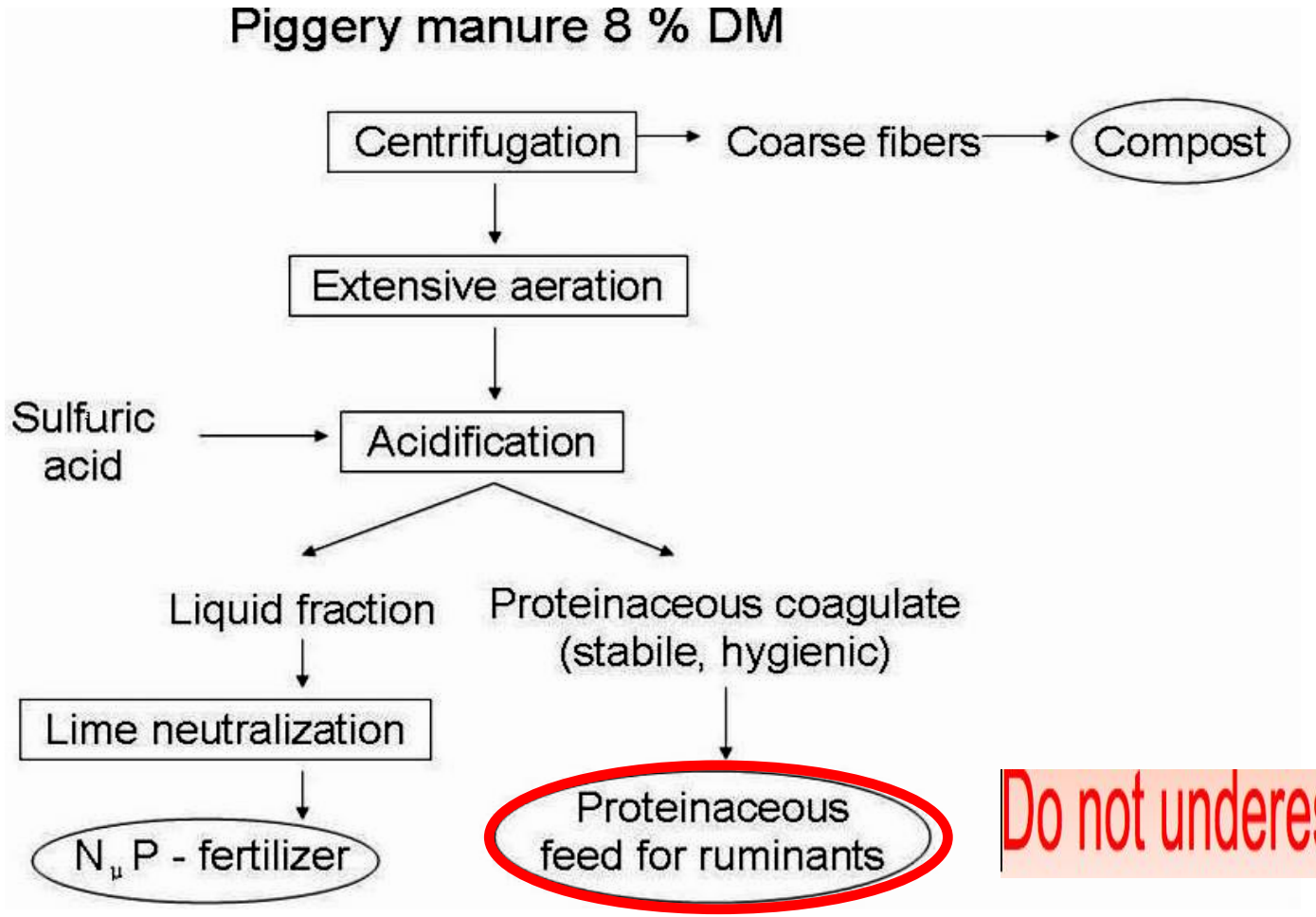
Overview

- The past: Experiences in protein production and water re-use using micro-organisms

- The present: What drives the cyclic economy

Production of SCP in intensive husbandry

Piggery manure to single cell protein (SCP) to feed
(Beernem (1974) IWA/R&D prize; LabMET).



Do not underestimate the Tabloids !!

