Play with Water: Introducing Ecological Engineering to Primary Schools to Increase Interest and Understanding of Natural Sciences

Science and Society Project
European Union 6th Framework Programme

Proceedings of the Conference on Ecological Engineering for
Science Education in Primary Schools

25th April 2008, Waedenswil, Switzerland

Edited by Ole Feuer and Ranka Junge

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Ecological Engineering for Science Education in Primary Schools

Conference presenting the results of the Science and Society Project
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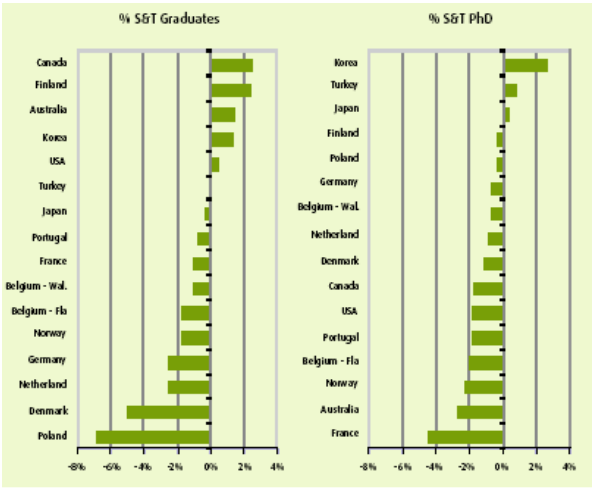
What can Ecological Engineers contribute to the education in natural sciences in primary schools?

Ranka Junge
Institute of Natural Resource Sciences,
Zurich University of Applied Sciences, Switzerland

Supported by the European Commission under the 6th Framework Programme

Why is EU concerned about scientific education in primary schools?

Average annual change in the share of ST students as a percentage of the total number of students (1993-2003).



European Commission, 2007

Why is EU concerned about scientific education in primary schools?

A major threat to the future of Europe: science education is far from attracting crowds and in many countries the trend is worsening.
(EU: girls account only for 31% of MST graduates)

A general consensus on the crucial importance of science education.
(Over 80% of Europeans consider that "young people's interest in science is essential to our future prosperity" (Eurobarometer 2005)).

The origins of this situation can be found, …, in the way science is taught.
Only 15% of Europeans are satisfied with the quality of science classes in school (Eurobarometer 2005).

European Commission, 2007

Report of the High Level Group on Science Education:

Recommendations

(excerpts)

- **Because Europe's future is at stake decision-makers must demand action on improving science education …**
- **Improvements in science education should be brought about through new forms of pedagogy: the introduction of inquiry-based approaches in schools ….**
- **Specific attention the participation of girls …**
- **Measures should be introduced to promote the participation of cities and the local communities …**
- **The articulation between national activities and those funded at the European level must be improved …**

European Commission, 2007

What is Ecological Engineering?

According to one of the most accepted definitions, ecological engineering
"*is the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both.*
It involves the design, construction and management of ecosystems that have value to both humans and the environment.
***Ecological engineering combines basic and applied science from engineering, ecology, economics, and natural sciences for the restoration and construction of aquatic and terrestrial ecosystems*"**

(Mitsch and Jørgensen, 2004).

The inherent nature, and definition of Ecological Engineering predisposes it to close the gap between the science and society and to act as vehicle for transporting concepts of natural sciences to children:

- **EE recognises the interlinked nature of all ecological systems of our planet**
- **EE seeks sustainable solutions, taking into account ecological, economical and social dimensions**
- **EE provides a link between the nature experience, ecological principles and technology.**

PRIORITY 11
SCIENCE AND SOCIETY
COORDINATION ACTION

Sixth Framework Programme

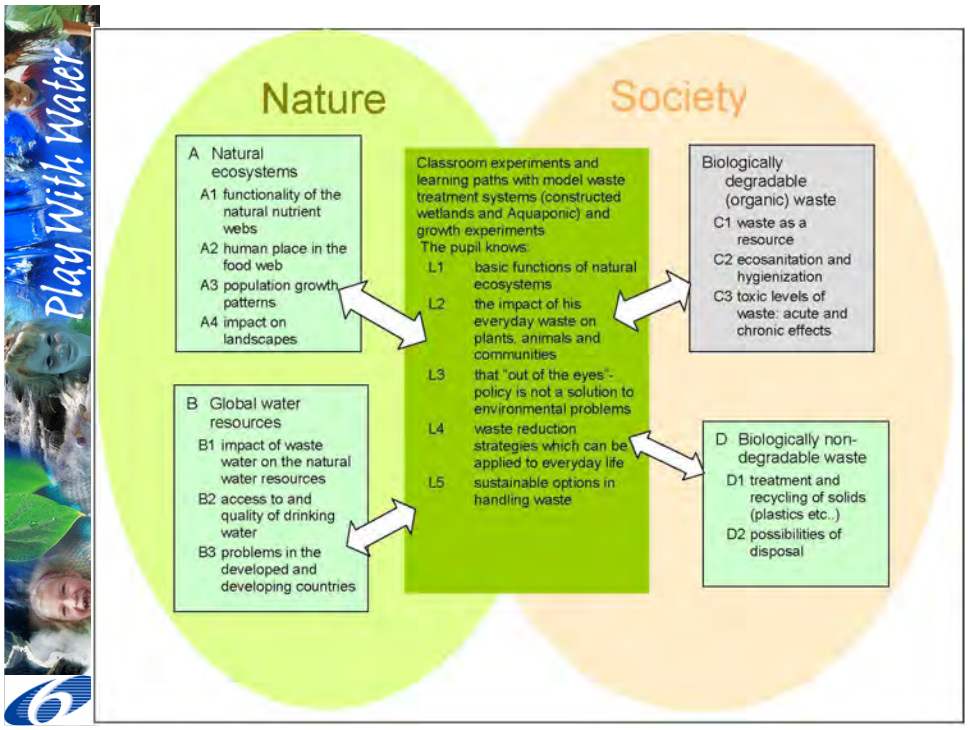
Waste Water Resource

Play with Water: Introducing Ecological Engineering to Primary Schools to Increase Interest and Understanding of Natural Sciences.

01.11.2005 – 30.06.2008 (32 months)

Consortium

- **ZHAW/IUNR, Switzerland**
- **Universitet of Aarhus, Denmark**
- **LIMNOS Company for Applied Ecology, Slovenia**
- **Norwegian University of Life Sciences**
- **Mid Sweden University & Regnbågen Fisk AB**
- **Training and demonstration center for decentralised sewage treatment, Germany**



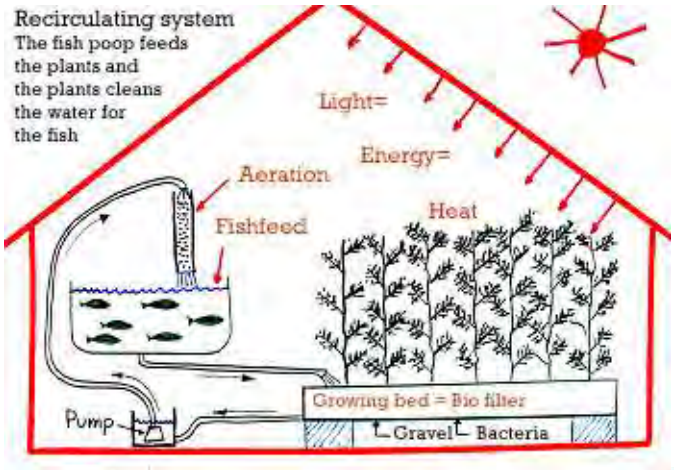
Objectives

1. **Assess task-based teaching materials in ecological engineering (classroom model ecosystems) as new teaching material for primary schools.**
2. **Initiate a discussion about the implementation of ecological engineering on primary school level in a close cooperation between research institutions and stakeholders.**
3. **Install an open internet platform to exchange information between the participants and to ensure an effective integration of stakeholders.**

Workpackages

1. **Define the methodology and link the network with local authorities and stakeholders.**
2. **Assemble an overview over the ecological engineering teaching units in partner countries and provide a standardised description in English.**
3. **Find the best practice: Translate the required materials into the local language and assess each teaching unit in at least two countries.**
4. **Build the Internet platform as a common information system for project partners, stakeholders, and other interested parties.**
5. **Disseminate the results. Plan further activities (dissemination, conference, and research work).**
6. **Administration of the project.**

From ecotechnological systems to classroom systems: Aquaponic (CH, S)



From ecotechnological systems to classroom systems: Aquaponic (CH, S)

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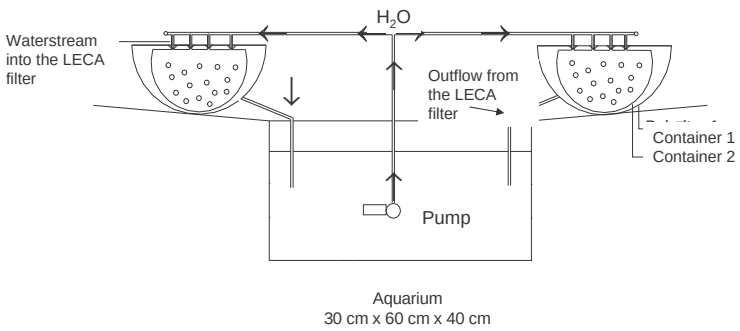

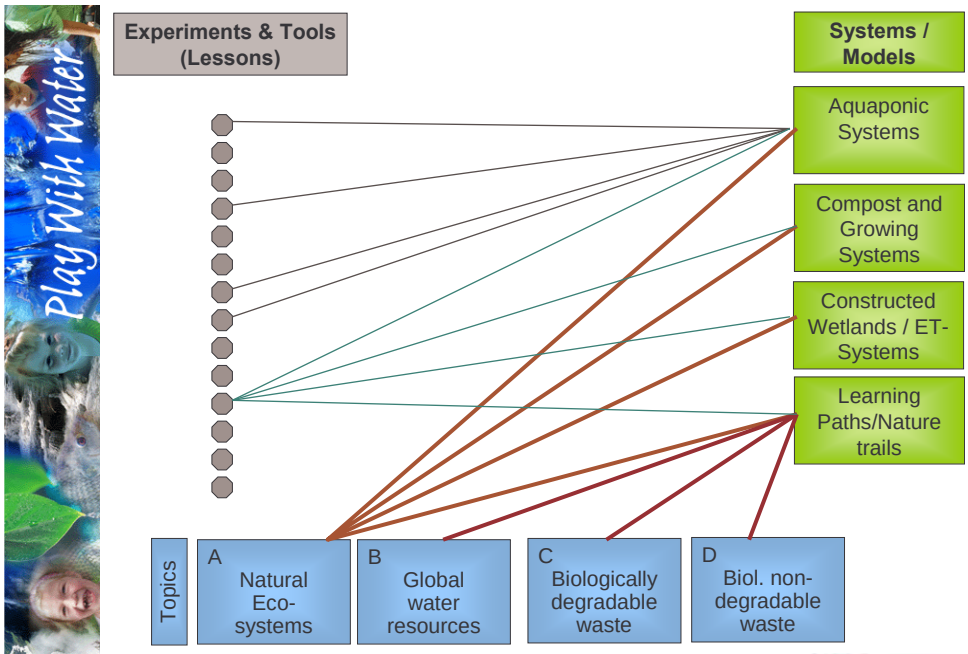

Common pedagogical framework: Interconnection and hierarchy of elements of tuition

What are the results?
Where are the results?

www.play-with-water.ch

Literature

European Commission (2007) EUR22845 - Science Education NOW: A renewed Pedagogy for the Future of Europe. Luxembourg: Office for Official Publications of the European Communities. 22 pp. ISBN 978-92-79-05659-8.

**Ecological Engineering for
Science Education in Primary Schools**

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Promoting system thinking through Classroom Aquaponic

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CLASSROOM AQUAPONIC

- **Introduction**
- Construction, Monitoring and Organisation
- Evaluation of teaching unit
- Evaluation of System Thinking
- Results
- Conclusion

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The profile of pupils

- School situated in agglomeration of Zurich
- 7th grade (12-14 years), 3 classes
- Total 68 pupils, 32 female, 36 male
- Language: all native german speakers
- Pupils
  - Concluded 5th grade with an average mark of 5 (from 6) in german, mathematics and natural sciences
  - Are used to autonomous work
  - Show consistent ability and general interests in different issues

Hypotheses

1. Incorporating Aquaponic into the teaching has positive influence on the system thinking of the pupils.
2. There are gender differences in improvement of system thinking.
3. There are differences in improvement of system thinking between the groups of pupils with different native languages.
   (This hypothesis could not be tested, because all pupils were native german speakers)

System thinking

System thinking includes four central dimensions (Ossimitz, 2000):

- ***thinking in models***
- ***interrelated thinking***: a thinking in interrelated, systemic structures
- ***dynamic thinking***: a thinking in dynamic processes (delays, feedback loops, oscillations).
- ***steering systems***: the ability for practical system management and system control.

Main goal of classroom aquaponic

The pupils should adopt tools which can help them to examinate complex problems.

They should know how to analyse systems, name the system variables and get a general idea of a system.

