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SIMULTANEOUS TREATMENT OF SOLID AND LIQUID ORGANIC WASTE VIA SPATIAL SUCCESSION OF MICROBIAL COMMUNITIES

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Modern Environmental Problems of Global Significance:

1. Solid natural organic waste degradation (including landfills)

2. Landfills leachate purification

3. Energy problem - obtaining of environmentally friendly H_2 from hazardous solid waste

Dumps in the world contain
1.3 billion m^3 of solid waste and 3.5 billion m^3 of leachate

Strategic issues

Degradation of huge volumes of decaying waste and toxic leachate

The main problem of Environment Protection - the rate of solid organic waste generation is an order higher than the possibilities of their industrial processing

Three modern strategies for solid organic waste processing

Three steps of Spatial Succession in Direct Flow Installation

Sequence of Succession

1 Anaerobic Bioreactor

- Hydrolysis of solid compounds
- Synthesis of H_2 and CO_2
- Synthesis of organic acids and alcohols

2 Air tank

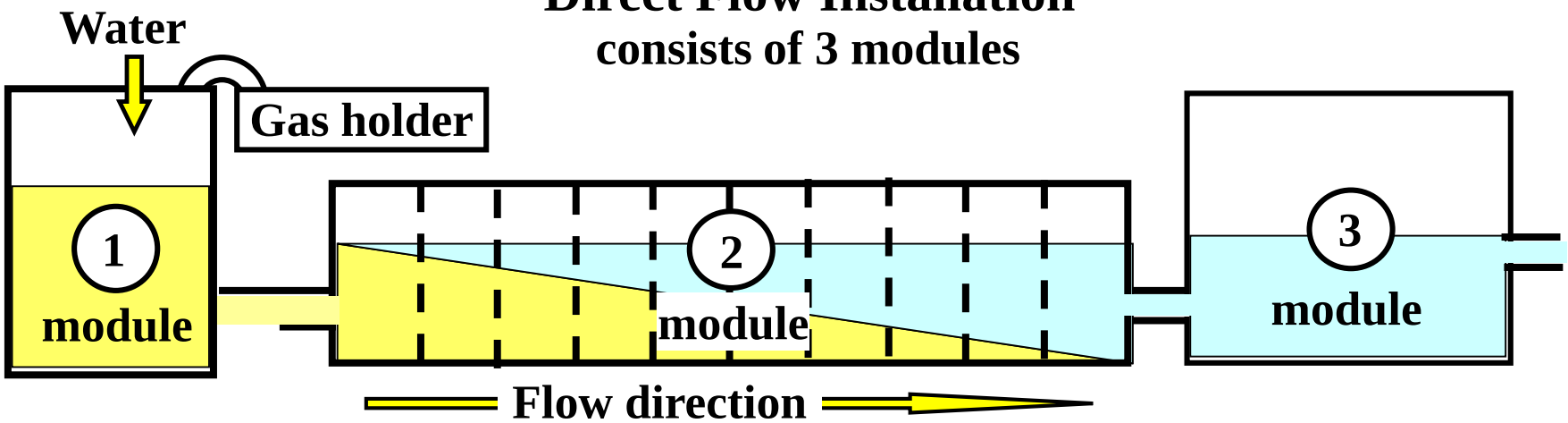
- Combined anaerobic and aerobic degradation of soluble organic compounds (organic acids, alcohols)
- Almost complete purification of sewage from organic compounds and microorganisms

3 Aquarium (aquatic ecosystem)

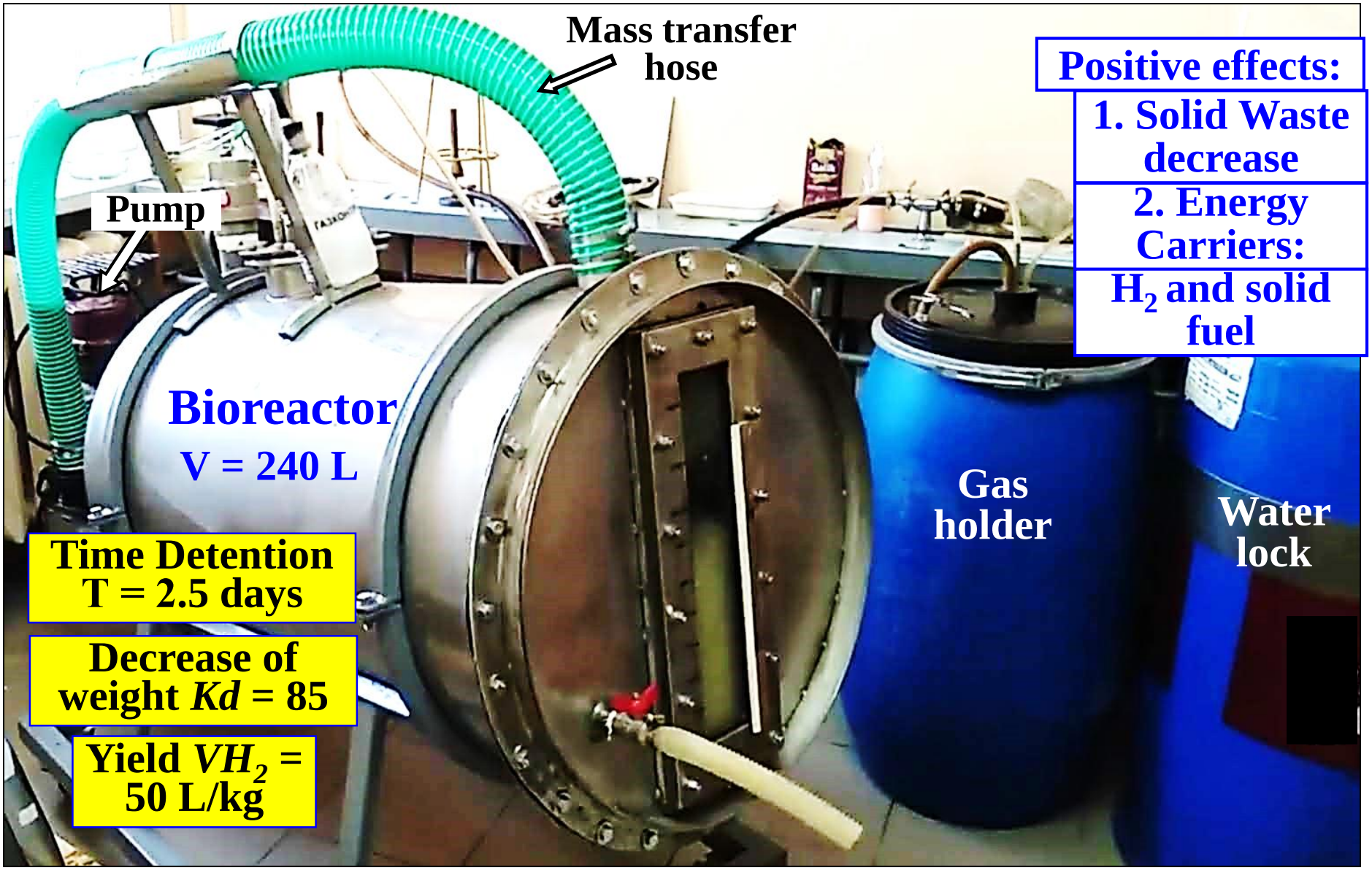
- Complete purification of sewage from organic compounds, microorganisms, protozoa etc.

