Demonstration of Innovative Functional food production systems based on more sustainable value chains of marine and freshwater raw materials for conscientious EU consumers

NOVAFOODIES

1.0 Production techniques of marine and algae biomass in the context of sustainability

1.3 Integration of sustainability in aquaculture

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This project has received funding from the European Union under Grant Agreement N° 101084180.

Main objective

- Know innovative aquaculture production techniques and understand their ecological background

Learning outcomes

- Describe production techniques that emphasise sustainable approaches
- Know best practice examples of the described techniques

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IMTA
Integrated Multitrophic Aquaculture

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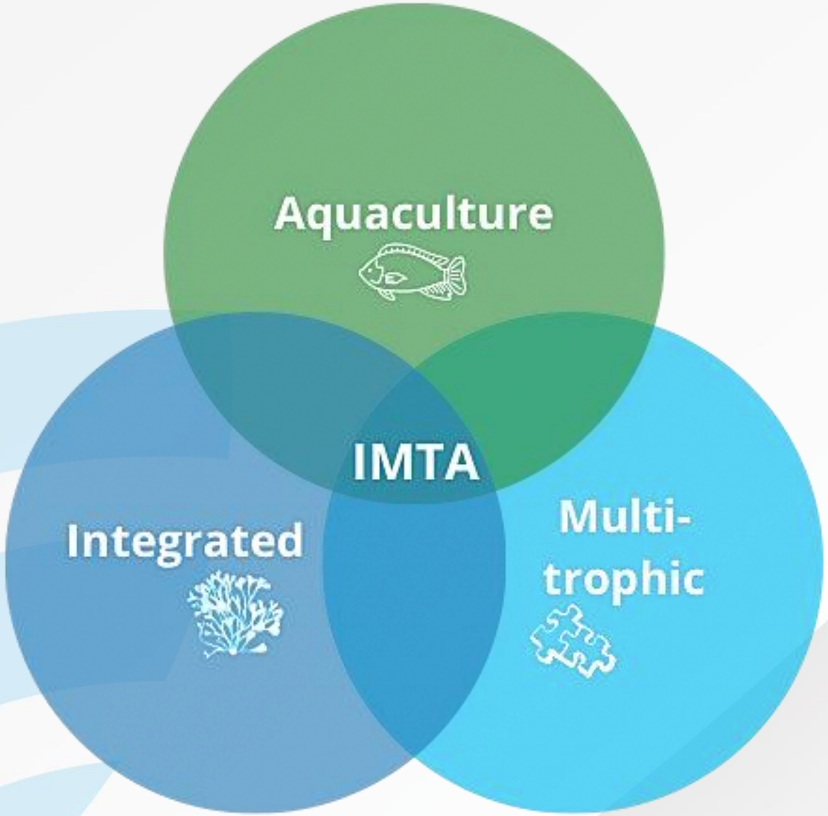

Farming of aquatic organisms (fish, molluscs, crustaceans, aquatic plants). Always implies some form of intervention (feeding, stocking, protection, etc.

Organisms that come from different trophic levels, meaning it contains at least 2 different species of the food chain.

Key element!
Cultured species serve complementary functions within the ecosystem. (e.g. wastes from one are nutrients for others)