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Construction of Aquaponic

- Requirements: as simple as possible
- The students figured out how to connect plant culture with fish farming and outlined a sheme of proposed arrangement
- In discussions, we developed the arrangement into the „right shape“
- The students were responsible for the construction, operation and monitoring of the aquaponic

Monitoring of aquaponic

- Measure the growth of the plants
- Weigh the food and feed the fish
- Monitor the behaviour of the fish
- Check the water temperature
- Calculate the evaporation of the water
- Refill the acquarium with water

All the results were noted in a journal.

Organisation

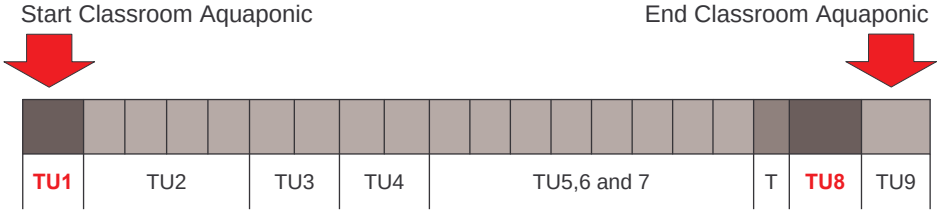
class	Aqua-ponic 1	Aqua-ponic 2	Aqua-ponic 3	Aqua-ponic 4	Aqua-ponic 5	Aqua-ponic 6
K 7.1	Group 1, only girls	Group 2, mixed	Group 3, mixed	Group 4, mixed	Group 5, mixed	Group 6, only boys
K7.2	Group 1, only girls	Group 2, mixed	Group 3, mixed	Group 4, mixed	Group 5, mixed	Group 6, only boys
K7.3	Group 1, only girls	Group 2, mixed	Group 3, mixed	Group 4, mixed	Group 5, mixed	Group 6, only boys

Teaching organisation

- Aquarium journal: for transfer of information between the three groups which worked on the same Aquaponic model
- Monitoring journal: to record plant measurements and fish observations
- Presentation: shows the growth of knowledge and understandig of the aquaponic arrangement
- Teachers input
- Teamwork

Sequence of teaching units

- Each grey box symbolizes one lesson
- 25 lessons were hold
- TU = teaching unit, T = Test
- TU1 and TU8 are the pre- and posttest



Sequence of teaching units

- TU2: System principles
- TU3: Connection circle
- TU4: Planning and construction of aquaponic
- TU5: Analysis of the systems variables fish and plant
- TU6: Monitoring
- TU7: Presentation of the analysis
- TU9: Aquaponic party

TU1	TU2				TU3		TU4		TU5,6 and 7							T	TU8	TU9

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- **Evaluation of teaching unit**
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Method

- The method of action research (Altrichter and Posch, 2007) was implemented.
- Useful and easy method for reflective teaching
- Teacher keeps a detailed journal, where all the pupils‘successes and problems and other observations are noted.
- Draw conclusions for the teaching.

My conclusions: Pro and contra classroom aquaponic

Advantages

- Training in system thinking
- Dealing with complexity
- Develop teamwork and possibility of social contact

Disadvantages

- A lot of material, which is not available
- Costs
- Preparation, construction and maintenance of aquaponic

Learning outcomes

- Understanding system thinking
- Transfer of knowledge in system thinking into other school subjects
- Social learning in working groups and increase of the self-esteem

CLASSROOM AQUAPONIC

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- Evaluation of teaching unit
- **Evaluation of System Thinking**
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Eintrittstest

Oftmals, an schön lauschigen Frühlingstagen auf dem Land, wenn die Fenster offen stehen und die Vögel ihre Frühlingsmelodien ausprobieren, schleicht ein nicht ganz angenehmer Duft durch die offenen Fenster ins Haus. „Nein, muss das denn sein!", ruft die Mutter entrüstet aus, „Kann der das nicht woanders tun?! Schnell, hilf mir die Wäsche nach drinnen zu bringen, sonst beginnt sie zu stinken!". Was ist geschehen? Der Bauer Abacher hat wieder einmal seine Gülle und seinen Mist auf die Felder gebracht. Jetzt zieht der unangenehme Jaucheduft durchs Dorf und lässt die Bewohner durch den Mund atmen, um den Gestank nicht in die Nase zu bekommen.

Wieso macht der Bauer das? Welche Gründe hat er, die Gülle und den Mist auszufahren?

Skizziere und beschreibe die obige Frage auf die Rückseite dieses Blattes. Schreibe auch deinen Namen auf das Blatt.

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The pre- and posttest

The pre- and post test were identical.

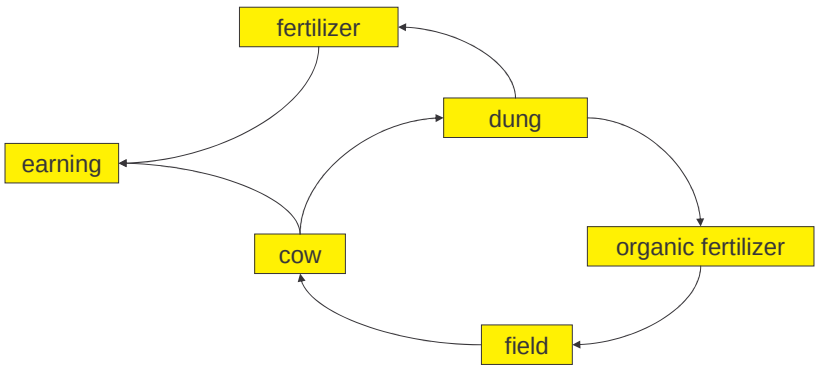
A short story about a farmer and his life is outlined. It containes a question:

„Why did the farmer put the manure on his fields?“

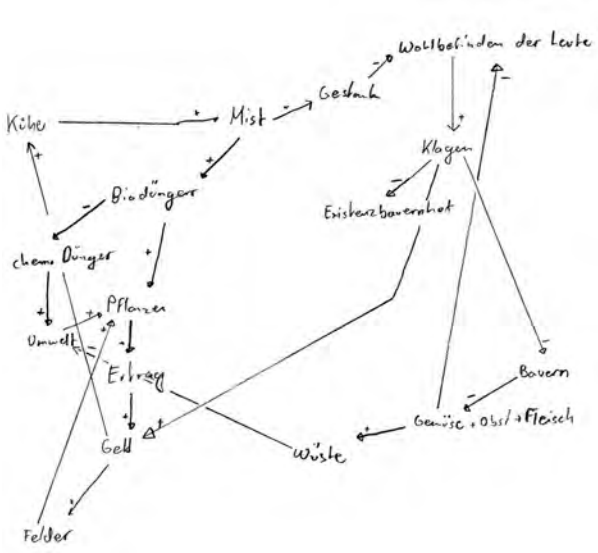
The pupils answered with a drawing and / or a description of the reasons.

One possible drawing to the question

„Why did the farmer put the manure on his fields?“



A pupil‘s answer



Method Bollmann – Zuberbühler to evaluate pre- and post test

4 indices are determined in the pre- and post test:

- Delineation of the system („Darstellungstyp“)
- Complexity index („Komplexitätsindex“)
- Interrelation index („Vernetzungsindex“)
- Structure index („Strukturindex“)

(Bollmann-Zuberbühler, 2005)

Method Bollmann – Zuberbühler to evaluate pre- and post test

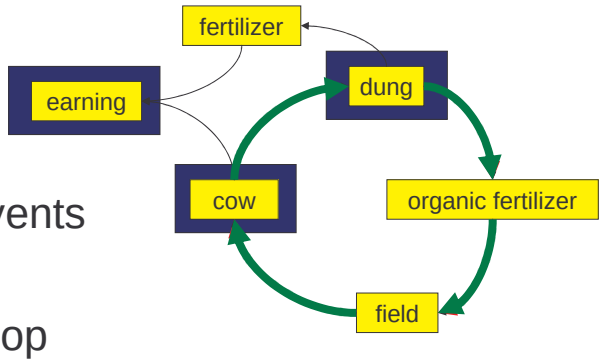
The 4 indices allow a comparison of the drawings from the pre- and post test.

It is a qualitative method with quantitative results.

Evaluation of System Thinking, Method Bollmann – Zuberbühler

Such a drawing includes the following system concepts :

- Variables
- Arrows
- Chains of events
- „Junctions“
- Feedback loop



Evaluation of System Thinking, Method Bollmann – Zuberbühler

Next steps:

1. Identify the delineation of the system
2. Identify the complexity index
3. Identify the interrelation index
4. Identify the structure index

Delineation of the system

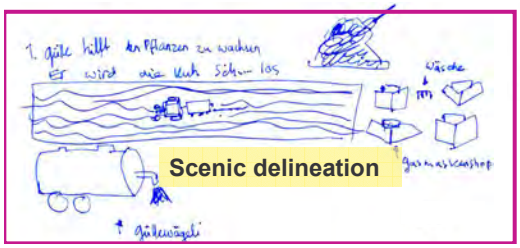
1. Identify the delineation of the system („Darstellungstyp“)

Gruppe	Darstellungstyp	Kennzeichnendes Merkmal
1	Keine Skizze	-
	Szenische Darstellung	Szenen ohne logische Verknüpfung.
	Stadienbild	Logische Abfolge von mindestens drei Szenen.
	Andere Diagramme	Alle den anderen fünf Darstellungen nicht eindeutig zuordnungsbaren Diagramme.
2	Lineares Wirkungsdiagramm	Mindestens eine Pfeilkette (drei aufeinander folgende Pfeile).
	Wirkungsdiagramm	Mindestens eine Verzweigung (zwei hinführende oder zwei wegführende Pfeile zu einem Systemelement).
	Netzdiagramm	Mindestens eine Rückkoppelung oder geschlossene Kette von Wirkungspfeilen (Kreisläufe).

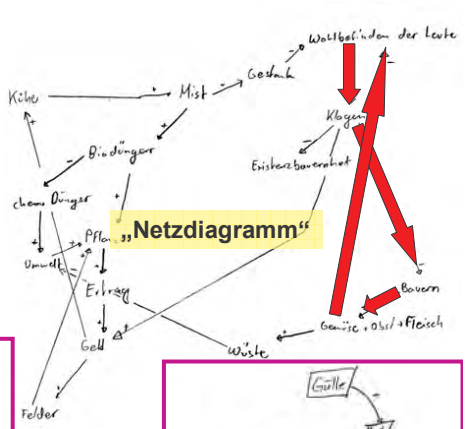
Delineation of a system: Examples

Other delineation

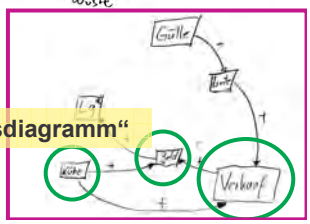
„Lineares Wirkungsdiagramm“



Scenic delineation



„Netzdiagramm“



„Wirkungsdiagramm“

Complexity index

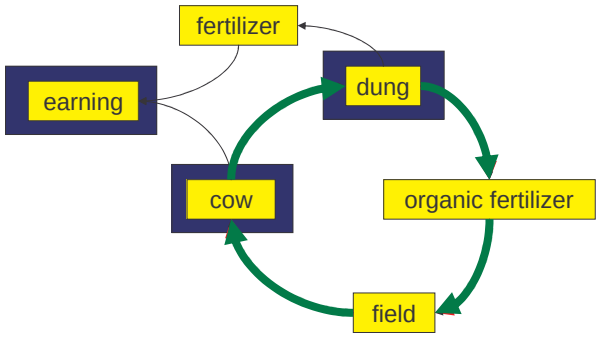
2. Identify the complexity index („Komplexitätsindex“, KI)

Formula: variables + arrows + chain of event + junction + feedback loops = KI

The complexity index shows how many system concepts the pupil had used.

Complexity index: Example

Variable	6
Arrow	7
Chain of event	1
Junction	3
Feedback loop	1
KI	**18**



Interrelation index

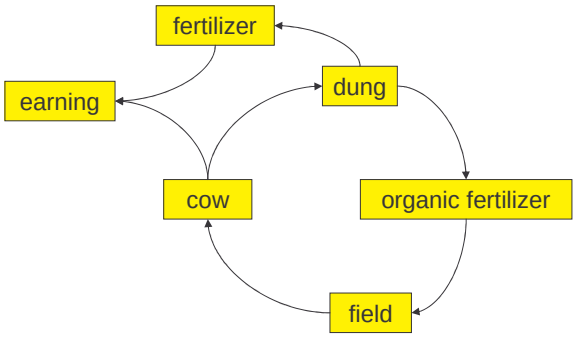
3. Identify the interrelation index („Vernetzungsindex“, VI)

Formula: 2 • arrows / variables = VI

The interrelation index shows the frequency of the correlation between the variables.

Interrelation index

Variable	6
Arrow	7



VI	**2 • 7/6 = 2.3**

Structure index

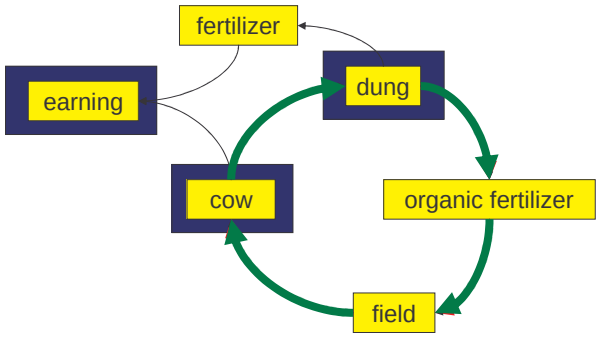
4. Structure index („Strukturindex“, SI)

Formula: (chains of events + junctions + feedback loops) / variables

The structure index shows how many complex system concepts the pupils had used.