Direct Flow Installation

consists of 3 modules

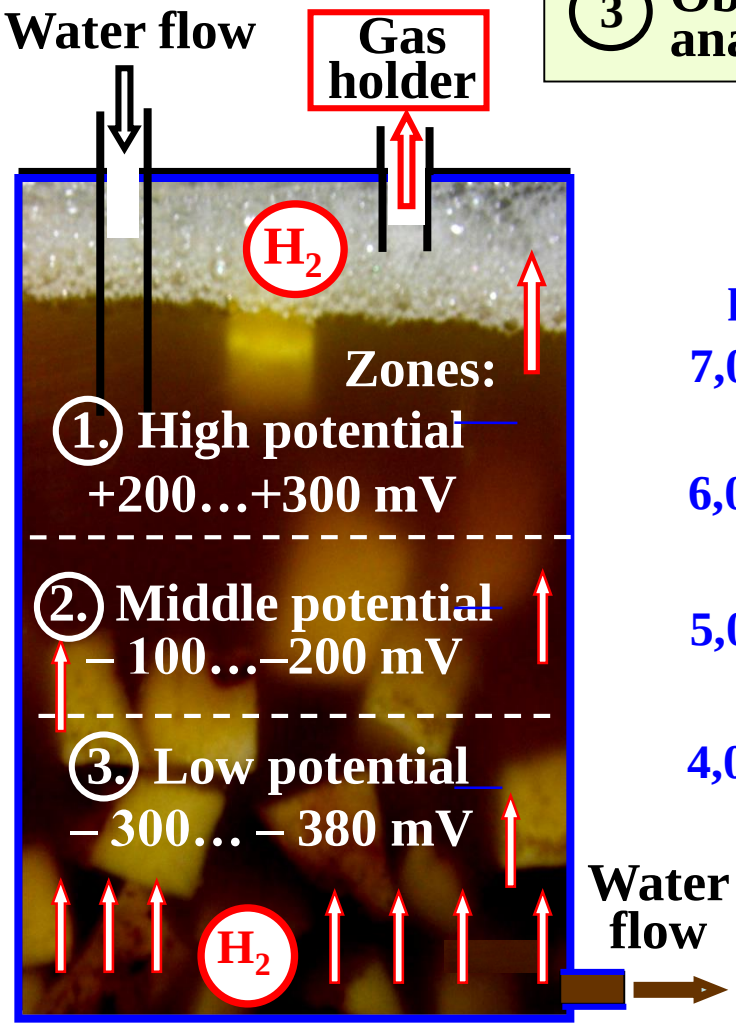


1. Anaerobic Bioreactor for Hydrogen Fermentation of Multicomponent Solid Food Waste

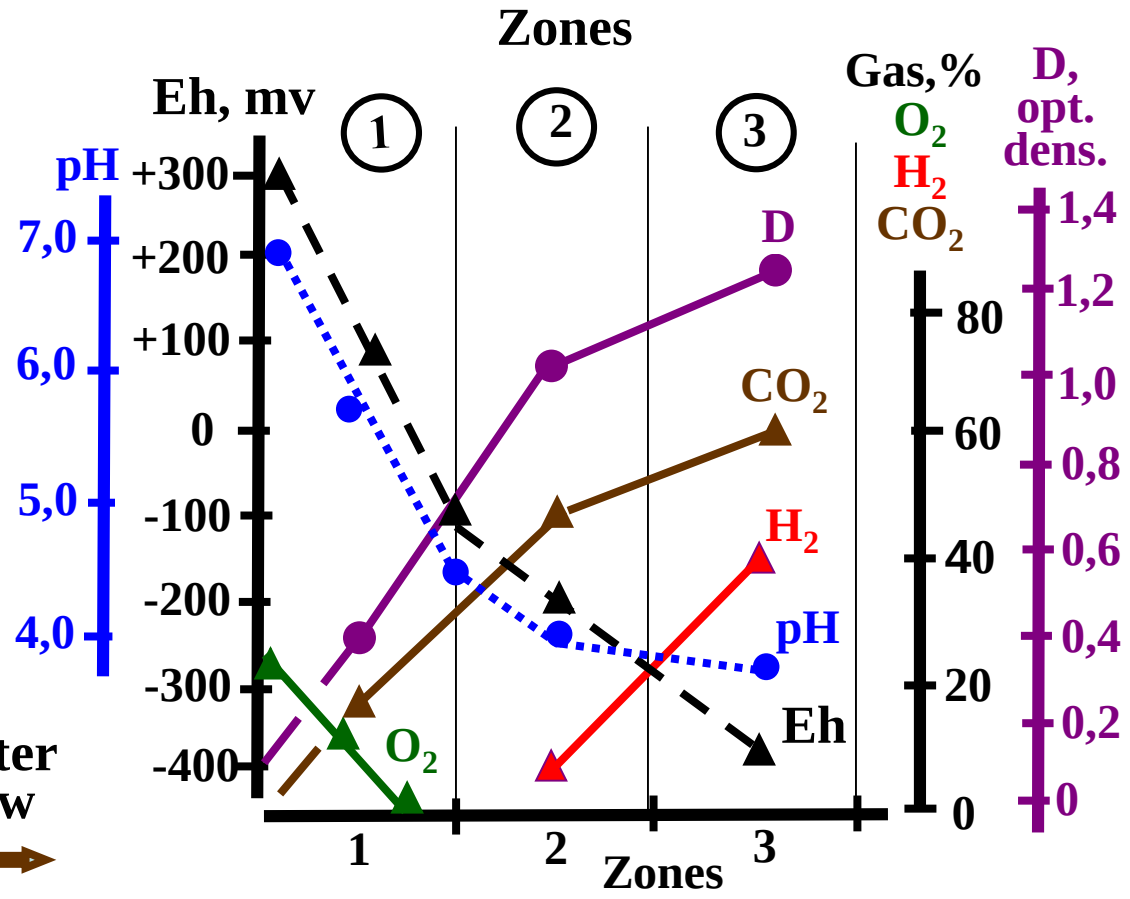


Spatial Succession

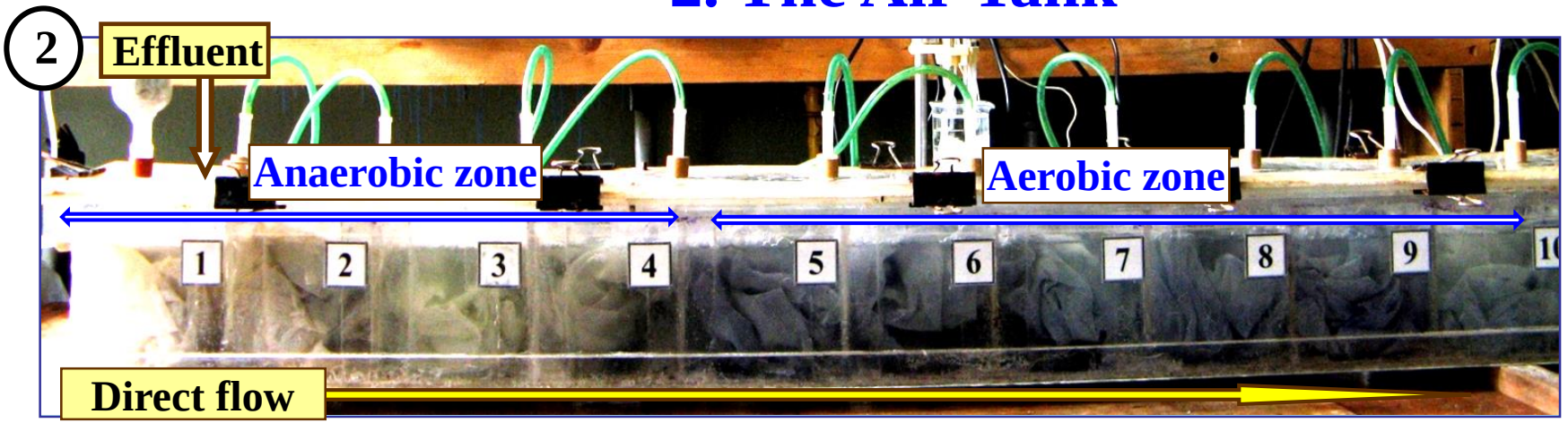
1. Anaerobic Bioreactor

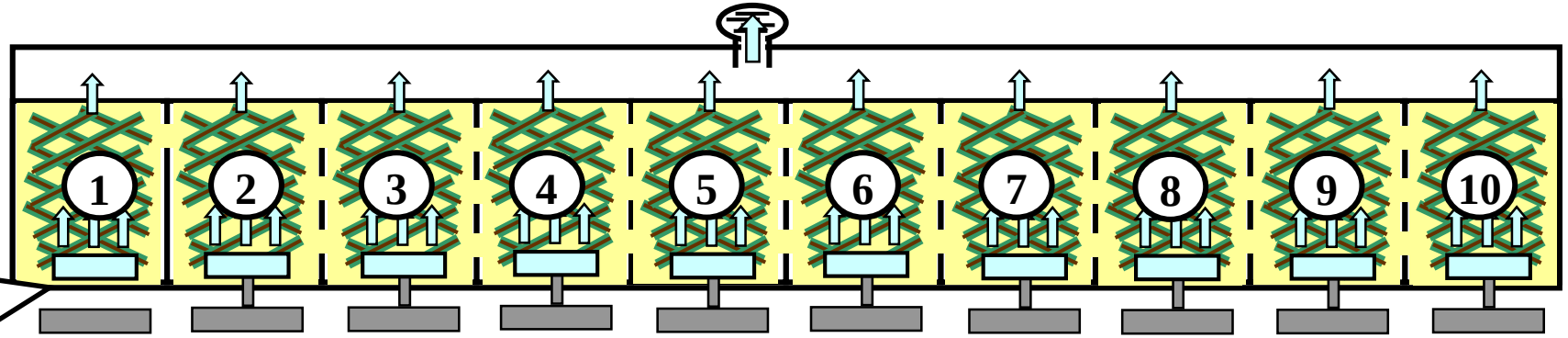