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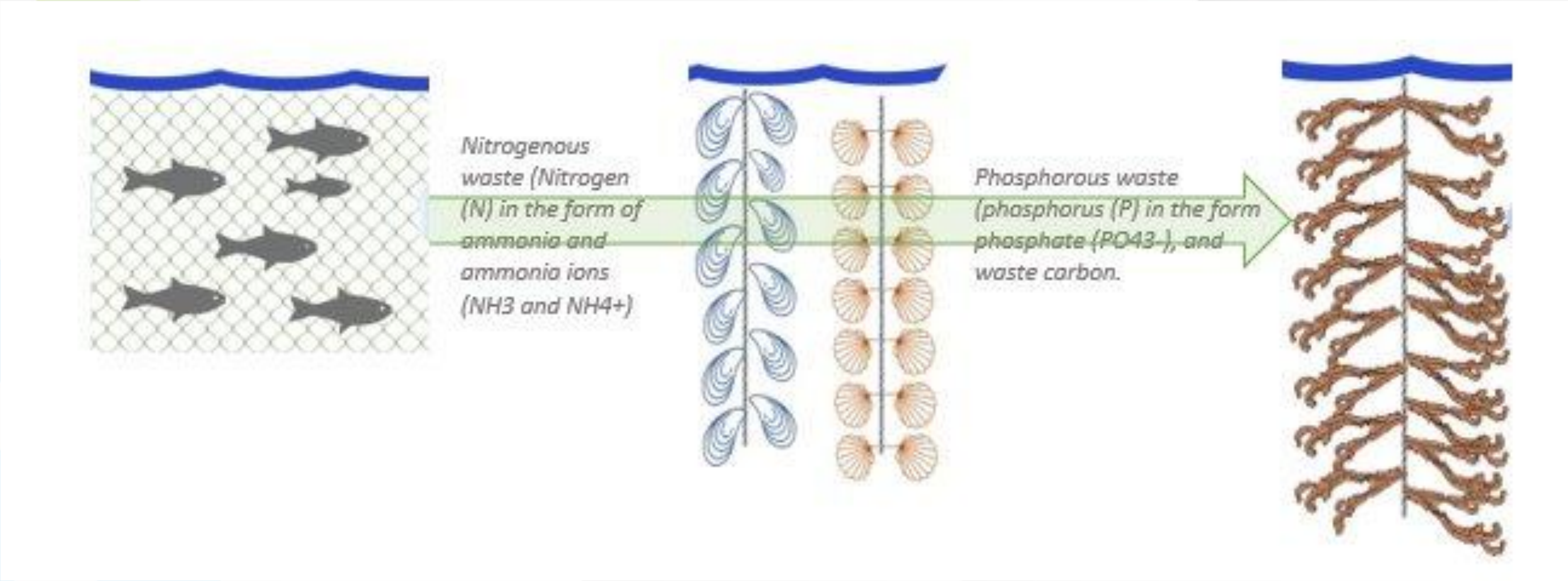
IMTA



Picture provided by *The Seaweed Company*

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Extractive species - examples

Bivalves	• Filter feeder (phytoplankton, detrital matter) • Mussels, oysters, scallops • Best grown near (<60m) fish tanks/cages (higher biomass production)
Seaweed	• Best grown within direct range of fish tanks/cages • Removal of nitrogen and phosphorous from fish (and other species) tank effluent and carbon sequestration • No need of external fertiliser
Sea cucumber	• Deposit feeder • Reduction of organic loading from e.g. fish or mussels
Lobster	• Feed on particulate waste (e.g. from fish) • Difficult cultivation (fighting and cannibalism) • In IMTA: cultivate until adults → release to natural habitat = restocking and preparing for wild fishing

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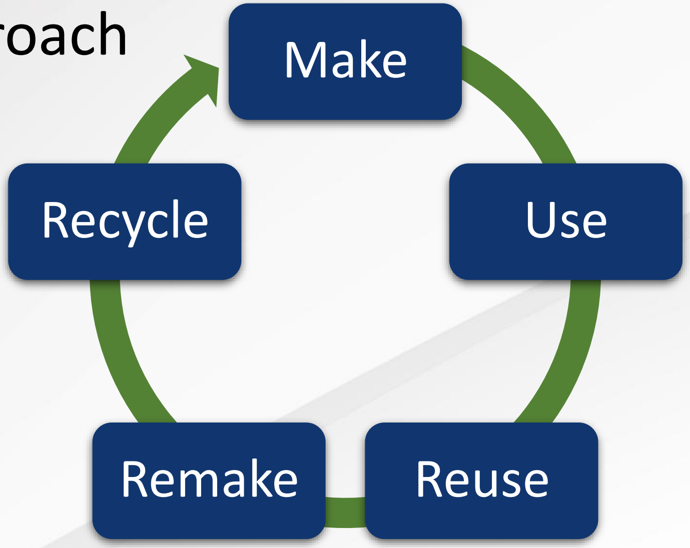
Key benefits of IMTA

- Transition to Circular Farming
  - Shift from linear production model to whole ecosystem approach
- Main areas → 3 sustainability dimensions:
  - Environmental dimension
  - Economic dimension
  - Social dimension



Göpel M. (2016)

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Environmental benefits

Reduction of environmental impact through:

- Copy of natural cycle in the ecosystem
- Ensures water can be discharged either pristine or reused
- Minimising environmental impact and interference with natural ecosystems near aquaculture operations
- High potential for nutrient load reduction and nutrient recycling (improves water quality and reduces waste)
- Ocean-based proteins are substantially less carbon-intensive than land-based proteins (actions that lead to a diet shift to lower carbon protein help reduce emissions)
- Supports polyculture systems by providing a variety of species (avoids monoculture)
- Enhances biodiversity (shelter and habitat for various marine species)