Structure index

Variables	6
Chain of events	1
Junctions	3
Feedback loop	1



SI **(1+3+1)/6=0.83**

CLASSROOM AQUAPONIC

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- **Results**
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Numbe of pupils for the pre- and posttest

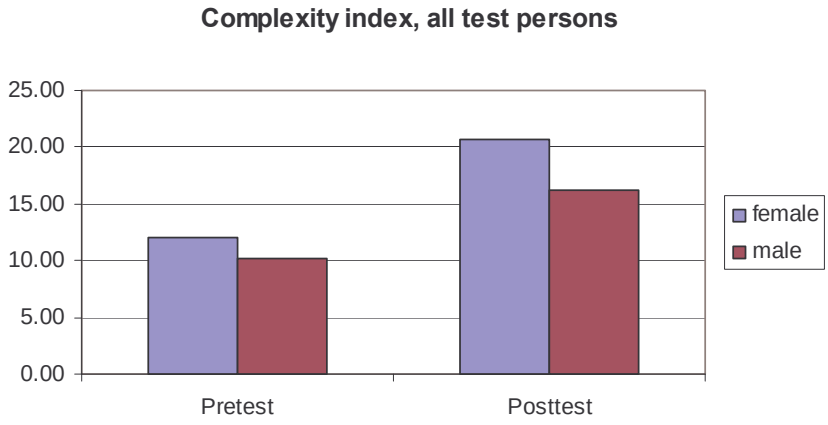
Pretest: 68 pupils, 32 female, 36 male

Posttest: 64 pupils, 28 female, 36 male

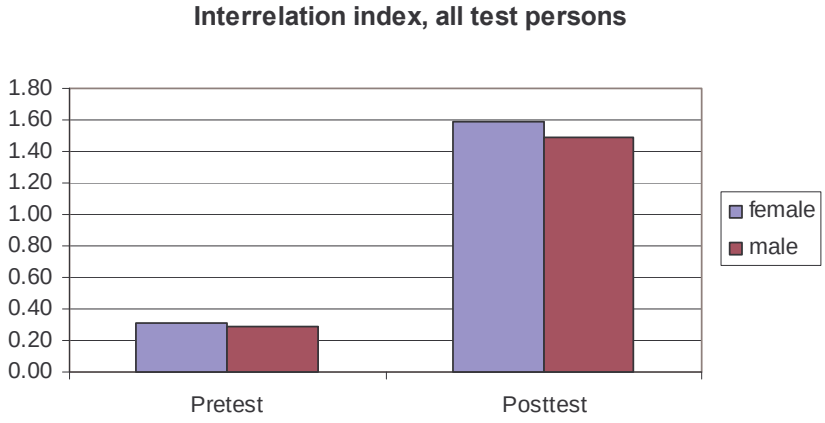
Delineation of systems

	Keine Skizze	Szenische Darstellung	Stadienbild	Lineares Wirkungsdiagramm	Wirkungsdiagramm	Netzdiagramm	Andere Diagramme	Total	
Total:									
Eintrittstest	3	38	17	4	1	2	3	68	
Austrittstest	3	16	5	3	1	40	2	64	4 Personen krank
Knaben:									
Eintrittstest	3	22	7	0	0	1	3	36	
Austrittstest	3	5	3	0	1	24	1	36	
Mädchen:									
Eintrittstest	0	16	10	4	1	1	0	32	
Austrittstest	0	5	2	3	0	17	1	28	4 Personen krank

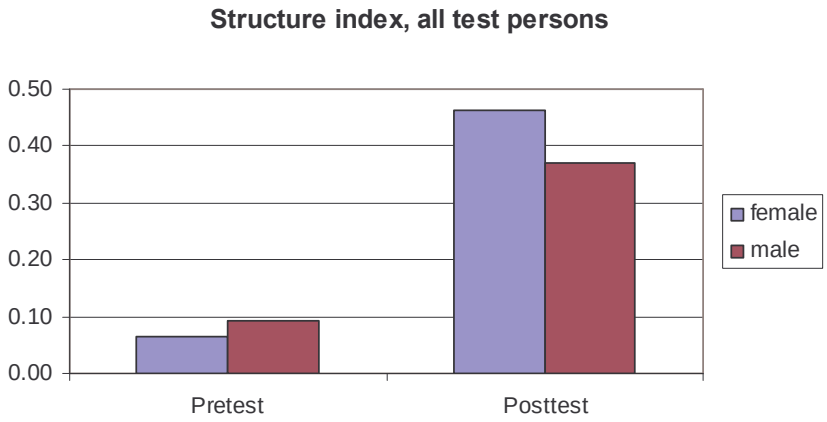
Complexity index



Interrelation index



Structure index



Hypothesis 1

(H1) Incorporating Aquaponic into the teaching has positive influence on the system thinking of the pupils.

➔ The analysis of all the four indices showed an increase in system thinking.

„Classroom Aquaponic“ is able to train pupils in system thinking.

Hypothesis 2

(H2) There are gender differences in improvement of system thinking.

Female pupils tended to achieve better results than male. Allthough, it is not possible to claim there was a significant gender difference. The number of pupils was to small for a generalization.

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Outcomes of classroom aquaponic

- Training in system thinking
- Training in scientific working and monitoring
- Training in planning and implementing this plan
- Independent working in groups and increase of the self-esteem
- Model of self-purification of water
- Contact with fish and plants

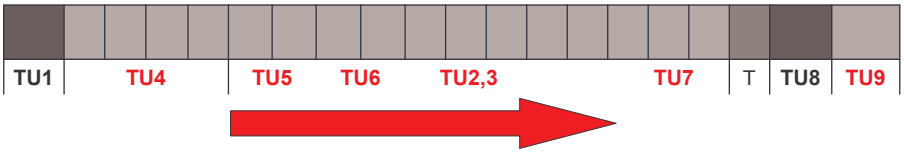
Critical points

- The results show an increase of the indices. Is this due to the system‘s instructions? Or are there other influences which can not be localized?
- System thinking needs a lot of knowledge. If there is no knowledge of details, there is no system thinking.

Recommended change of sequence

Instead of the sequence above, I propose the following:

- Pre- and post-test and TU9 no modification
- The theoretical section (TU2, TU3) should be placed after the TU4,TU4, TU5: **first act then reflect the work**
- At the end TU7



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Play with Water

Participants from Sweden

Rainbow Fisheries, Stefan Goës
MidSweden University, Nils Ekelund

Part 1.
Rainbow Fisheries Aquaculture on Cat Beach

From idea to realization

A short story about Pecka and his idea

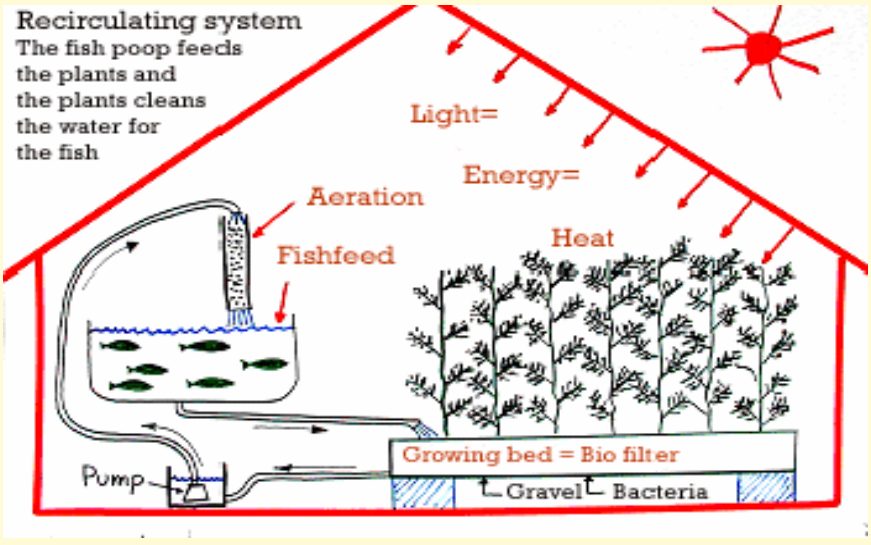
Stefan Göes, Rainbow Fisheries, Sweden

This is Regnbågen Fisk KB

- **Pecka Nygård**
  - With a lifetime experiance of fishing and traditional fishfarming
- **Stefan Goës**
  - Helping Pecka with administration and bureaucracy
- **The first Aquaponic project 1997**

The first Aquaponic smallscale project

A recirculating system



Which are the advantages of this system?

- Little consumption of water.
- The system is protected from the weather, storms, ice problems and disease.
- No poison can be used - there must be ecological balance for the system to survive.
- The plants get the nutrients from the fish and the fish get clean water from the plants. The different components support each other and the products taste so much better.
- For every kilogram the fish grow the plant produce 10 - 20 kg of vegatables.

Why Aquaponic?

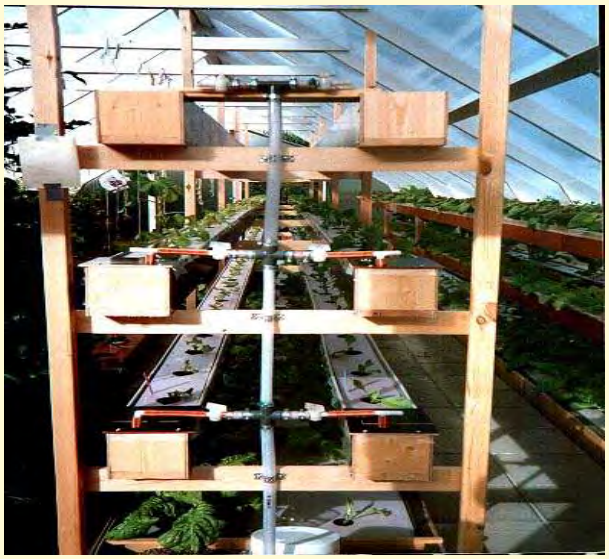
– Fishfarming is helping to reduce poverty and food insecurity, the United Nations Food and Agriculture Organization (FAO) says.

– Traditional fish farms and agricultural farms are industrialized and contribute massivly to the pollution of the oceans.

– Aquaponics is a technique, which contribute very much to avoid murky waters.

Important lessons

- Pecka learned a lot:
  - How to start a system
  - How to regulate pH
  - How to check nitrite - nitrate
  - How to heat and cool the system
  - How to handle a break in electricity supply
- 1 kg fishfeed results in 1,2 kg fish and 12 kg tomatoes



Part II.

Partners in the project:

Älandsbro skolan, primary school, Leif Lundin
Geresta skolan, primary school, Tina Degerman
Technichus, Lizzie Stener

During spring 2006 we have organized the structure of the project in the different schools.
Projects started in autumn 2006.

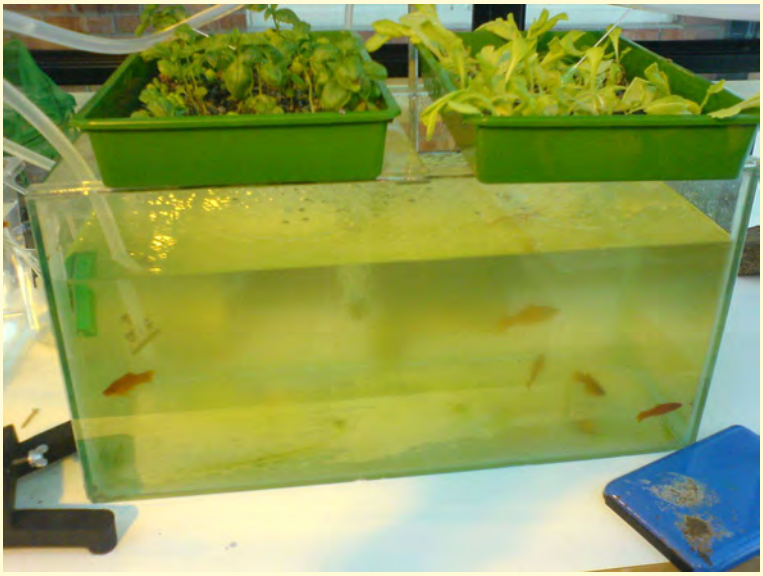
Results from Älandsbro.

Aquaponic in Älandsbro


Kreis
loppet


Krets
loppet

Problems! Growing algae!