Experiences with Photo bacteria growing on light

- The year 1985 : The **Rhodospirillaceae**

Short Communications | Published: January 1985

Chemical control of eucaryotic and blue-green algae in anaerobic photoreactors culturing Rhodospirillaceae

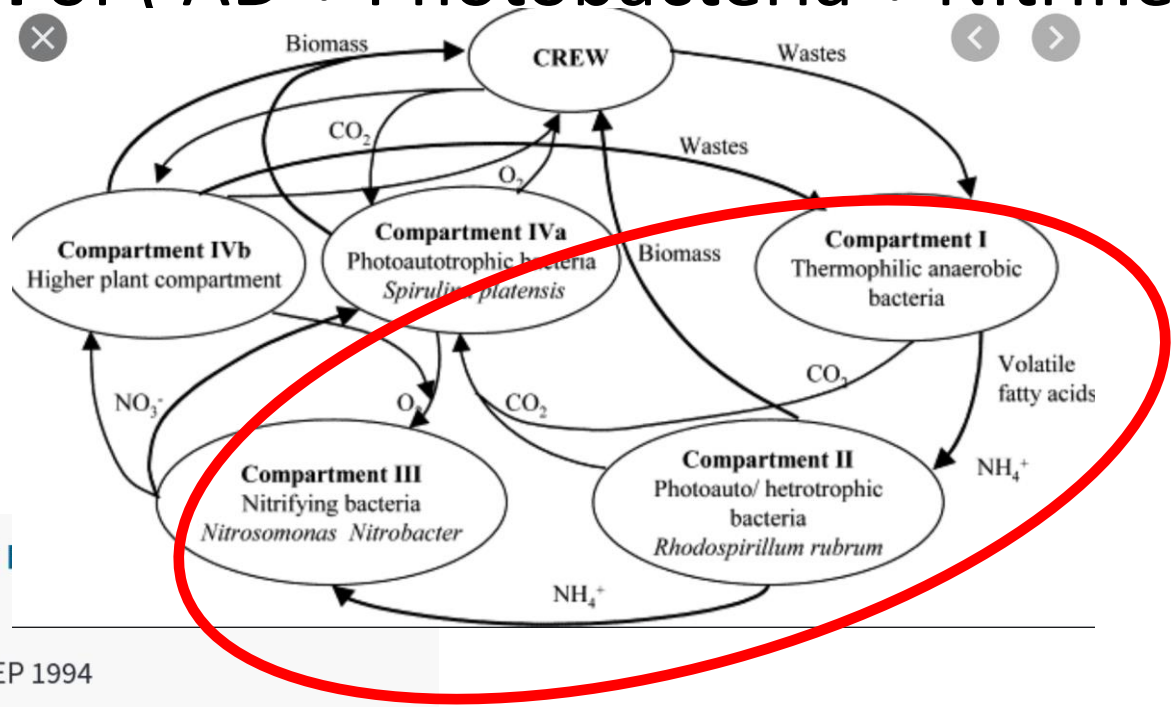
L. Segers & W. Verstraete

Experientia **41**, 99–101(1985) | Cite this article

- Nice production , not economically competitive at that time

Experiences with with full cycling of water in a space craft

- The 90's :**The combi** of (AD + Photobacteria + Nitrifiers) in Melissa



MELISSA IS EITHER AN ECOSYSTEM OR A UNIT

By: GROS, JB; LASSEUR, C; VERSTRAETE, W

BIOFUTUR Issue: 137 Pages: 35-37 Published: SEP 1994

* Perfectly do-able but expensive

Experiences with water recovery

- **The year 2000: Full reclamation of used water** to become drinking water at Oostduinkerke B;