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Economic benefits to farmer

- Alternative incomes, cashflows and revenue streams
- Providing diverse product offerings
- Reduces the need for costly water treatment, especially in land-based IMTA systems
- Enables premium pricing for niche product (the product is more circular and environmentally sustainable than most others)
- Encourages cooperation among farmers (e.g. everyone responsible for other species)
- Enhances business resilience in many aspects (e.g. environmental, due to global warming, economic, due to consumer demand, …)
- Optimises space use (various products are produces within the same space)

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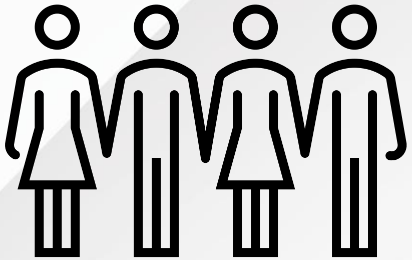
Social benefits



- Compared to fish farmers, workers in aquaculture benefit from:
  - certainty of working location (household stability)
  - access to education, health provision, and appropriate housing
  - regularity of working hours
  - more predictable returns (in both time and value) - easier to make informed financial planning decisions and investments
- Compared to conventional aquaculture systems:
  - Benefits above are at risk – IMTA is more resilient (disease outbreak, food safety recalls, natural disasters
- In conventional aquaculture systems those benefits are at risk, as compared to IMTA, they collapse more easily e.g. due to disease outbreaks, food safety recalls, natural disasters
- In addition, conventional aquaculture leads to aesthetic impacts (perceived environmental damage)
  e.g. cluttered views of the seascape

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Challenges of IMTA

What do you believe?
Why isn't it common practice?

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Challenges of IMTA

Regulation

- Licencing systems are designed for monoculture practices.
- Licencing systems differ across countries, are complex, time-consuming and lack predictability regarding the processing time and expected outcome.
- Licencing for multi-species cultivation often displays a problem.

Market value

- Market uncertainty.
- Farmed species on lower trophic level like shellfish, invertebrates, seaweed and other plants have lower market value than cultured fish.
- High investments for fish farm conversion or new builds, specialized equipment and infrastructure

Complexity

- Complex system management.
- More trophic levels mean more complexity, more costs and effort.
- Unknown species interactions, disease transmission, competition, imbalanced nutrient uptake can turn out problematic.

Familiarity and skills

- New skills are necessary.
- Familiarity with the current system → change is a risk.
- Few large-scale and successful IMTA farms → limited demonstration models.

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IMTA
Pilot case studies

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IMTA Examples in Europe: Saaremaa, Estonia

- University of Tartu
  Estonian Marine Institute
- Fish effluents are directed to tanks for algae cultivation

Ulva intestinalis, University of Tartu

Key facts

System	Cultivated species	Video
Raceway cultivation	*Ulva intestinalis* Rainbow trout	University of Tartu Estonian Marine Institute

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IMTA Examples in Europe: Kefalonia, Greece

- Kefalonia Fisheries
- Seaweed biomass for use in agriculture as raw material for biofertilizer or biostimulants

Key facts

System	Cultivated species	Video
Land-based IMTA	Sea bass, *Ulva spp*. and *Chondracanthus teedei*	KEFALONIA fisheries EST 1981

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IMTA Examples in Europe: Gulf of Tigullio, Genova, Italy

- AquaDeMâ and Universita di Genova
- Implementation of IMTA in an existing monoculture layout

Key facts

System	Cultivated species	Video
Off-shore IMTA	Sea bream, sea bass, finfish, *Ericaria amentacea* and oyster	Università di Genova

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Other forms of algae cultivation

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Key facts of macro and microalgae cultivation

Macroalgae

- Growth environment
  - Intertidal and subtidal zones
  - Often attached to seabed/solid substrate
- Methods
  - Flow-through systems
  - RAS with natural or artificial seawater
  - Cage culture
  - Long lines
- Challenges
  - Environmental Conditions
  - Legislation and Permits

Microalgae

- Growth environment
  - Freshwater, saltwater, wastewater
  - Freely suspended or attached to substrate
- Methods
  - Open systems (ponds, raceways)
  - Fermenters
  - Photobioreactors
- Challenges
  - Risk of contamination
  - Efficient harvesting

→ Each aspect is influenced by a diversity of factors and by each other.