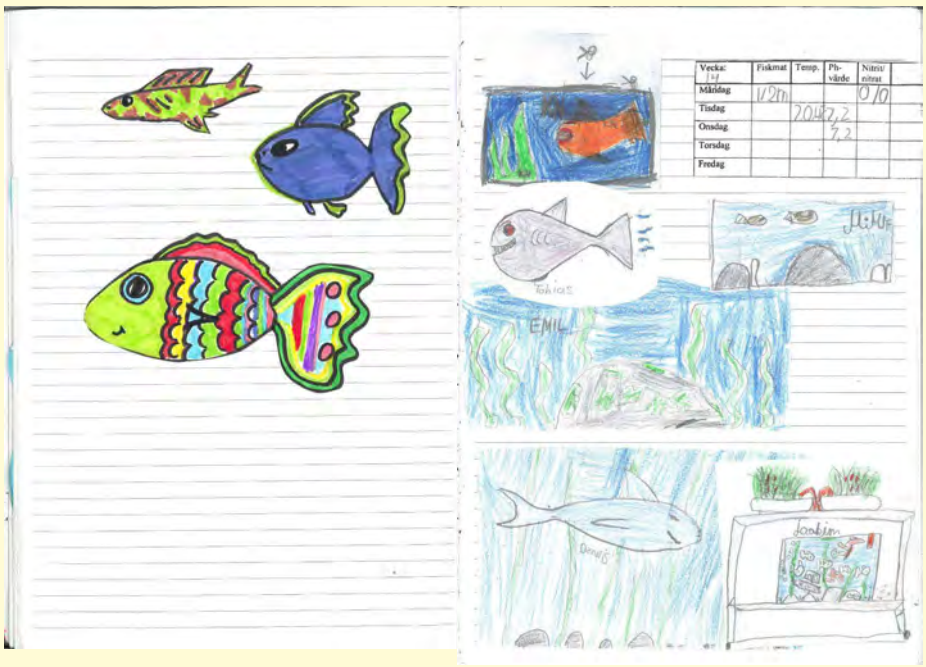


Subjects using the aquaponics

- Music – Water songs
- Visual arts – Doing models
- Swedish language – Documentation of the work in a book. Poems.
- Maths – Calculating the volume, amount of fish…
- Science/environment – Older pupils teached younger pupils about water and water resources.
- Science – Discussed recirculating systems, doing experiments.

Model of a recirculating system

Documentation of the system in a book



Erica Johansson och Maria Lundgren
EXAMINATION WORK,
Teaching Education Autumn 2007.

The objectives with this report are to
describe the aquaponic systems and
how the work with them has proceeded,
to evaluate the possibilities to use
the systems in education
and to evaluate the pupils understanding
of the systems before and after they had
worked with them at school.

Bild 1

Bild 2

Summary of questionnaires

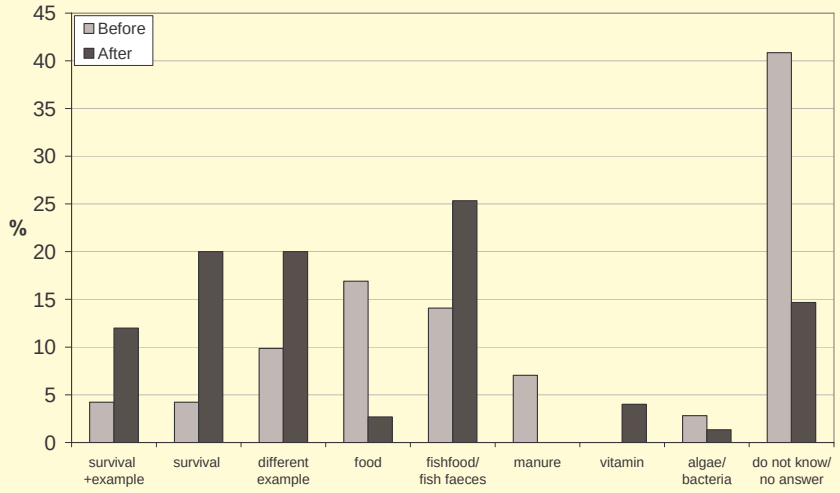
❖ The work with the aquaponic systems has a great potential to help the pupils to attain relevant learning goals in the Swedish curriculum for biology and natural science.

❖ The teachers thought the work gave natural opportunities to talk about cycling of matter and that it attracted the pupils' interest.

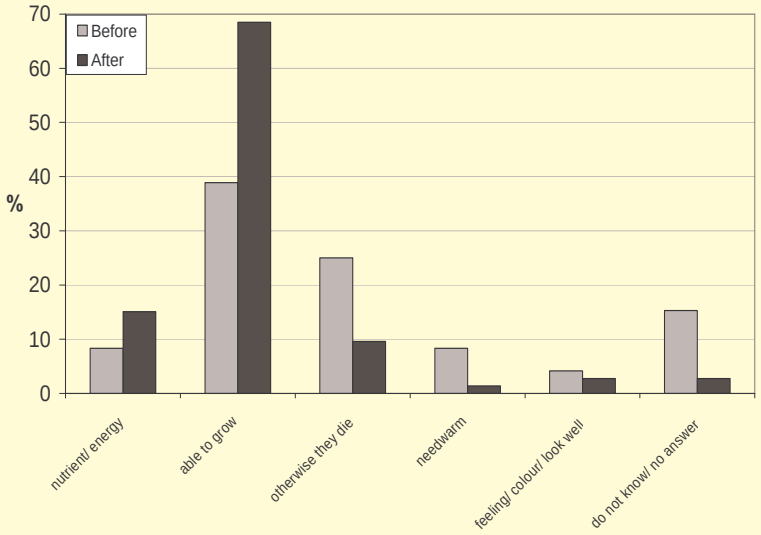
❖ The questionnaires showed that a large number of the pupils had changed opinion before and after they have worked with the systems.

❖ The interviews with the older pupils showed that they had good knowledge about the system.

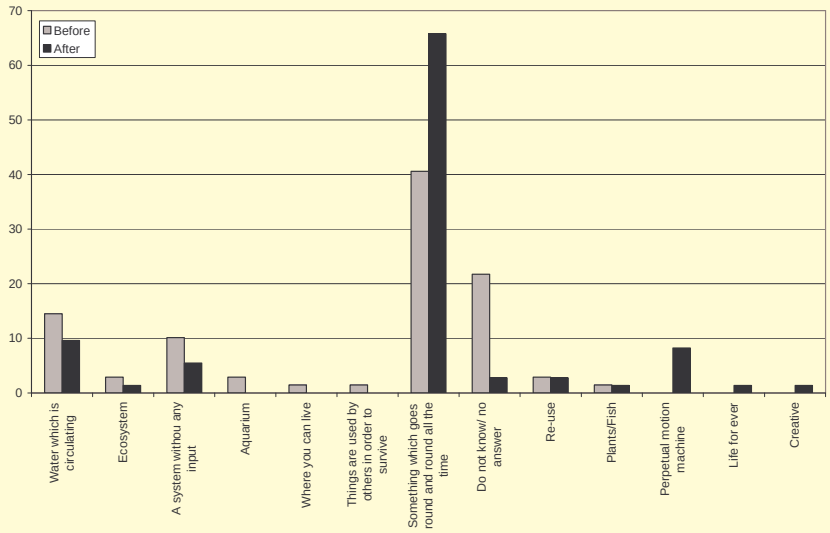
What is nutrient and what forms of nutrients do we have?



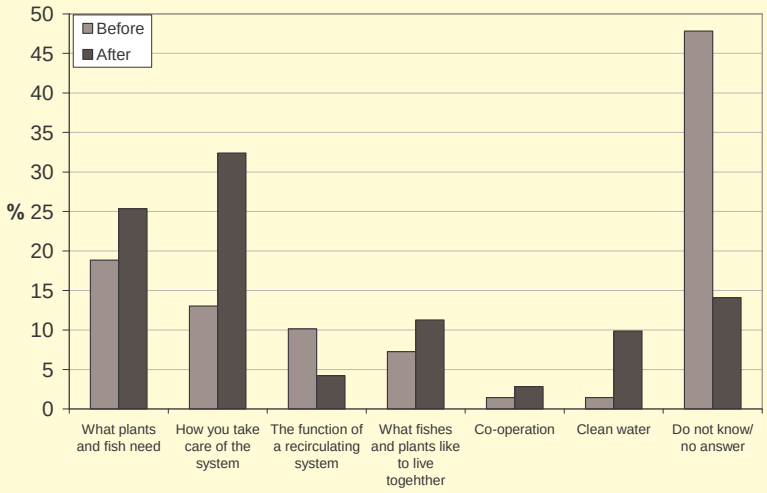
Why do plants need solar energy?



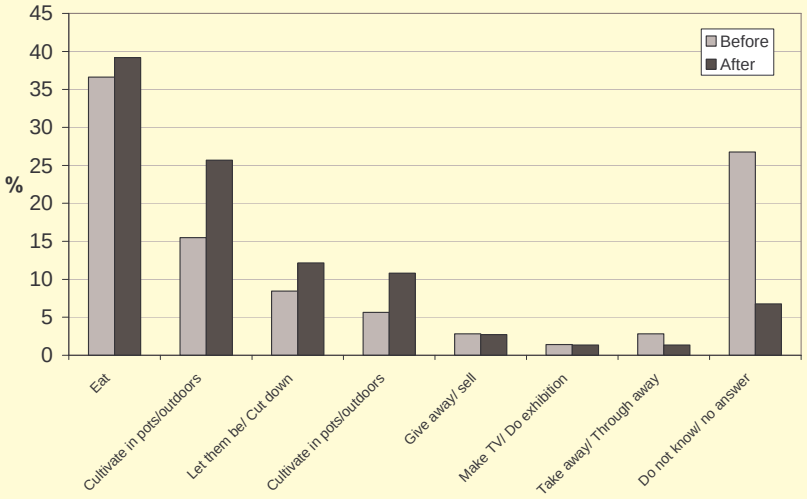
What does a recirculating system mean for you?



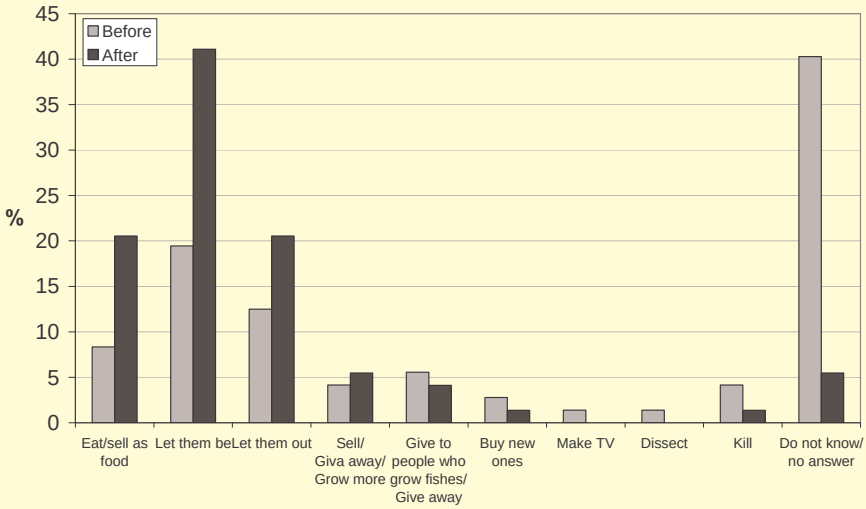
What is the most important to know in order to cultivate fish and plants together?



What can you do with the plants when they have finished to grow?



What can you do with the fish when they have finished to grow?



miljöpartiet de gröna

Miljöpris 2007

tilldelas

Älandsbro skola

för deras stora engagemang i miljöfrågor med särskild tonvikt på kretsloppet med akvarium, där fiskar och växter samspelar.

I projektet Play with water, ett internationellt samarbete mellan Schweiz, Tyskland, Slovenien, Danmark, Norge och Sverige, har Älandsbros skola med Leif Lundin i spetsen fått beröm för pedagogiken. Alla elever och lärare är delaktiga och ett faddersystem mellan äldre och yngre elever stärker samhörigheten och förståelsen för miljön. Deras anteckningar om kretsloppet har blivit en bok, som imponerat på övriga länders deltagare.

Härnösand den 9 mars 2008
Miljöpartiet de gröna

Prize from the Green Party

TIDNINGEN ÅNGERMANLAND · TORSDAG 7 FEBRUARI 2008

NYHETER 5

Tidningen på nätet
allehanda.se
- Senaste nyheterna dygnet runt
- Lämna tips och skicka bilder
- Kommentera artiklar
- Var med i omröstningar

Utfodring ger fåglar fördelar

Fågelmatning ökar inte bara fåglarnas chanser att överleva vintern. Den ger dem också ett övertag under resten av året. De startar häckningen tidigare och får fler ungar än sina omatade artfränder.