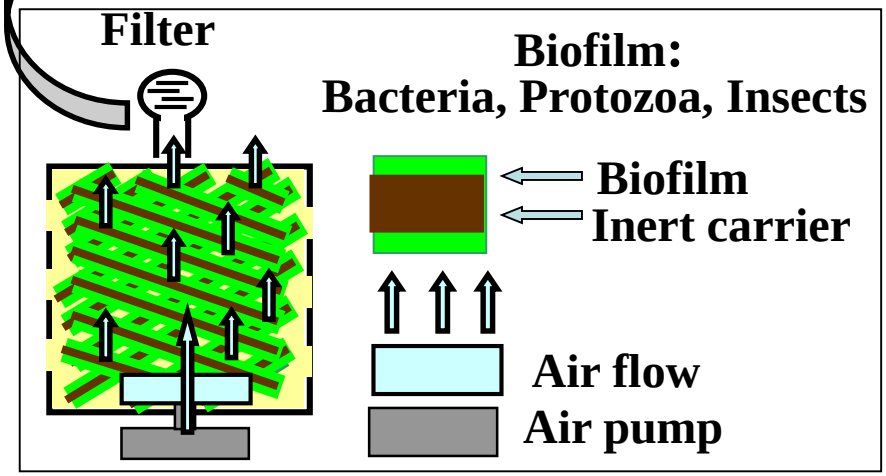
1	Aerobes growth	- Decrease of O_2 and Eh - Formation of anaerobic conditions
2	Facultative anaerobes growth	- Hydrolysis of polymers - Formation of deep anaerobic conditions
3	Obligate anaerobes growth	- Synthesis of H_2, CO_2, alcohols and organic acids



2. The Air Tank

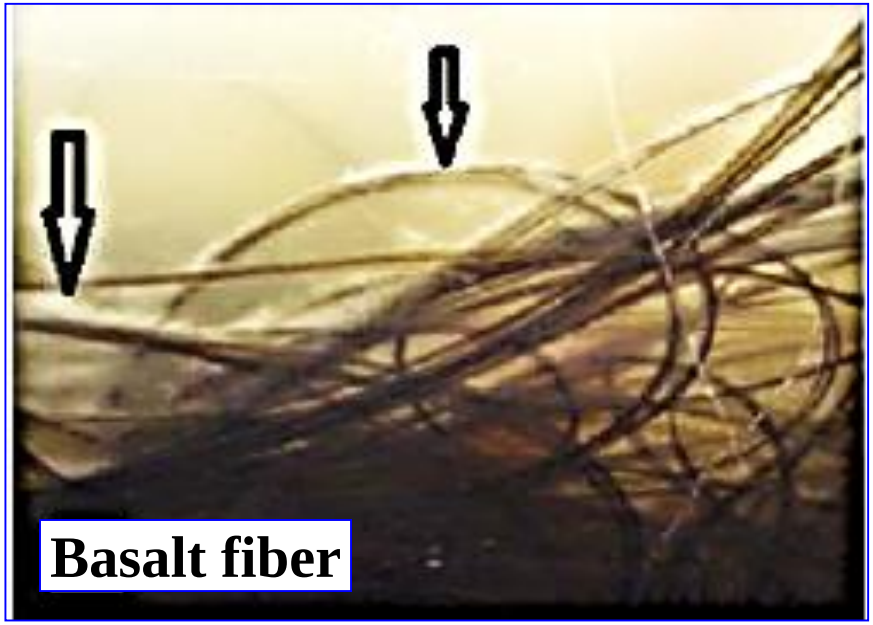