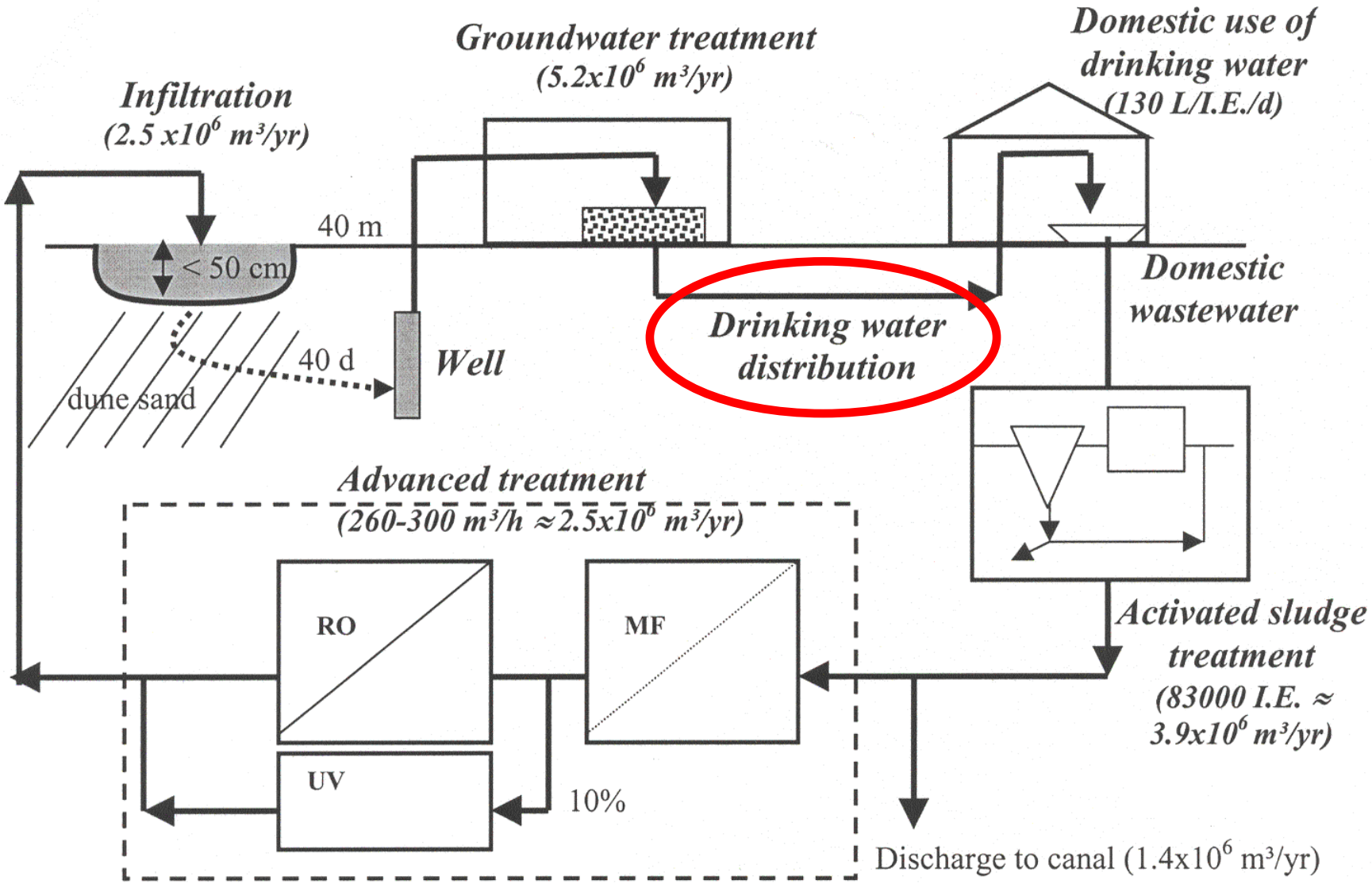
Unique in its kind. Fully functional and top of the world .

HACCP as cornerstone !

Not evident these days : PFOS , ….

Closed water cycle / HACCP and plenty of PR !!!

Oostduinkerke - Belgium (Dewettinck et al. 2001)