Spelar in tv för hela Europa

Elever från Älandsbro beskriver kretsloppet i spanska Euronews

EuroNews

Euronews/futuris

Play with Water: Introducing Ecological Engineering to Primary Schools to Increase Interest and Understanding of Natural Science

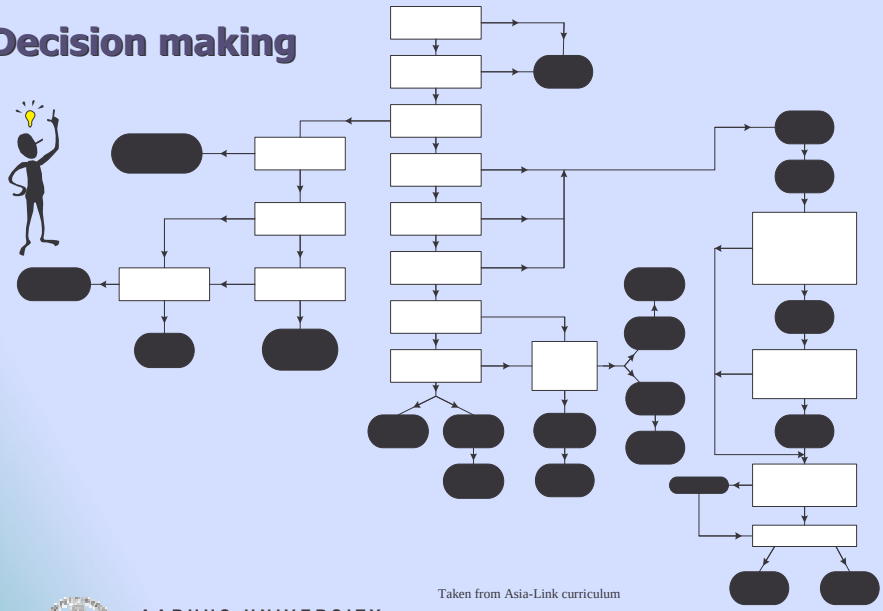
Contract Number
021028
WasteWaterResource

From an engineered evaporative wastewater treatment systems to a functional classroom model

C. A. Arias[1], Hans Brix[1] and Geert Bilander[2]
carlos.arias@biology.au.dk; hans.brix@biology.au.dk; geert@bilander.dk
[1] Aarhus University, Department of Biological Sciences
[2] Syddjurs Friskolen
Denmark

AARHUS UNIVERSITY
Department of Biological Sciences
Wastewater Water Resource, Wädenswil, April 2008

Decision making



Taken from Asia-Link curriculum

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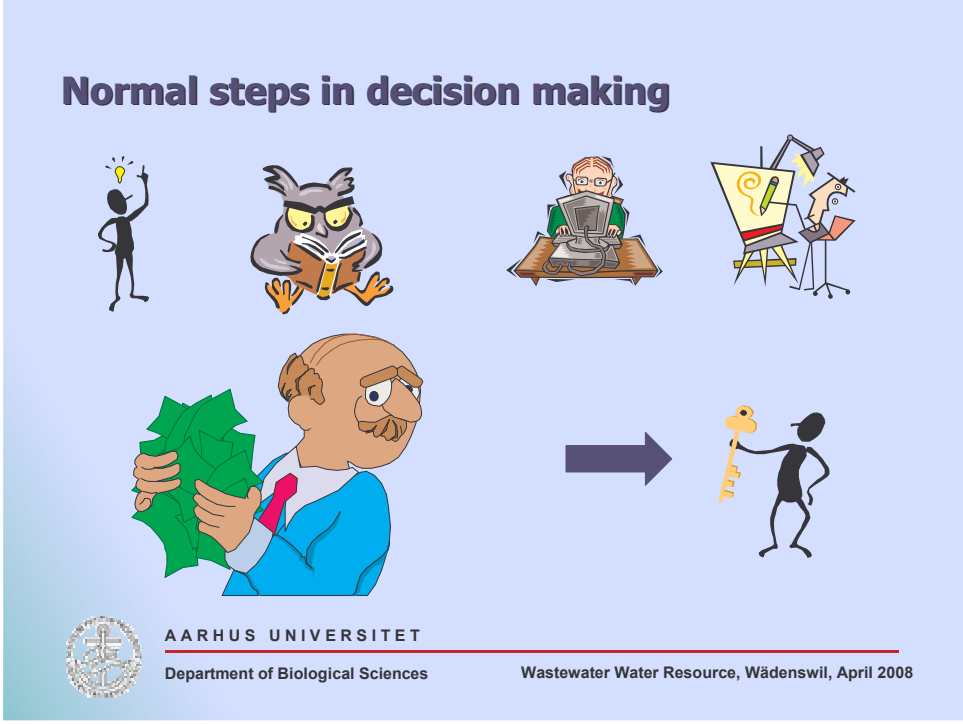
Normal steps in decision making
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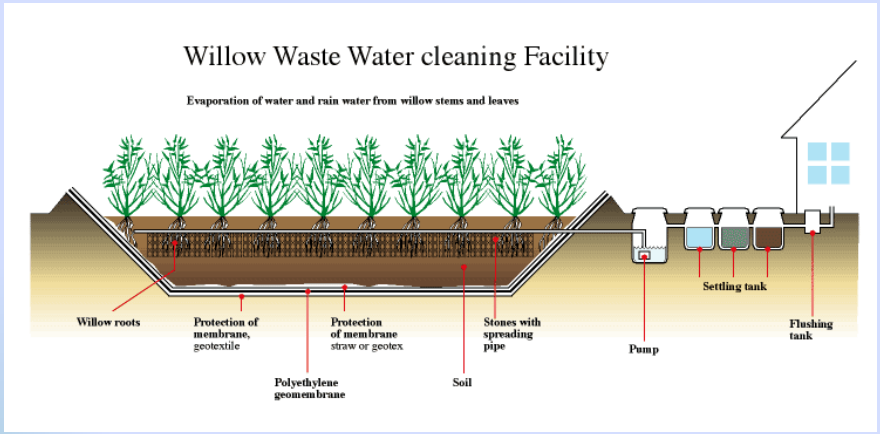
Willow Waste Water cleaning Facility
Evaporation of water and rain water from willow stems and leaves
Willow roots
Protection of membrane, geotextile
Protection of membrane straw or geotex
Polyethylene geomembrane
Soil
Stones with spreading pipe
Pump
Settling tank
Flushing tank
AARHUS UNIVERSITY
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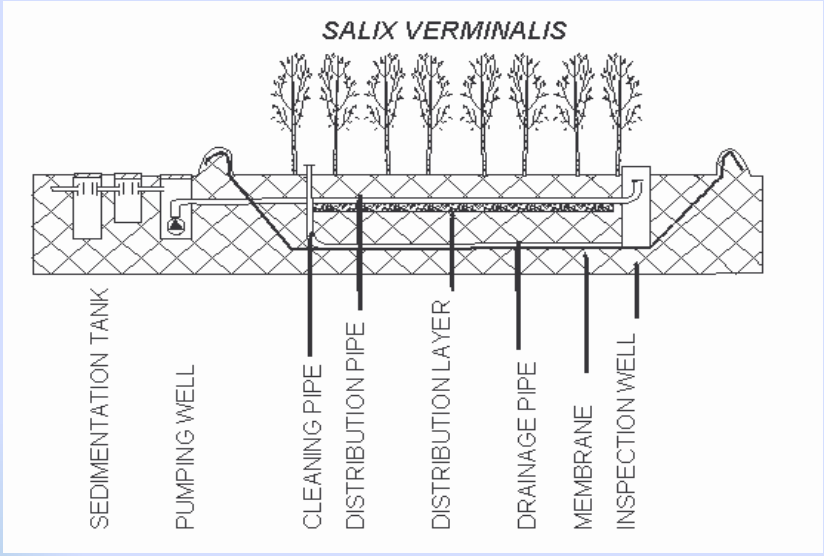
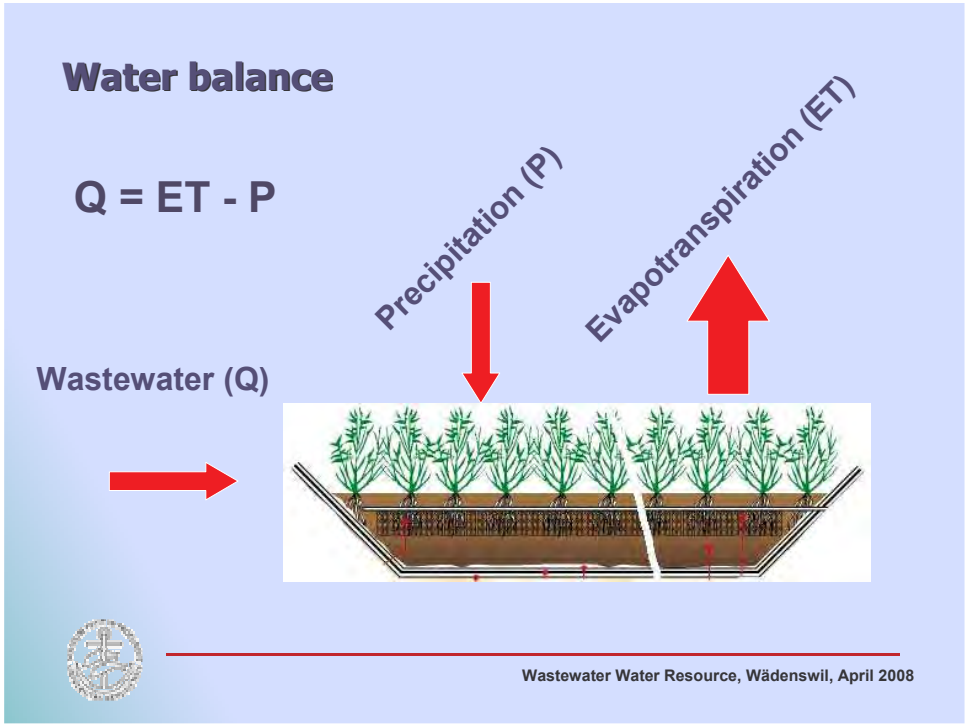
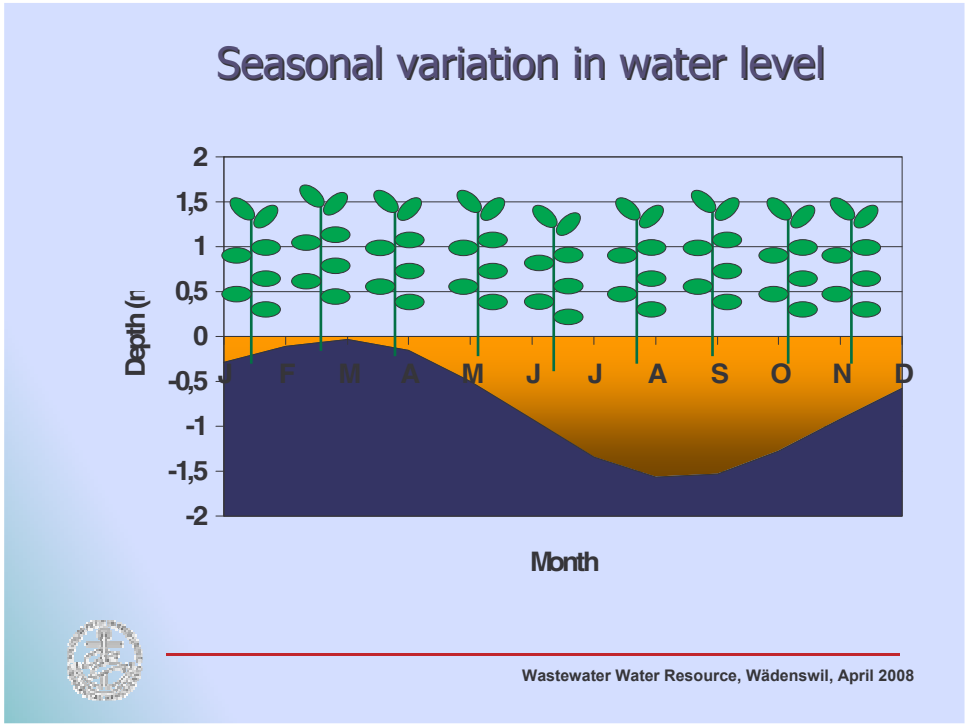
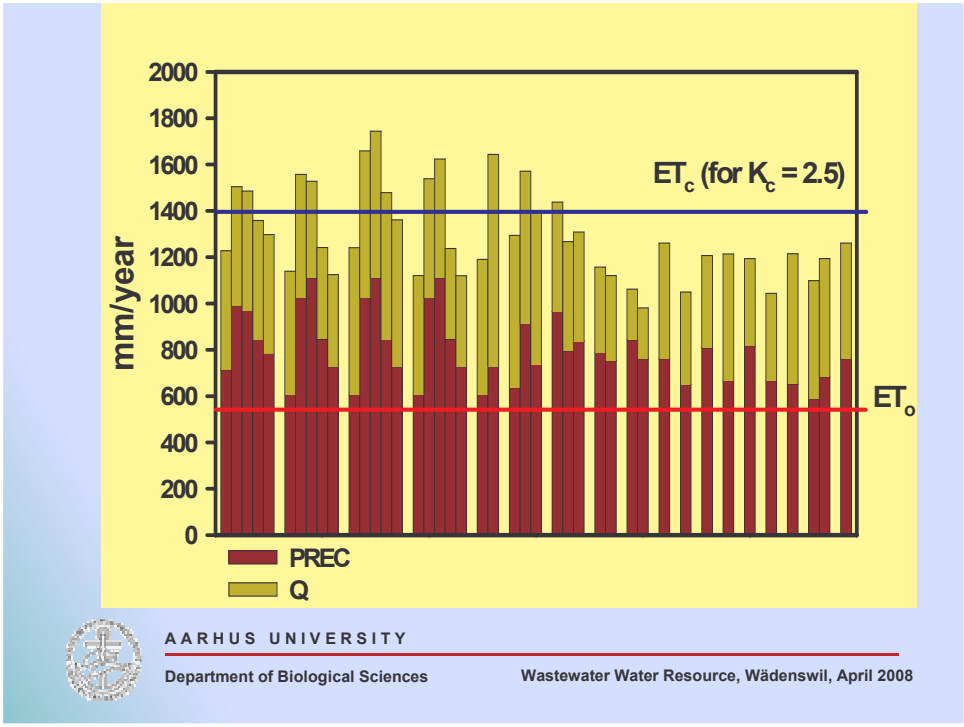
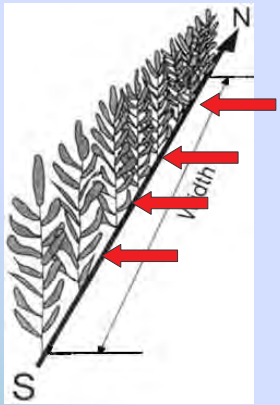