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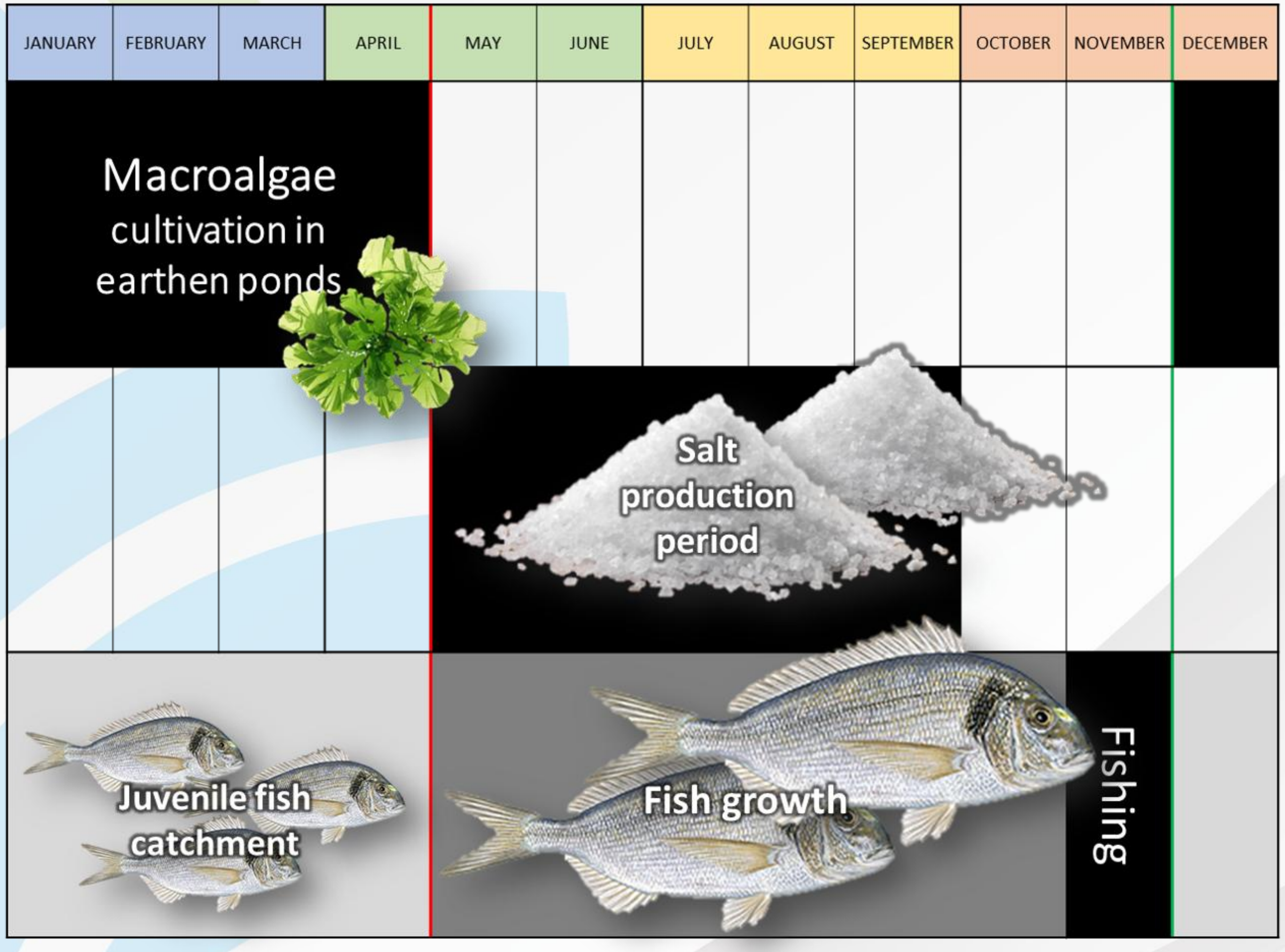
Cultivation of macroalgae in earthen ponds



Picture provided by Aquaculture Technology Centre CTAQUA

- Earthen ponds used for marine salt extraction (in disuse or during the period of no salt production)
- Advantages for algae cultivation: solar evaporation and tidal cycle
- Salt extraction combined with extensive fish aquaculture, both during summer and autumn

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Cultivation of macroalgae in earthen ponds

It would bring many advantages to use the earthen ponds in winter and spring for algae cultivation

- Extensive pond aquaculture can support biodiversity and offer environmental services and business opportunities (beside food production)
- Conservation of biodiversity and cultural heritage
- Profitable commercial activity
- Macroalgal species with marketable value

Picture provided by Aquaculture Technology Centre CTAQUA

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Cultivation of macroalgae in estuarine areas – Cadiz, Spain

Aquaculture Technology Centre CTAQUA

Aquaculture Technology Centre CTAQUA

Key facts

System	Cultivated species	Video
Open pond systems	*Chondracanthus* *Codium* *Ulva*	ctaqua CENTRO TECNOLÓGICO DE LA ACUICULTURA

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Algae cultivation in wastewater