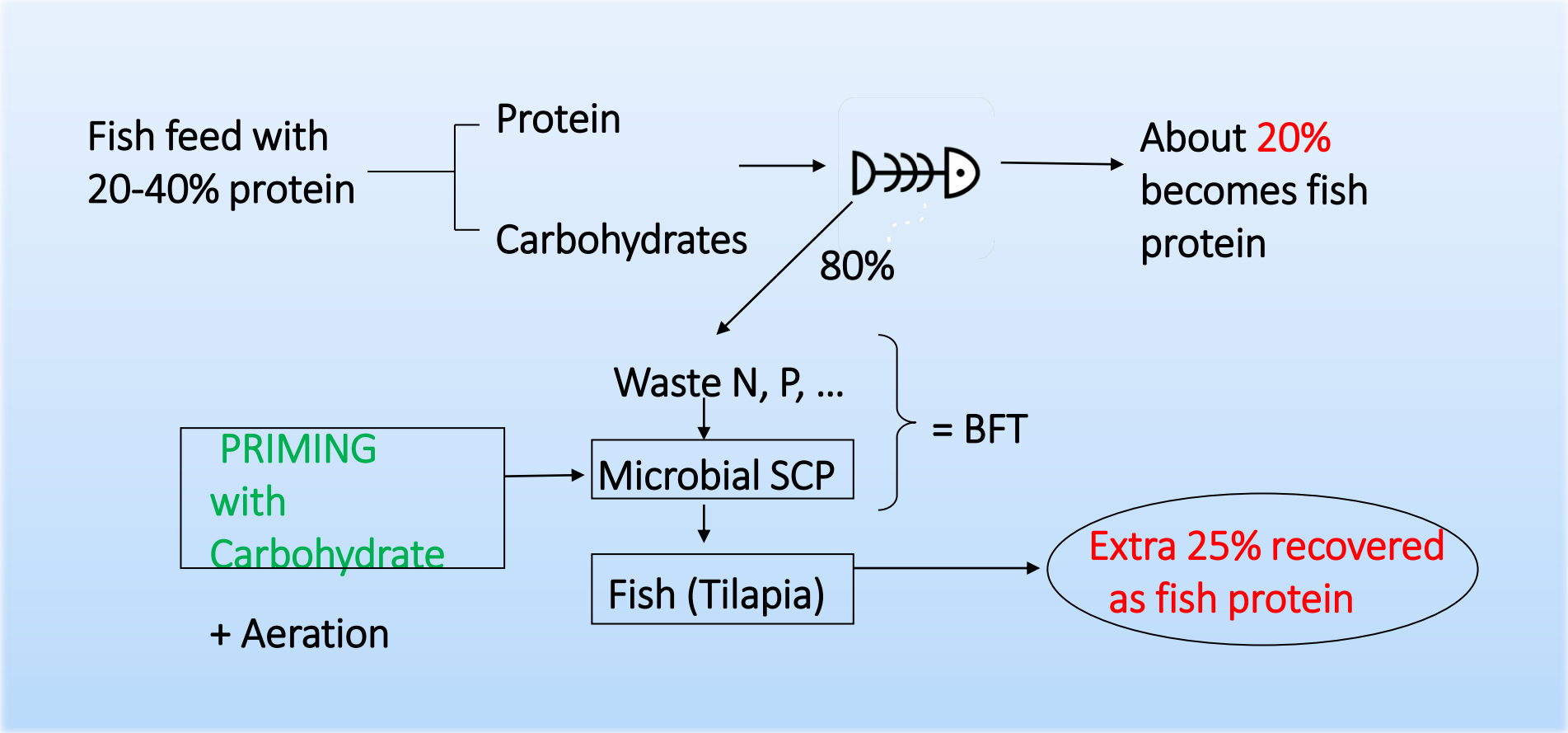
Experiences with aquaculture

- **The year 2003:** Outcry from Aquaculture **:** why not in situ **direct upcycling of fish fecal matter** –Avnimelech