SALIX VERMINALIS
SEDIMENTATION TANK
PUMPING WELL
CLEANING PIPE
DISTRIBUTION PIPE
DISTRIBUTION LAYER
DRAINAGE PIPE
MEMBRANE
INSPECTION WELL
AARHUS UNIVERSITY
Department of Biological Sciences
Wastewater Water Resource, Wädenswil, April 2008


Water balance
Q = ET - P
Precipitation (P)
Evapotranspiration (ET)
Wastewater (Q)
Wastewater Water Resource, Wädenswil, April 2008


Seasonal variation in water level
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
J F M A M J J A S O N D
Month
Wastewater Water Resource, Wädenswil, April 2008

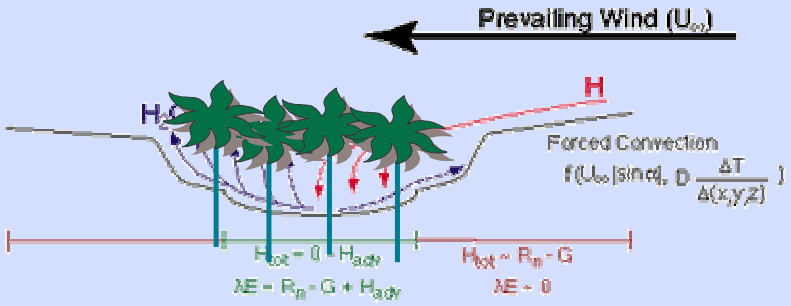


Clothes line effect



- Small expanses of tall vegetation that are surrounded by shorter cover can exhibit a clothesline effect. This occurs where turbulent transport of sensible heat into the canopy and transport of vapour away from the canopy is increased by the 'broadsiding' of wind horizontally into the taller vegetation

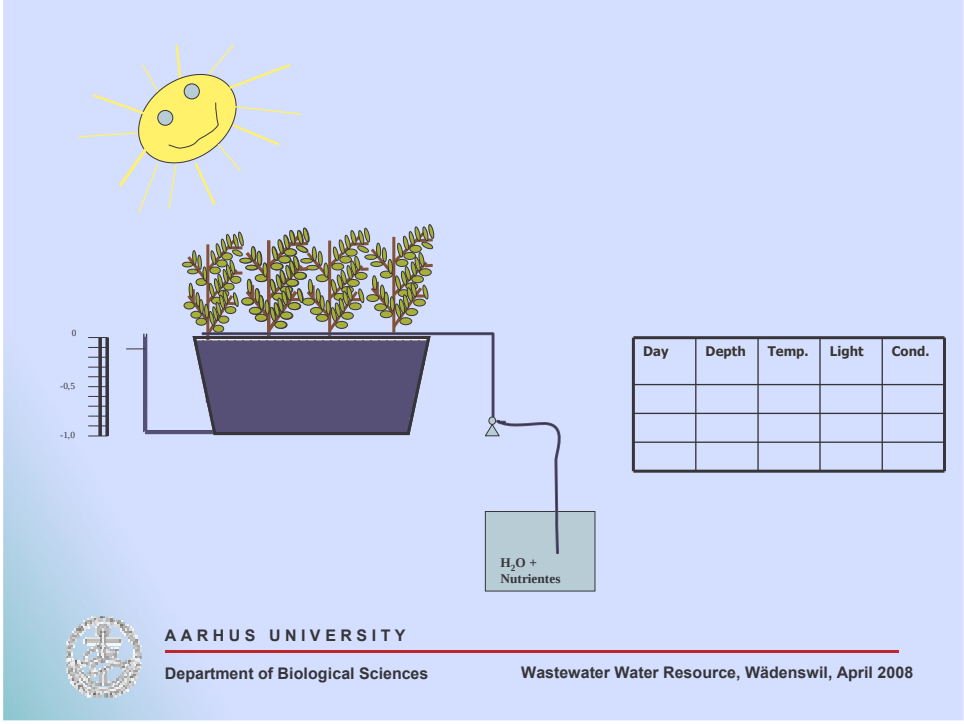
Oasis effects



- Where vegetation has higher soil water availability than the surroundings. Hot dry air flows across and creates rapid evaporation using sensible heat from the air.

The sizing of a willow system will be based on the yearly balance between wastewater production, precipitation and evapotranspiration.

A willow system uses solar radiation, wind velocity, temperature, humidity and location to increase the potential evapotranspiration rates.


0
-0,5
-1,0
Day
Depth
Temp.
Light
Cond.
H2O +
Nutrientes
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Department of Biological Sciences
Wastewater Water Resource, Wädenswil, April 2008


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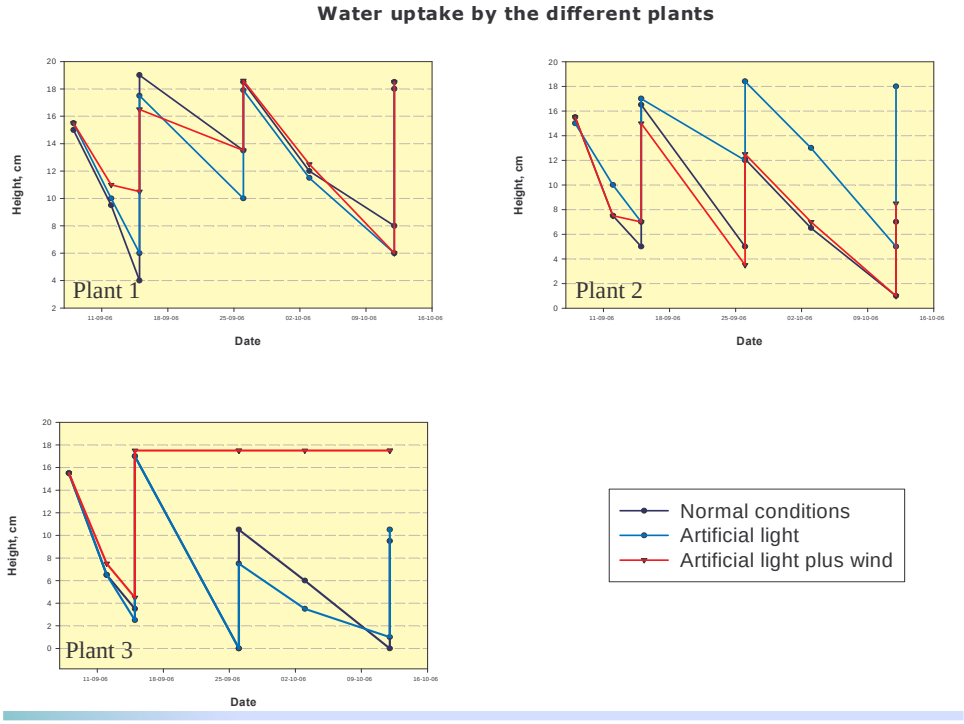
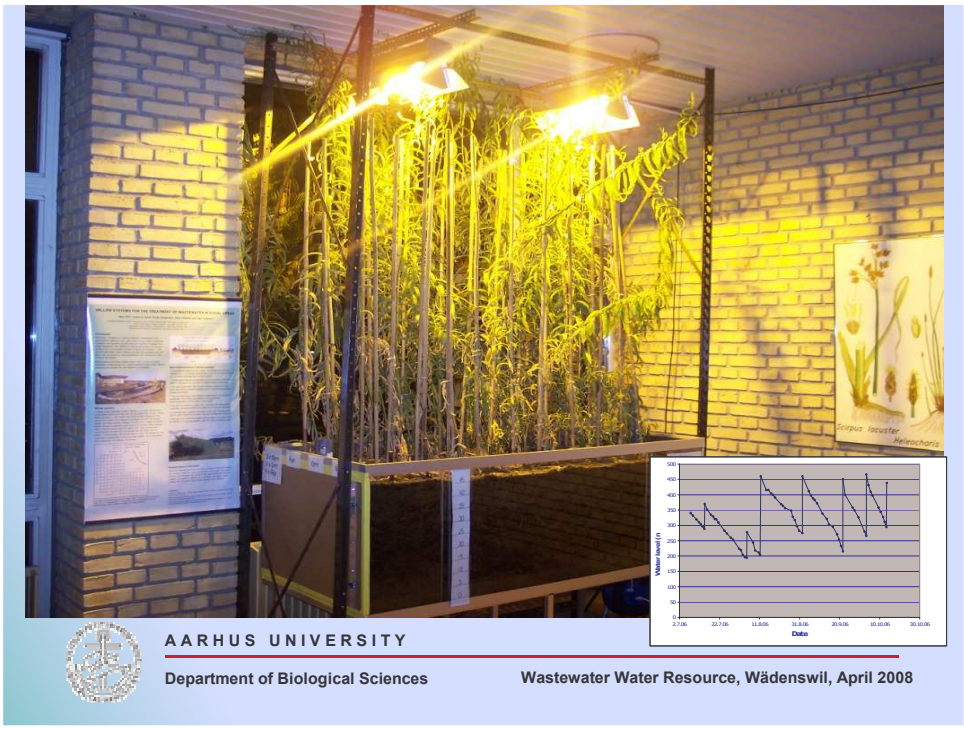
Department of Biological Sciences
Wastewater Water Resource, Wädenswil, April 2008


3
C


Water uptake by the different plants
Height, cm
Date
Plant 1
Plant 2
Plant 3
Normal conditions
Artificial light
Artificial light plus wind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Wastewater Water Resource, Wädenswil, April 2008

Final Remarks

- An evaporative system can be established relatively easy, economically and functionally as a classroom model
- The model can be built by the pupils with the guide of the teacher
- Reliable data can be gathered from the system and can be used in other subjects
- The system is easy to manatain and does not demand much care

AARHUS UNIVERSITY

Department of Biological Sciences

Wastewater Water Resource, Wädenswil, April 2008

Syljurs Friskole

Geert Bilander,
Syddjurs Friskole,
Denmark

Implementation of "Play With Water" models in science teaching for elementary schools: the Syddjurs Friskole experience

A private school inspired by the ideas of Celestin Freinet

160 pupils from age 6 to 17
10 classes from grade 0 - 9

Science starts in 2. grade

- **We work from inside ➔ out**
- **Starting with the narrow world**
- **Moving to the local world**
- **Ending at the global world**

- **From 6. grade the science lessons are divided in:**
  - geography
  - biology
  - physics
  - chemistry

I teach in:

2. to 5. grade: Science
6. to 9. grade: Physics and chemistry

About 25 lessons a week.

Water !

On going water activities:

- vandtjek.dk
- Kolå
- Coachwatch
- ”The energy day”
- m/s Skødshoved
- Play with water

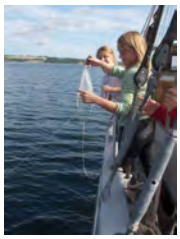
www.syddjursfriskole.dk/syddjurs_sider/fagene_naturfag_play_with_water.htm

Vandtjek.dk and Kolå

Coachwatch

”The energy day”

m/s Skødshoved

Where does Play with Water fit in?

The Play with water ”experiments” were fit into the lessons in order to comply with the Danish curriculum.

From the danish national goals:

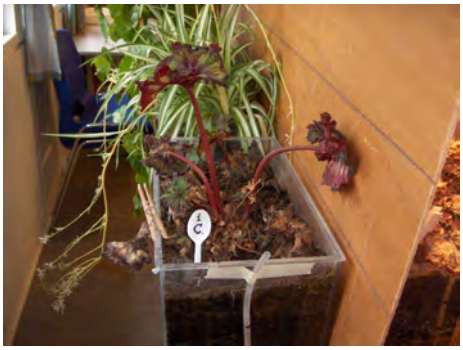
- ***Learn how people influence (affect?) the environment***
- ***Learn about local and global enviromental problems, and propose solutions***
- ***Learn that the use of technology can create enviromental problems***
- ***Building simple models***
- ***Gathering, organising and presenting data***
- ***Categorising results of experiments***
- ***Comparing results and summarising simple rules***

Play with water models prepared by the students in the class room




A mini sevage evapotranspiration plant



A compost factory

Wastewater quality analysis

A wetland model

A nice aggregated (and integrating!!!) benefit:

The results of the experiments can be used by other teacher´s in other subjects:

- Mathematics
- Biology
- Physics
- Chemestry

And you can even implicate other subjects:

- Writing
- Creative (and not very creative) art

Most important result of the
”Play with water” project
from the stakeholder´s point off view:

- **I got a view into the university-world from almost inside**
- **I learned about the conditions of teachers from other countries**
- **And I got an impression of the MULTIPLE demands for an EU-project**

”the primary school is the first link in the feedline!”