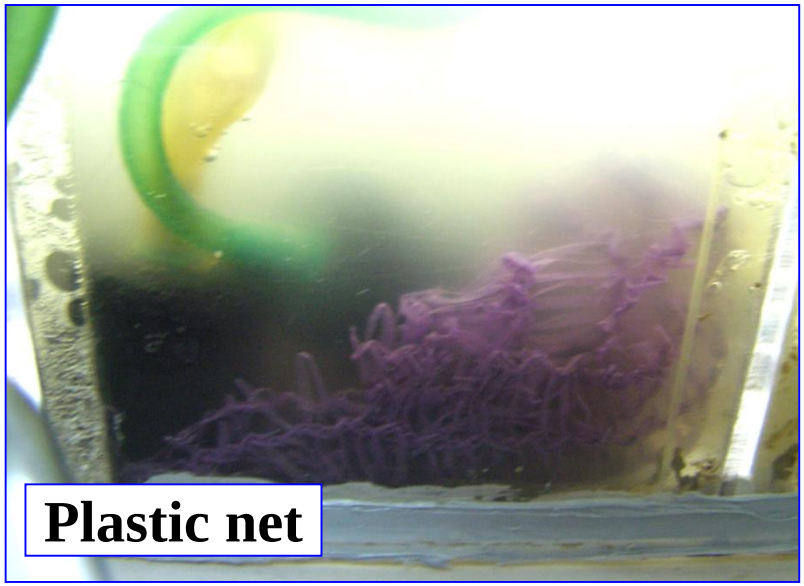


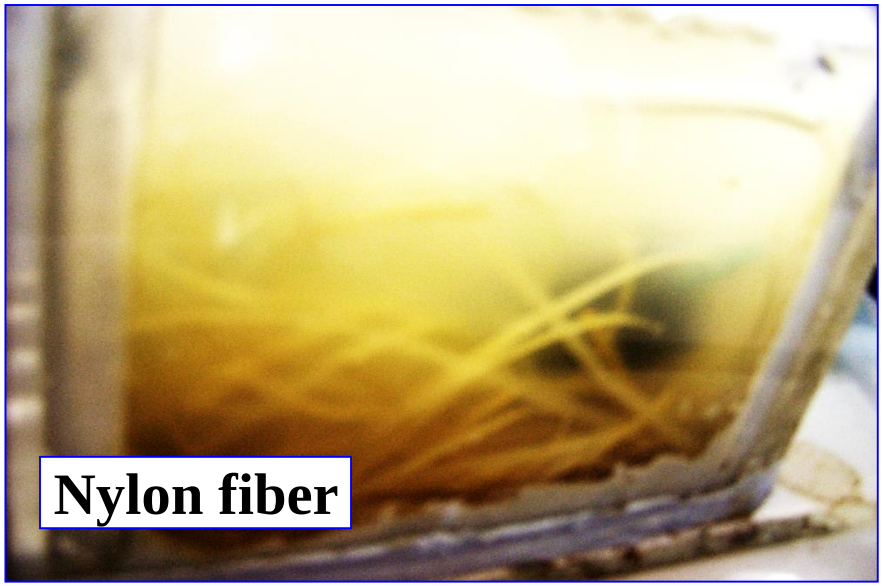


Inert carriers in sections: 1- Basalt wool. 2 - Basalt fiber. 3 - Plastic net for products. 4 - Nylon fiber. 5 - Nylon fiber + polyethylene foam. 6 - Dried field grasses (hay). 7 - Dried wild cereals (straw). 8 - Dried marigold stalks. 9 - Dried stems of a mixture of weeds. 10 - Wood shavings.