  The biofloc technology / Ever since a growing application

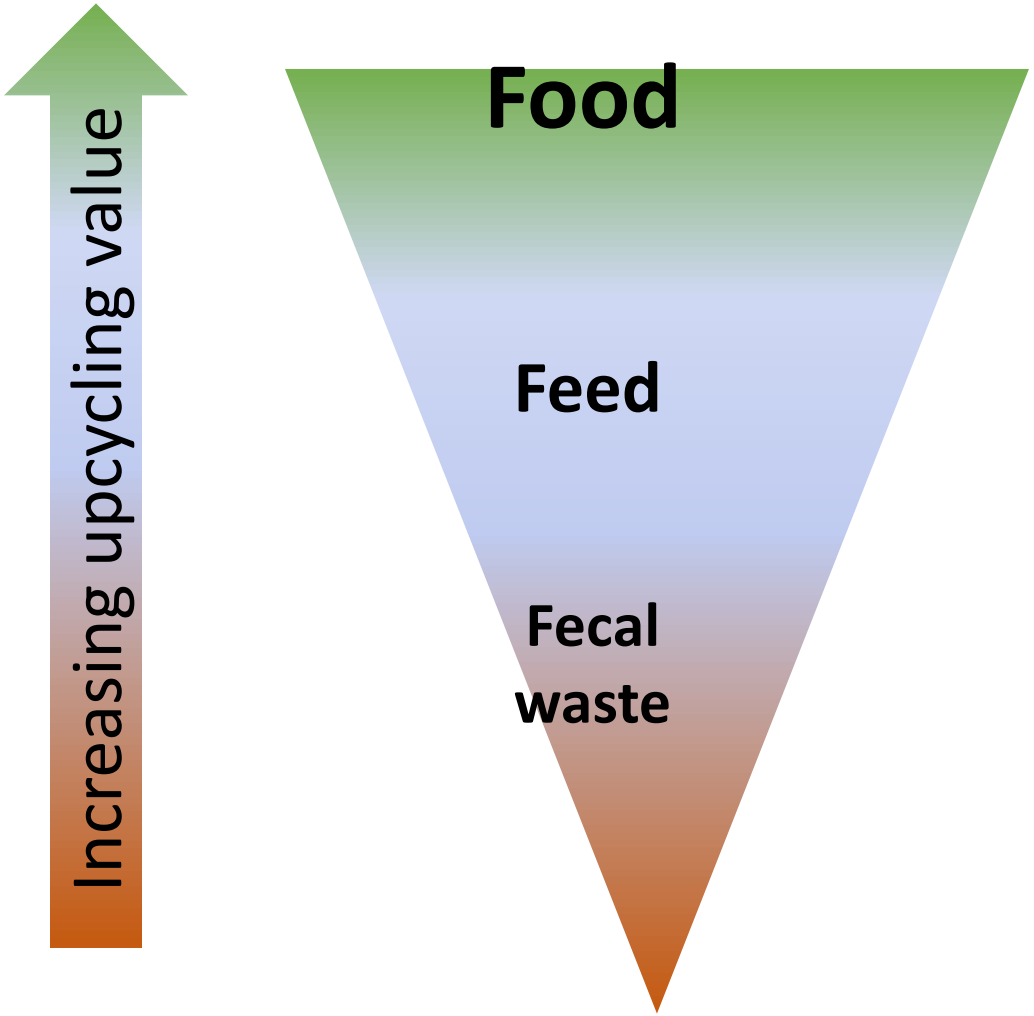
The Aquaculture BioFloc Technology

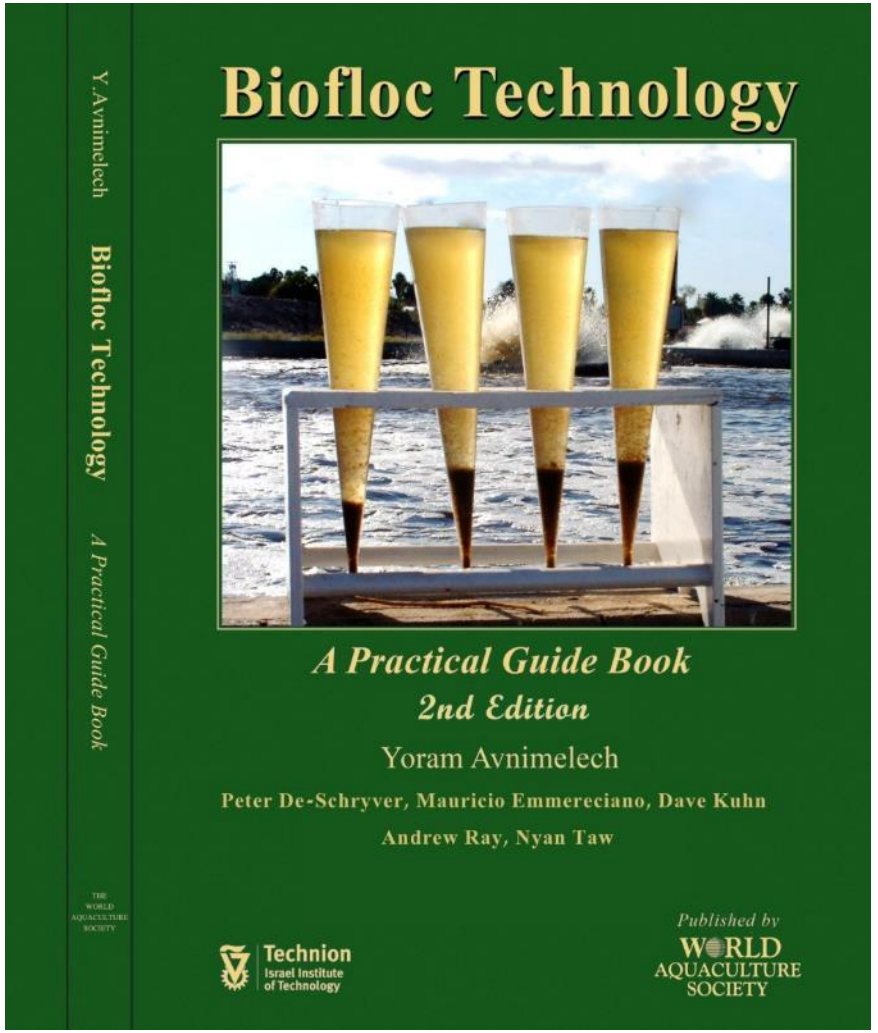
Direct recycling of fecal N as feed in aquaculture