Improve the conditions for the first link,
and you can improve the conditions
at the end of the line!

Final Report

Teaching unit
“Constructed Wetland”

Manfred van Afferden
Roland Müller

Richterswil Switzerland 22.04.2008

Objective

Develop and assess teaching materials in ecological engineering (classroom model ecosystems) as new teaching materials for primary schools.

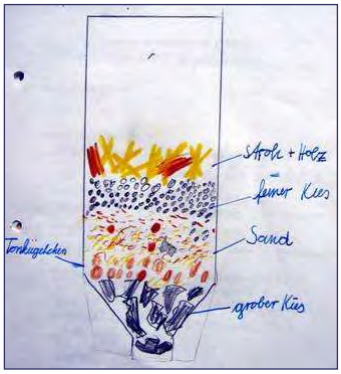
The BDZ package: Constructed wetland and wastewater rally

Introduction into the Water Cycle

Learning Goals
- Students will understand the global water cycle as a closed system.
- They learn that on its way through the cycle water becomes polluted and cleaned by natural processes.

Time Requirement
Preparation time:25min
Teaching time: 1 hour

Material Costs
Approximately € 10



Introduction into the Water Cycle

Introduction game

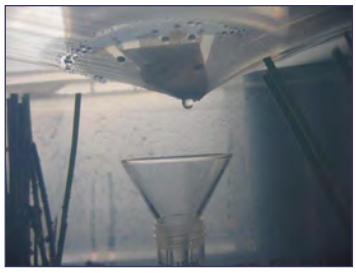
Students have to imagine a journey of a water drop.

Constructing a soil filter

Introduction into the Water Cycle

Evapotranspiration box






Constructing a wetland model

Learning Goals

- An understanding of the set-up and the way it works.
- Principles of nature are used to clean wastewater (soil filter, degradation, evapotranspiration).
- Handle technical equipment and insight into the practical work of engineers and scientists.

Time Requirement

Preparation time: 2-3 hours (incl. shopping)
Teaching time: 1.5 hours

Material Costs

Approximately € 25


Constructing a wetland model

- Install the plastic tap and transparent plastic hose
- Fill in gravel and expanded clay
- Implant the plants
- Form the inlet gravel filter

Constructing a wetland model

- Washing the gravel bed
- Fix the measuring tape next to the plastic hose
- Pour 1 L of artificial wastewater into the system
- Fill up with clean water to a water level of 10 cm
- Taking the water sample once a week

WASTEWATER ANALYSIS

Learning Goals

- Pupils will learn how to define the terms "clean water" and "quality guidelines".
- They should understand the principles of water analysis and how to measure different substances in water.

Time Requirement

- Preparation time 1-2 hours
- Activity time 45 min (lesson) or 15 min (routine analysis)

Material Costs
Approximately € 25

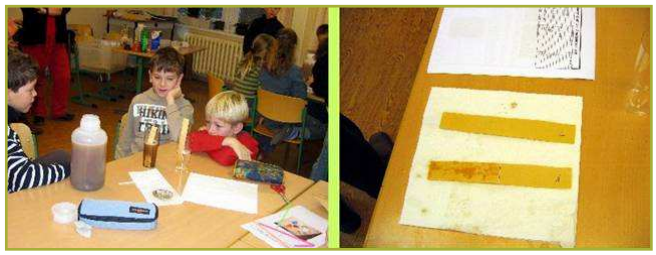
WASTEWATER ANALYSIS

Preparation of artificial wastewater

Big particles

WASTEWATER ANALYSIS

Oil



Smell and colour

WASTEWATER ANALYSIS

Small particles

Turbidity

WasteWaterResource

WASTEWATER ANALYSIS

Detergent

Acid (pH)

WasteWaterResource

WASTEWATER ANALYSIS

Analysis of results

Wastewater analysis
Test results

Group name: ..... Date: .....

Type of water: .....

Parameter	Approximate result	Accurate result	Points
Big particles	Yes / No	How full is the sieve: Only bottom of sieve = 0 points Sieve half full = 1 point Sieve full = 2 points	
Oil	Yes / No	Surface area of oil marks: Less than half the size of the paper= 1 point More than half the size of the paper = 2 points	
Smell	Yes / No	Smell: Light=0 points Medium=1 point, Intensive=2 points	
Colour	Yes / No	Colour: Light=0 points Medium=1 point, Intensive=2 points	
Small particles	Yes / No	Estimate the number of particles: Less than 10 = 0 points More than 10 = 1 point	
Turbidity	Yes / No	Slightly turbid = 0 points Medium turbid = 1 point Very turbid = 2 points	
Detergents (Foam forming)	Yes / No	Little foam= 0 points Medium foam = 1 point A lot of foam = 2 points	
Acids (pH)	Yes / No	pH 6 or 7 = 0 points pH 5 = 1 point pH 4 or below = 2 points	
Number of X for Yes:		Number of points:	

WATER DISTRIBUTION AND USE

Learning Goals
- Pupils develop care and concern for water as a scarce resource and an awareness of the need to preserve and conserve water resources.
- Pupils obtain a feeling for different water amounts.

Time Requirement
- Preparation time:20-30 min
- Teaching time: 30-45 min

Material Costs
Approximately € 10

WATER DISTRIBUTION AND USE

Demonstration

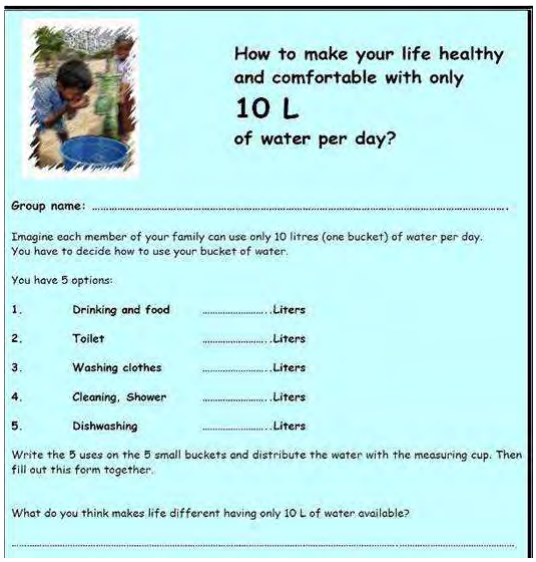
Action game

Balance race

WATER DISTRIBUTION AND USE

Role play

imagine life with only one bucket of water per day



How to make your life healthy and comfortable with only

10 L

of water per day?

Group name: .....

Imagine each member of your family can use only 10 litres (one bucket) of water per day.
You have to decide how to use your bucket of water.

You have 5 options:

1. Drinking and food .....Liters
2. Toilet .....Liters
3. Washing clothes .....Liters
4. Cleaning, Shower .....Liters
5. Dishwashing .....Liters

Write the 5 uses on the 5 small buckets and distribute the water with the measuring cup. Then fill out this form together.

What do you think makes life different having only 10 L of water available?

.....

EVAPOTRANSPIRATION EXPERIMENT

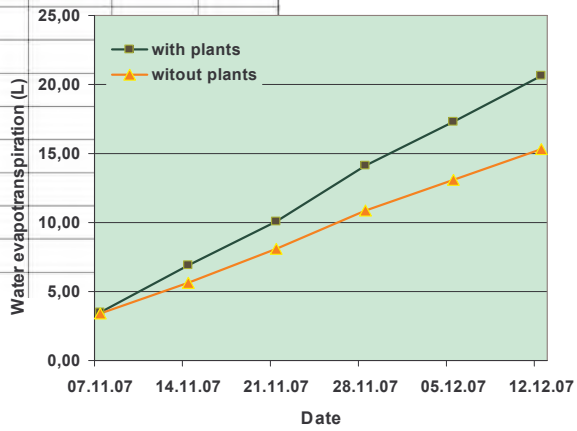
Two countries

- Evapotranspiration experiment: Aarhus University, Denmark

Two countries

- Evapotranspiration experiment: Aarhus University, Denmark

Date	water level (cm)	Added water (Liter)	Sum of added water (Liter)	Observations	Pupil
07.11.07	10				
14.11.07	10				
21.11.07	10				
28.11.07	10				
05.12.07	10				
12.12.07	10				



The wastewater rally

Date: March 22, 2007 at the "World Water Day"

Installations: UFZ-Helmholtz Center for Environmental Research in Leipzig

Participants: 78 pupils (4 classes) in the age of 9-10 years (3. grade)

Schools: Adam-Friedrich-Öser Schule and BIP Kreativschule, Leipzig

Personnel: 4 supervisors from BDZ, 3 from UFZ and 8 teachers

Schedule of the wastewater rally

Exercise	Time (min)
Introduction	15
Closing the water cycle	25
Distribution of water on earth	30
Break	20
Water a rare good	20
Wastewater treatment	35
Awards ceremony	20

Beforehand-preparation

- Some knowledge on the elements of the water cycle
- Divide classes into groups consisting of 4 to 5 pupils
- Group names such as rain, cloud, river, spring or water drop

Introduction (15 min)

- Background music
- Story „The long journey of AGUA, the rain water drop“

Closing the water cycle (25 min)

- Repetition: the water cycle
- Filling the missing link for each cycle
- Solution word: Agua

Water distribution on earth (30 Min)

- Lead-in: „A drop of potable fresh water“
- Find the drinking water (identify the balloons with water and hit as many water-filled balloons as possible with darts

Water a rare good (20 Min) after break

- short story of Palesa, an African girl
- footrace carrying a plastic bucket with 3 water-filled balloons on the head

Wastewater treatment (35 Min)

- soil layers and the pore structure
- constructing a wastewater filter
- copying the natural soil filter

Awards ceremony (20 Min)

- winning team received a bag filled with small toys
- acknowledgment (ball) and a Water Day button

Assessment of the teaching unit and wastewater rally

Questionnaire pupils

Interview teachers

Profession

March 22, 2007 39 pupils	total	girls	boys	%
Sportsman	14	7	7	16
Policeman, fire-fighter, detective	13	4	9	15
Veterinarian, zoo/keeper	12	8	4	14
Teacher	9	8	1	11
Musician, artist, dancer, actor/actress	8	6	2	9
Salesperson, others	7	4	3	8
Scientist, researcher	5	3	2	6
Doctor	5	4	1	6
Astronaut, seaman, pilot	5	0	5	6
Building worker, craftsman	3	0	3	4
Engineer, architect	2	0	2	2
Soldier	2	0	2	2
Sum	**85**	**44**	**41**	**100**

Nov. 07, 2007 44 pupils	total	girls	boys	%
Veterinarian, zoo/keeper	28	27	1	25
Sportsman	15	5	10	13
Policeman, fire-fighter, detective	14	1	13	13
Musician, artist, dancer, actor/actress	13	12	1	12
Astronaut, seaman, pilot	11		11	10
Building worker, craftsman	11	4	7	10
Scientist, researcher	6	1	5	5
Doctor	6	3	3	5
Teacher	4	4		4
Engineer, architect	3		3	3
Salesperson, others	1		1	1
Sum	**112**	**57**	**55**	**100**

Like it or not

Like

March 22, 2007 39 pupils	total	girls	Boys	%
Darts – Find the drinking water	25	9	16	37
Balance the water bucket	23	12	11	34
Constructing filters	12	6	6	18
Quiz	8	3	5	12

Nov. 07, 2007 44 pupils	total	girls	boys	%
Constructing filters	14	6	8	31
Darts – Find the drinking water	12	7	5	27
Games	7	5	2	16
Everything	6	5	1	13
Balance the water bucket	5	1	4	11

Like not

March 22, 2007 39 pupils	total	girls	boys	%
Darts – Find the drinking water	7	4	3	64
Balance the water bucket	2	1	1	18
Constructing filters	2	0	2	18

Nov. 07, 2007 44 pupils	total	girls	boys	%
Nothing	18	3	15	51
Balance the water bucket	6	3	3	17
havent won, Laut, crowdy, listening	5	3	2	14
Darts – Find the drinking water	3	2	1	9
Constructing filters	2	2		6
Questions	1	1		3

Question of reflection

March 22, 2007 39 pupils	total	girls	boys	%
Shower, bath	20	11	9	16
Cloth washing	20	10	10	16
Cocking, Eating	17	9	9	14
Watering of plants	14	6	8	11
Drinking	13	7	6	10
Toilet	11	5	6	9
Brush teeth	10	6	4	8
Dish cleaning	9	4	5	7
Swimming-pool	5	3	2	4
Cleaning of hands	3	1	2	2
House cleaning	2	1	0	2
Sum	**124**	**63**	**61**	**100**

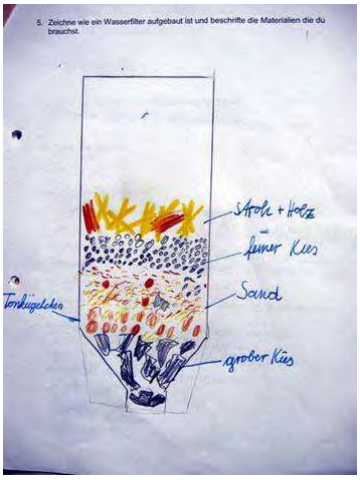
Nov. 07, 2007 44 pupils	total	girls	boys	%
Shower, Baden	33	17	16	28
Cloth washing	23	12	11	20
Toilet	16	8	8	14
Drinking	11	4	7	9
Cocking, Eating	10	6	4	9
Dish cleaning	9	5	4	8
Watering of plants	5		5	4
Brush teeth	4	2	2	3
Cleaning of hands	4	3	1	3
Swimming-pool	1	1		1
House cleaning	1	1		1
Sum	**117**	**59**	**58**	**100**