Immobilization of Microbial biomass on the Surface of Synthetic Carriers

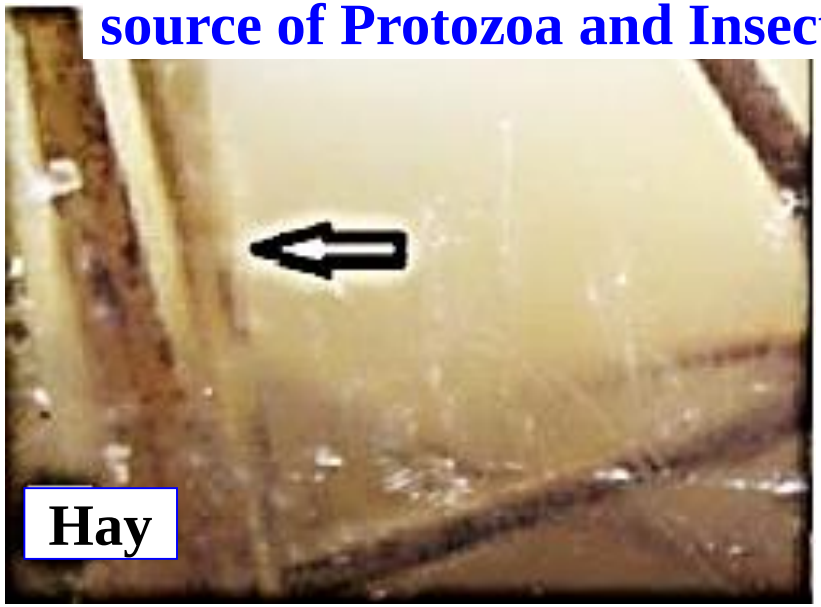


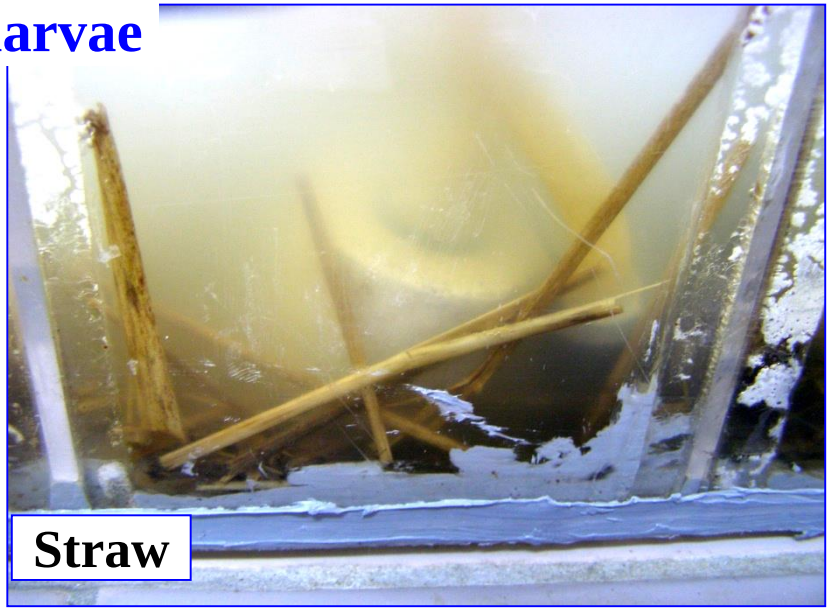


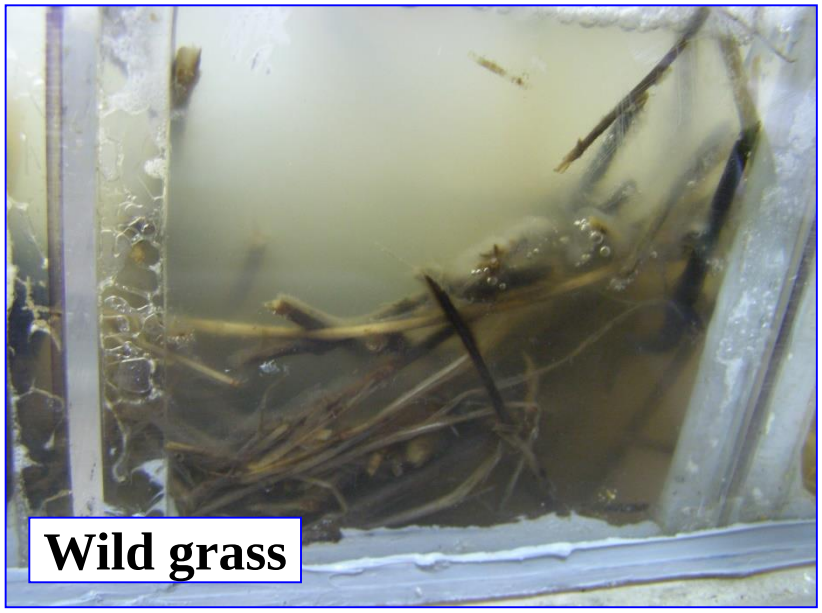


Immobilization of Microorganisms on the Natural Carriers