(Crab et al., 2007; Aquaculture 270: 1-14; LabMET;
(De Schryver et al. 2008; Water Res. 42: 1-12; LabMET)

From fecal to feed to food !! This time Nice acceptance !





Overview

- The past : - Take Home with respect to Resource Recovery :

Technically no major difficulties

Market economy sets the boundaries

Communication to and acceptance by the public is crucial !!

- **The present : The Cyclic Economy**

Quoi de neuf ?

The potentials

- Grow novel bacteria on low cost inputs : they make cells which contains 60% or more very digestible protein -- Their value in aquaculture is becoming established = Bacterial Protein

- Grow conventional yeast /fungi on inputs such as sugar and starch : they have less protein (40-50%) - Their value in aquaculture is well known = Yeast Protein

- NOTE: PROTEIN REPRESENTS REACTIVE NITROGEN , AND THE ORIGINE OF THE LATTER IS MAINLY THE HABER BOSCH PROCESS (1 KG N = 2 L FOSSIL FUEL)

Aerobic fermentation to bacterial biomass

Organotrophic route

- Oxygen
- Organic **Carbon**
- Reactive Nitrogen

Autotrophic route

- Oxygen
- **CO_2**
- Reactive Nitrogen
- Hydrogen/CO/CH_4

In-reactor
Bacterial Biomass
production

Bacterial Protein
PROMIC

Food /Animal Feed

OR

Carbon captured in the form Microbial Based Biomass = Slow Release **Organic Fertilizer**
This in case the Quality of Product is low

OR

Material Composites

Potato waters to Promic

- Amino acid composition better than soy; almost that of fish protein
- Piglets, Shrimps: Excellent digestibility, feed uptake and conversion
- Schrimps challenge tests with pathogenic *Vibrio* (Immaqua Lab): dose from 0 tot 75% of diet with Promic: **survival factor 2 better; weight gain factor 1.5 better when Microbial Protein is fed**

LSAQUA
aquafeed innovators

Bacterial Protein updated

Recent Barriers :

*The (EU) regulator : prefers strongly the so-called

'precision fermentation'

For food only fermentation with established strains under sterile conditions is allowed . VERY expensive .

For feed , plenty of uncertainties in the EU (beyond the EU : plenty of possibilities)

* The energy costs : bacterial cultures have , upon harvest , some 10% dry matter ; costs to dry such 90% water suspensions have become very high / reactive nitrogen has risen factor 5 in cost

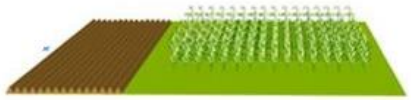
In-reactor protein production on conventional carbohydrates of Yeast/Fungi/..

BIOLOGICAL NITROGEN FIXATION as much as possible

CLEAN MINERALS

Haber Bosch Reactive N

CO_2



High C/N plants
Low amounts of industrial N-fertiliser

Carbohydrates

Production of Yeast / Fungal /Algal biomass

Low cost Sustainable Protein

Food /Animal Feed

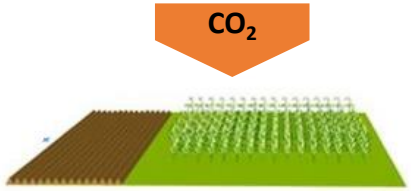
This type of cellular biomass dewaters to 20-30% and is easier to dry

In-reactor protein production on conventional carbohydrates BUT without fossil fuel based nitrogen