- **Bioremediation** and **waste valorisation**
- Algae recover nutrients from wastewater that would otherwise be lost promoting circularity.
- Various wastewater streams multiple industries due to their ability to grow in various waste substrates
- Biomass for a range of applications/products (not to be used for food, but can be used in nutraceuticals, pharmaceuticals and promising for biofuel production)
- Many influencing factors (e.g. nutrient load, algae species, microorganisms, contaminants, weather and environmental conditions, etc)

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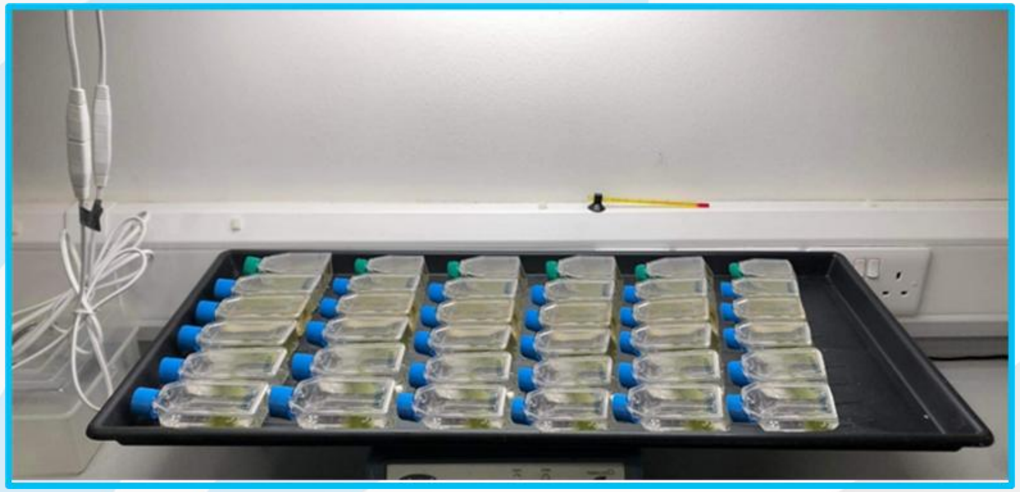
Cultivation of macroalgae in wastewater – Port of Limassol, Cyprus

- Cyprus University of Technology
- Use of swine wastewater and ship-derived effluents as nutrient source



Pilot trial, Cyprus University of Technology

Key facts

System	Cultivated species	Video
Open-air	Cladophora sp. from Cyprus	Cyprus University of Technology

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On-land cultivation of macroalgae in recirculated systems – Bremerhaven, Germany

- Alfred-Wegener-Institut
- E.g. basis for Eco-Packaging and Functional Food

Above: algae-based packaging
Right: production system
Alfred-Wegener-Institut

Key facts

Land-based RAS	Ulva spp.	ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG
System	Cultivated species	Video

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(Low cost) Microalgae cultivation

Biotechnological fermentation in bioreactors

Monitoring and regulation	Versatility	Process optimisation	Scalability	Safety
• Precise control of environmental conditions	• Adaptable system for different applications and organisms	• Enhanced control leads to higher reproducibility and productivity	• Cost efficiency • Automated control systems makes upscaling easier	• Closed system • Reduced risk of contamination

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(Low-cost) Microalgae cultivation – Cork, Ireland

- University College Cork
- Pilot studies on:
  - Heterotrophic production
  - Phototrophic production

Here, only the heterotrophic production is showcased.

Key facts

System	Cultivated species	Video
Bioreactor	*Schizochytrium* S31	UCC Coláiste na hOllscoile Corcaigh, Éire University College Cork, Ireland

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Group exercise

Analyse examples – What is good (or bad) from a sustainability point of view?

- Form groups of 4-5 people
- Each group talks about one example:
- Take the One Health approach into account: Human health, animal health and environmental health
- Afterwards: One person per group gives a short summary of the collected input

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Introduced techniques:

- Integrated multitrophic aquaculture
- Cultivation of macroalgae in earthen ponds
- Algae cultivation in wastewater
- On-land cultivation of macroalgae in recirculated systems
- (Low cost) Microalgae cultivation

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Time for your presentations!

- What cultivation method have you discussed?
- What advantages and disadvantages did you come up with?
- Are there any points you are unsure about?

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Literature

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Intelligent Management System for Integrated Multi-trophic Aquaculture

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Thank you very much for your attention!

Quiz – Test your knowledge!

Follow this way to the Quiz about Production techniques of marine and algal biomass in the context of sustainability

https://forms.office.com/e/rrJX1ZtcNq?origin=lprLink

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