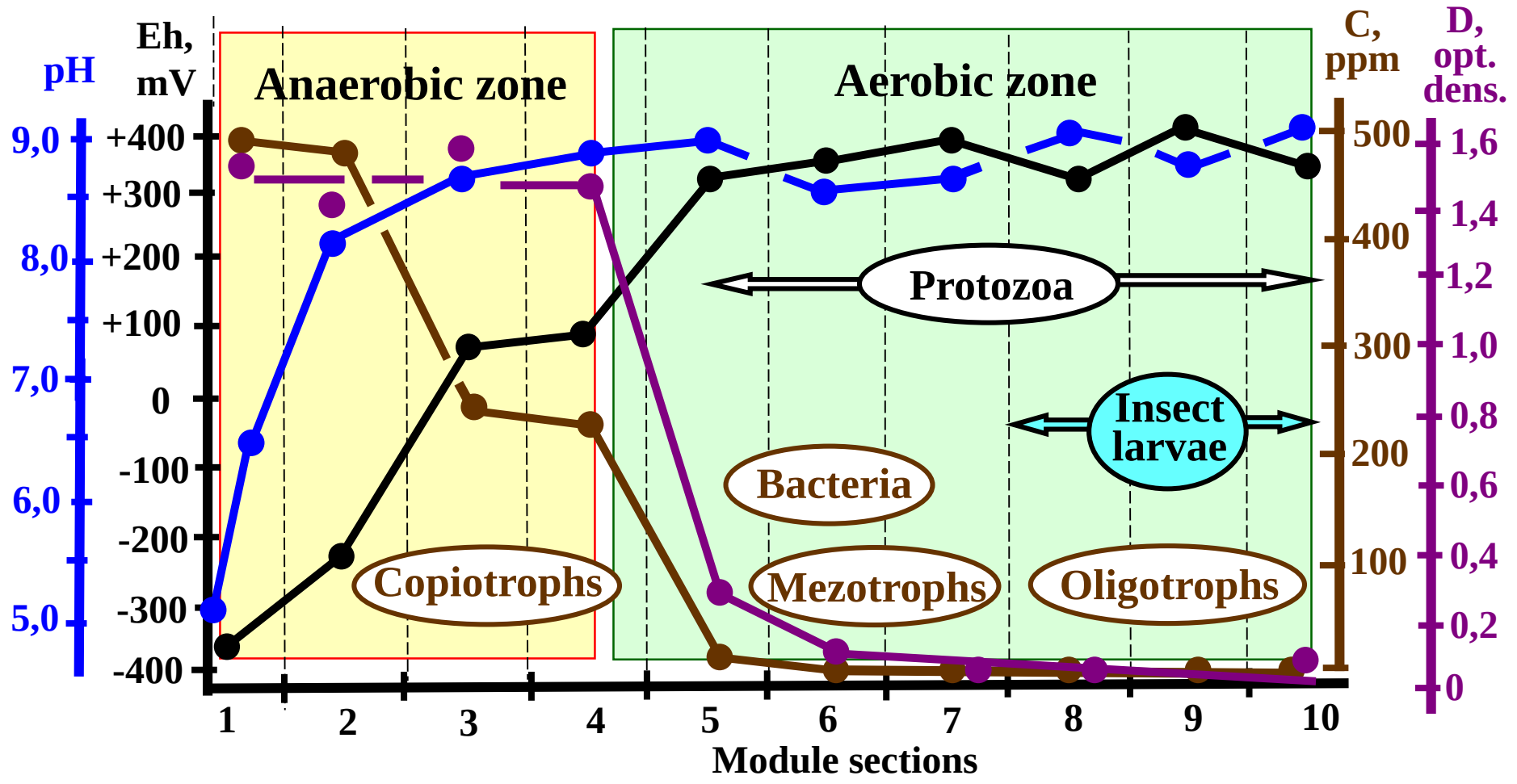
Natural Carriers also serve as the source of Protozoa and Insect larvae

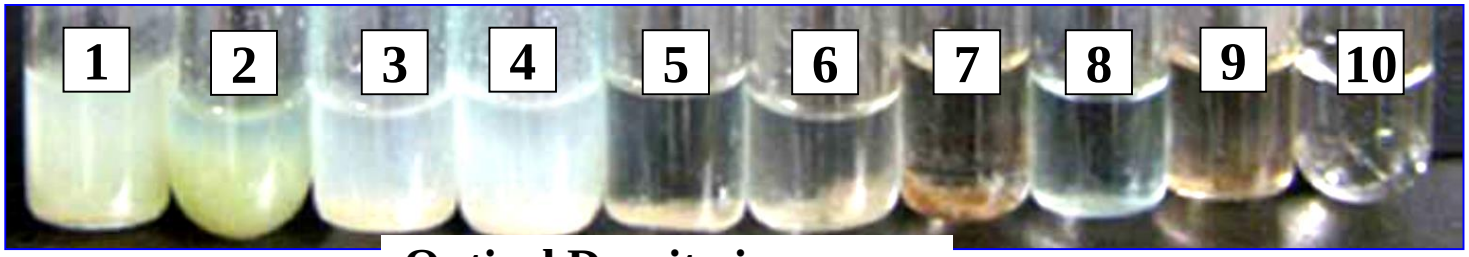






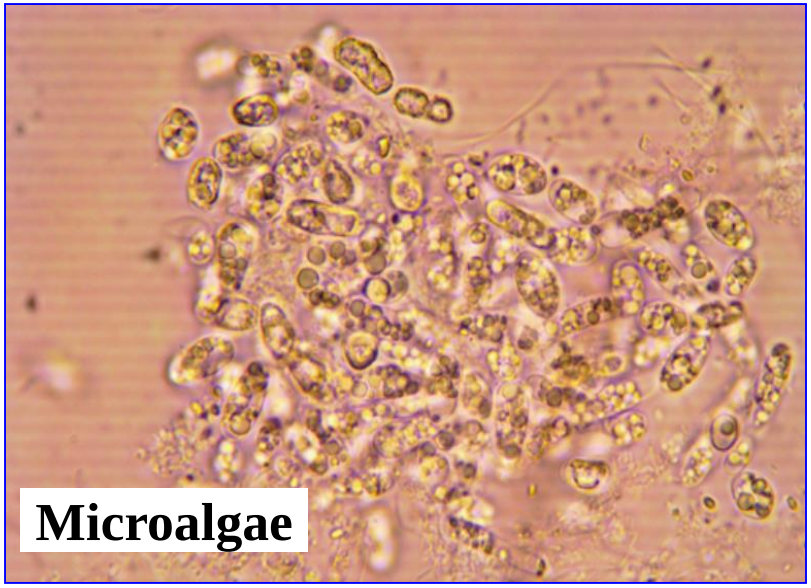
Spatial Succession in the Air Tank Ecosystem