BIOLOGICAL NITROGEN FIXATION as much as possible

CLEAN MINERALS

No Haber Bosch N



High C/N plants
Low amounts of industrial N-fertiliser

Carbohydrates

Production of microbial biomass which incorporates bacteria fixing N from N2

Low cost TOP Sustainable Protein

Supply to Consumers of

" Planet proof'

feed and food

Cyclic economy: the future of Microbial Biomass in AgroFOOD

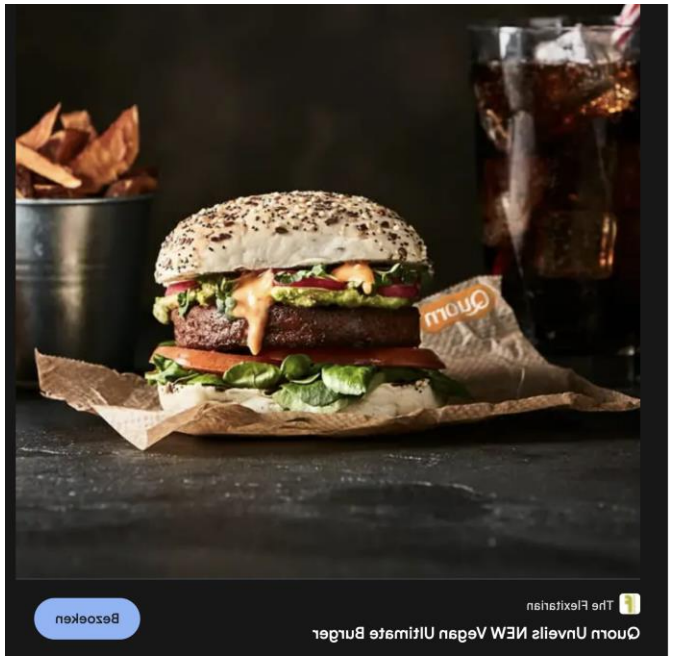
YES : provided 1. EASY to Harvest & Process

2. ‘ Familiar to the consumer’

3 . ‘Planet Proof’

FUNGI

Quorn Burger-Fungal biomass



YEAST

How Yeast Is Used in Cooking

ALGAE

Take home messages about new proteins and about resource recovery today

*Cyclic Economy must be “do-able” and “understand-able” **for the man and the woman in the street**

- Not imposing major costs
- Being safe and sound and understandable
- Not facing heavy regulatory issues
- Showing net environmental benefits (LCA)

Take home messages about new proteins and about resource recovery today

1.The current economic situation certainly opens perspective for proteins produced by micro-organisms , particularly from low value carbohydrates

2.In the near future , more and more people will desire fully ‘planet proof; ie without N produced by using fossil fuel .For this group of consumers , micro-organisms fixing N will become of central significance .eg. Azotobacter biomass

Photobacteria biomass

Take home messages about new proteins and about resource recovery today

3. Aquaculture is quite ‘unsustainable’ in terms of protein supply

(fish protein from the high sea resp soy protein from haber bosch based plant production) .

There is a strong urgency to act for this sector.

4 .EDUCATION AND BEING ALERT FOR SOCIETAL TRENDS

ARE KEY FOR THE FUTURE


Probiotic bacteria as biological control agents in aquaculture
Verschuere, L; Rombaut, G; (...); Verstraete, W
Dec 2000 | MICROBIOLOGY AND MOLECULAR BIOLOGY REVIEWS 64 (4) , pp.655-+
There is an urgent need in aquaculture to develop microbial cona ol strategies, since disease outbreaks are recognized as important constraints to aquaculture production and trade and since the development of antibiotic resistance has become a matter (... Show more
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Biofloc technology in aquaculture: Beneficial effects and future challenges
Crab, R; Defoirdt, T; (...); Verstraete, W
Aug 1 2012 | AQUACULTURE 356 , pp.351-356
As the human population continues to grow, food production industries such as aquaculture will need to expand as well. In order to preserve the environment and the natural resources, this expansion will need to take place in a sustainable way. Biofloc technol ... Show more
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How can we possibly resolve the planet's nitrogen dilemma?

From essential nutrient to ecological threat: rethinking the anthropogenic nitrogen cycle in times of global crisis

Authors:

Silvio Matassa, Pascal Boeckx, Jos Boere, Jan Willem Erisman, Miao Guo, Raffaele Manzo, Francis A Meerburg , Stefano Papirio, Ilje Pikaar, Korneel Rabaey, Diererik Rousseau, Jerry Schnoor, Pete Smith, Stefan Wuertz, Willy Verstraete

Target Journal: Microbial Biotechnology

Type of article: Minireviews/Reviews