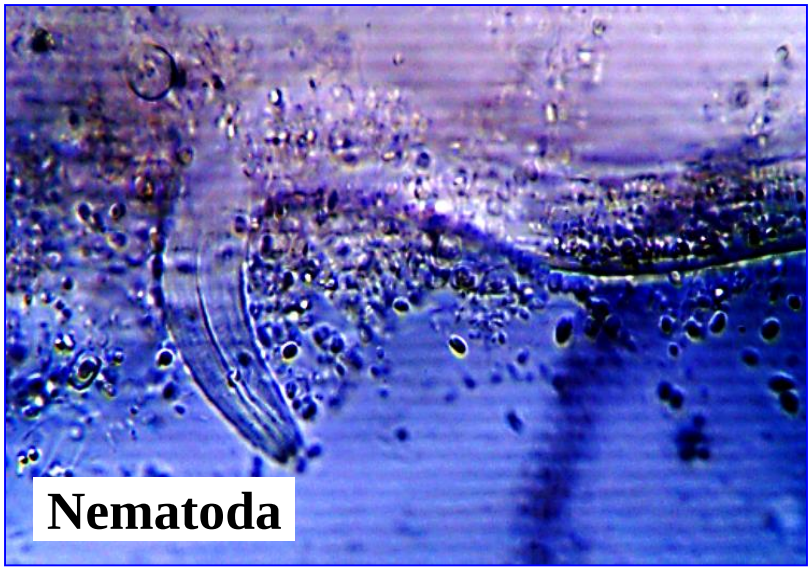


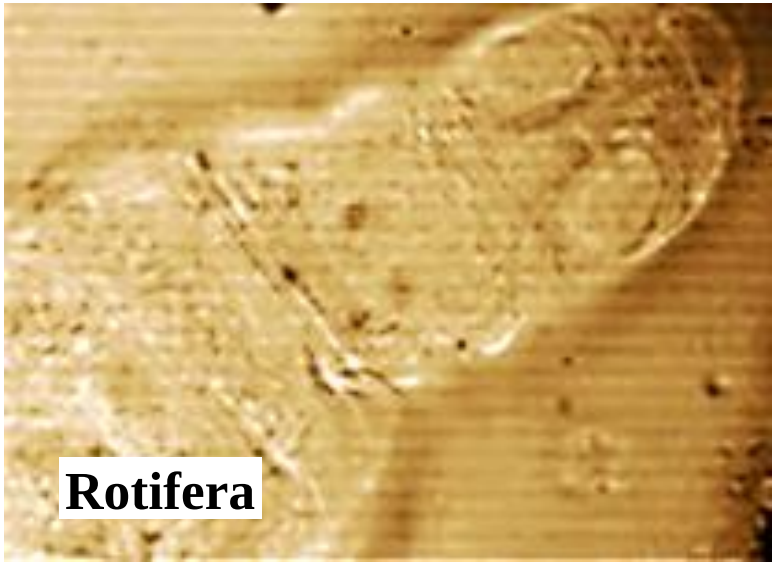


Optical Density in sewage

Components of the Air tank and Aquarium Ecosystems

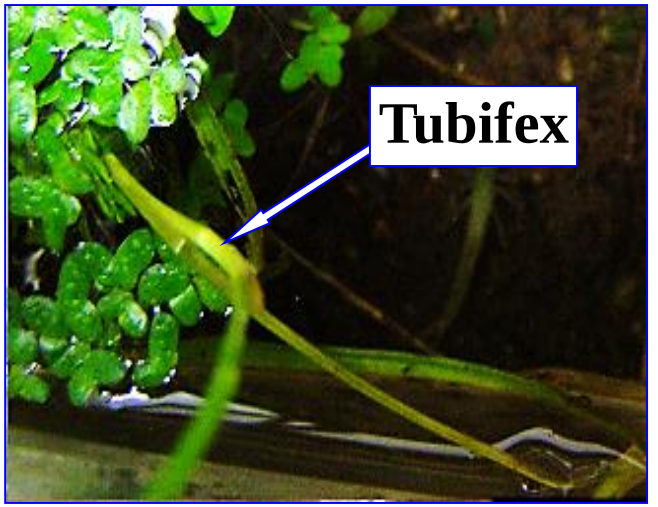




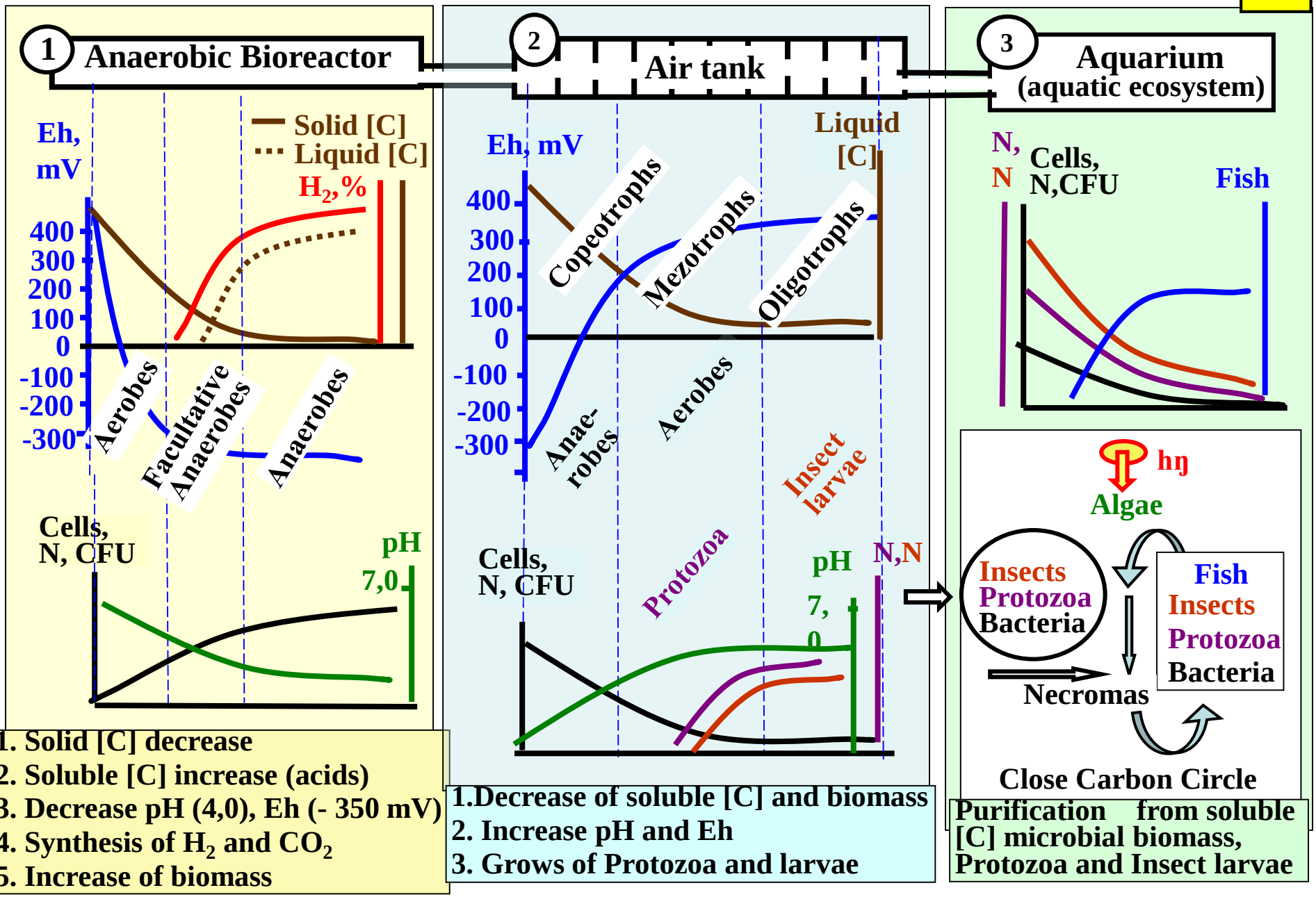


3. Aquarium Ecosystem for complete Sewage Purification

Components of Food Chains in the Aquarium Ecosystem



Generalized Theoretical model of Spatial Succession



1. Solid [C] decrease
2. Soluble [C] increase (acids)
3. Decrease pH (4,0), Eh (- 350 mV)
4. Synthesis of H_2 and CO_2
5. Increase of biomass

1.Decrease of soluble [C] and biomass
2. Increase pH and Eh
3. Grows of Protozoa and larvae

Purification from soluble [C] microbial biomass, Protozoa and Insect larvae

Conclusions

An integral model of the spatial succession of biomes (including the microbiome) to apply in environmental biotechnologies has been theoretically substantiated.

The detoxification of toxic compounds in a flow-through installation was carried out due to the phenomenon of spatial succession:

1. **Anaerobic degradation of decaying solid organic compounds (multicomponent food waste) to obtain the energy carrier H_2.**
2. **Combined anaerobic-aerobic leachate purification, i.e. degradation of toxic organic acids and alcohols - products of anaerobic hydrolysis of solid organic compounds.**
3. **Complete purification of the leachate from microorganisms and protozoa.**


Thank you
for attention!

[1] Hereinafter concentrations are provided of atomic carbon, unless specified otherwise

[2] Copeocarbotrophic microorganisms – microorganisms with high optimal level of carbon in the medium (more than 10 mg/l)

[3] Mesocarbotrophes – microorganisms with medium optimal level of carbon in the medium (around 5 mg/l)

[4] Oligocarbotrophes – microorganisms with low optimal level of carbon in the medium (1 mg/l or less)

Spatial Succession, References

1. Spatial succession modeling of biological communities: a multi-model approach. WenJun Zhang & Wu Wei. Springer Link. Published: 11 October 2008 Strong **spatial correlation** may exist in the **spatial succession** of biological communities, and the spatial succession can be mathematically described. It was confirmed by our study on **spatial succession of both plant and arthropod communities** along a linear transect of natural grassland.

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2. DOI:10.1016/j.ecolmodel.2003.12.055 Corpus ID: 6508743
Improving the formulation of tree growth and succession in a spatially explicit landscape model. S. Schumacher, H. Bugmann, D. Mladenoff
Published 2004 Biology
Long-term forest landscape dynamics are determined by a set of driving forces including large-scale natural disturbances, and stand-scale succession processes. Landscape models have an important role as tools for synthesizing information and making projections of possible future dynamics on **large spatial scales**.

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3. A Spatial simulation model to explore the long-term dynamics of podocarp-tawa forest fragments, northern New Zealand. Narkis S. Morales, George L. W. Perry. Biology. 2017

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4. Assessing the impacts of economic and climate changes on land-use in mountain regions: A spatial dynamic modeling approach. Simon Briner, Ché Elkin, Robert Huber, Adrienne Grêt-Regamey. Biology.2012

Основными составляющими пространственной сукцессии являются:

At ultrahigh concentrations of organic matter (10,000 – 50,000 mg/l[1]) its destruction is commenced by anaerobic microorganisms.

1.At anaerobic conditions, organic matter concentration is reduced by 100 times.

2.Following the deconcentration of the organic matter, there appear conditions for the development of aerobic and facultative anaerobic copeocarbotrophic[2] microorganisms. Henceforth, the treatment is completed in an aerobic flow system.

3.Successively in the flow system, copeocarbotrophes are followed by mesocarbotrophes[3] and then by oligocarbotrophes[4].

4.For the spatial succession providing sewage purification from organic matter to occur, the use of inert carriers is necessary to immobilise the above microbial groups (copeocarbotrophes *et c.*)

5.Following the decrease of dissolved organic matter content to trace concentrations (1-2 mg/l) occurs a succession from microorganisms to lower invertebrates (infusoria *et c.*)

6.Invertebrate organisms remove the excess microbial biomass by consuming it. Due to this, the spatial succession in a flow system not only purifies the filtrate from a wide range of concentrated organic matter, but also from excess microbial biomass.