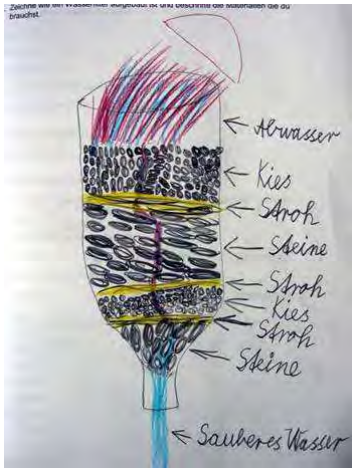
Content related questions

March 22, 2007 39 pupils	total	girls	boys	%
Is it possible for a drop of water to travel from a cow into an apple?				
Yes	23	10	13	59
No	16	9	7	36
Where do you find the most drinking water?				
Germany	26	15	11	54
North Pole	17	8	9	35
Ocean	5	1	4	10
Spain	0	0	0	0
How you can reuse the dish washing water?				
Watering tomatoes	19	9	10	40
Flushing toilet	20	9	11	43
Not at all	8	5	3	17
Drinking	0	0	0	0

Nov. 07, 2007 44 pupils	total	girls	boys	%
Is it possible for a drop of water to travel from a cow into an apple?				
Yes	40	18	22	91
No	4	3	1	9
Where do you find the most drinking water?				
Germany	23	14	9	47
North Pole	12	3	9	24
Spain	9	4	5	18
Ocean	5	2	3	10
How you can reuse the dish washing water?				
Watering tomatoes	28	14	14	51
Flushing toilet	21	10	11	38
Not at all	5	3	3	9
Drinking	1		1	2

Constructing a filter





Teachers interviews

- General comments: well- organized, nice ideas, simple but very effective, pupils liked it very much
- The costs of approx. 100€ per class are to high
- Curriculum: Fit perfectly in the curricula of the 3rd and 4th grade
- Integration of experiments into other lessons, e.g. evaporation → rain forest
- Advantages: Fun factor, a lot of variation in the event, self-awareness, under-performing pupils participated very well, all pupils listened carefully, few supervision necessary
- Time requirements/structure: Good mixture of action and quietness, logical thinking and manual skills, excitement and relaxation, very useful to as a project (action-) element at the end of a teaching unit
- Indicators learning outcome: talked about the rally even weeks later and paid attention to water consume at school - dropping taps - flowing tap water. Qualifications of an examination that included the water cycle and the filter construction were above-average

Dissemination and gender issues

- Campus Day Leipzig 07.07.07
- Girls Day UFZ Leipzig 26.04.07

Thanks to all

Pupils:	Classes 3a and 3c	Adam Friedrich Öser Schule
	Classes 3a and 3b	BIP Kreativschule
	Classes 4a and 4c	Adam Friedrich Öser Schule

Teachers: Frau Hinrich, Frau Dietrich, Frau Winter, Frau Kwauka

BDZ: Adriana Müller, Katrin Peretzki, Silke Reimann, Manfred van Afferden

UFZ: Doris Böhme, Susan Walter, Roland Müller

LEARNING PATH DRAGONJA

Tjaša Griessler Bulc, Sandra Krivograd Klemenčič, Darja Istenič

Contract Number 021028
WasteWaterResource
Play with Water: Introducing Ecological Engineering to Primary Schools to Increase Interest and Understanding of Natural Science
Instrument: Coordination Action (CA)
Thematic priority: Science and Society; Science education and careers 2004; FP6-2004-Science-and-society-11

CONTENTS

- DRAGONJA RIVER
- ECOREMEDIATION
- LEARNING PATH
  - Pond
  - Gravel deposit
  - Reed beed
- TEACHING GOALS
- CONCLUSIONS

Characteristics of the Dragonja River

- The learning path Dragonja is placed along the Dragonja river basin in the Slovenian/Croatian border region of the Adriatic coast (Ethnic Minorities and Immigrant Children)
- Dragonja River is 28 km long
- Sub-Mediterranean climate
- It flows into the sea at the salt pans
- It has extreme hydraulic conditions

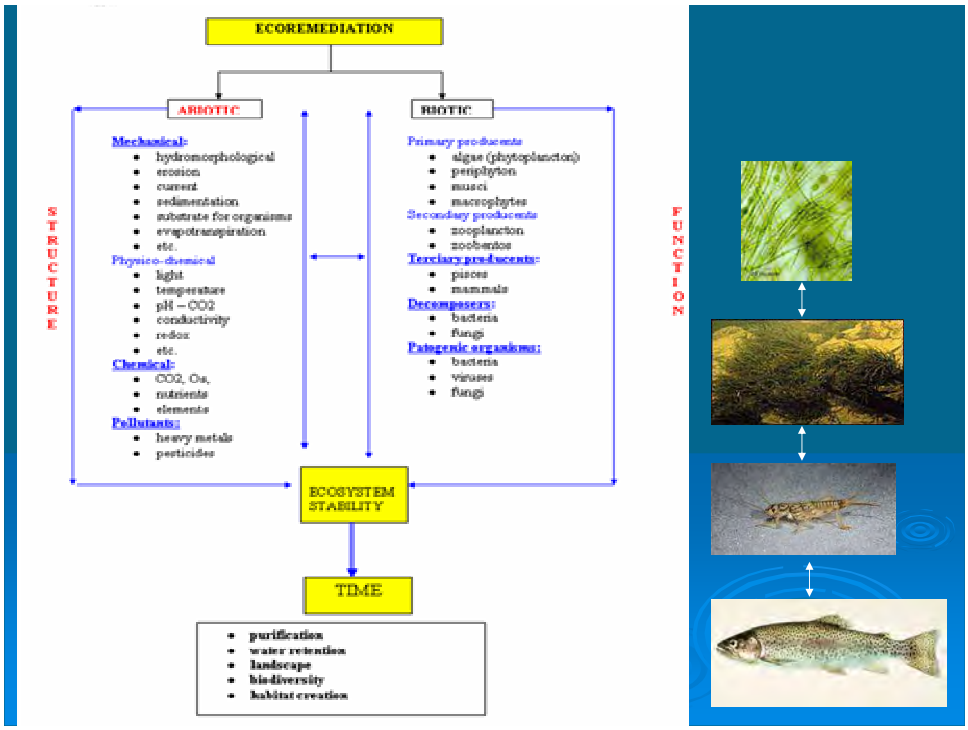
DRAGONJA RIVER OFFERS MANY OPPORTUNITIES FOR TEACHING AND PROMOTING NATURAL SCIENCES

- Dragonja is the only river in Slovenia flowing to the Adriatic Sea, which has more or less preserved its natural characteristics.
- In the Dragonja river basin there are many rare and endangered species, which are protected in Slovenia and/or in Europe.
- During the summer the river is polluted mainly due to alochthonous organic material of natural origin.
- Man-made pollution are agriculture, untreated wastewater discharges and illegal waste dumps.

Learning trail Dragonja focuses on ecoremedation

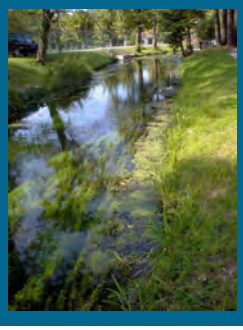
What is ecoremedation?

Ecoremediation (ERM) comprises methods of protection or restoration of the environment by means of natural processes existing in ecosystems. The basic functions of ERM, which can be utilized and improved respectively, are its high buffer, self-protective and habitat characteristics.



ERM SERIES

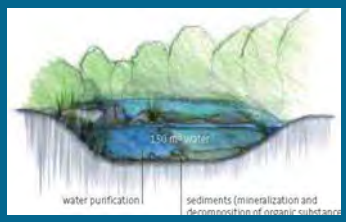
- Mill streams
- River branches
- Vegetated strips
- Buffer zones
- Revitalized rivers
- Co-created wetlands
- Constructed wetlands



NATURAL ERM

Pond

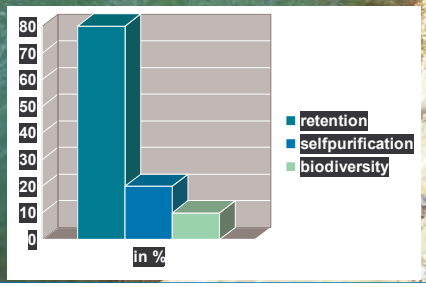
- Demonstrative educational device for environmental management.
- River pools, rapids, gravel detritus, marshes, and puddles…

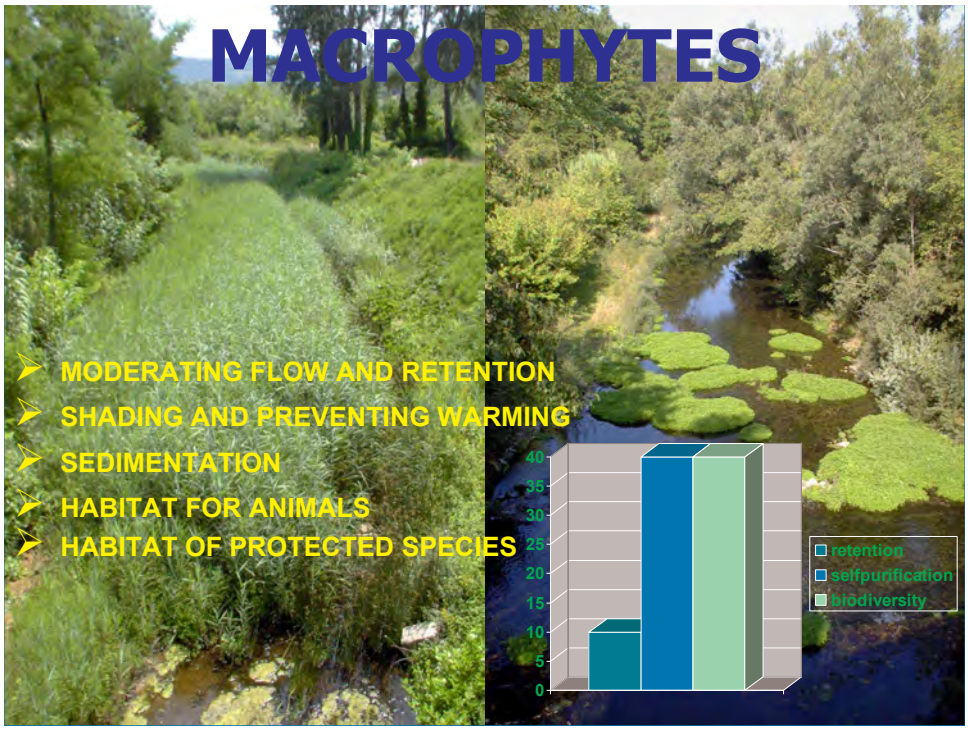


Functions:
Retention,
Treatment, self-purification
Habitat function.

POOL

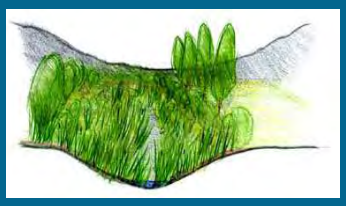
- RETENTION AND SEDIMENTATION
- FLOOD PREVENTION
- MODERATING FLOW
- INFILTRATION TO THE GROUNDWATER
- HABITAT FOR FISHES AND WATER ANIMALS





OLD ECOREMEDATION METHODS

Vegetation zone



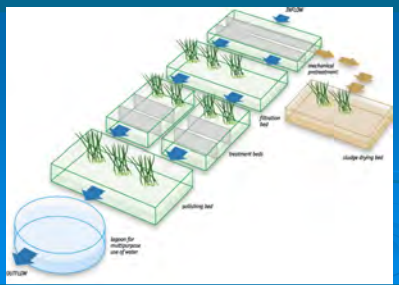
Functions:

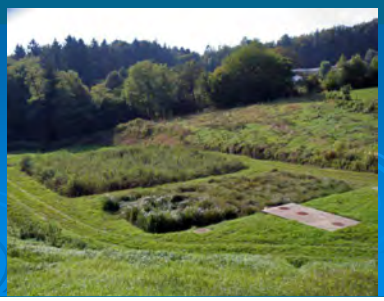
- **Water retention**
- **Purification of water from agricultural land**
- **Prevention of erosion**
- **Habitat: plants, waterside animals, nesting ground and hideout of birds.**

MAN-MADE ERM / METHODS

Constructed wetlands

Treatment of different wastewaters





FUNCTION of ERM

- Water **retention** and compensation of hydraulic peaks
- **Erosion** reduction
- **Sedimentation** of particles
- **Removal** (retention) of toxic substances and nutrients
- Creating new **habitats**
- **Biodiversity**

MAIN TEACHING GOALS

- Pupils obtain an understanding about transmiting natural process into green technology, where principles of nature are used to clean wastewater.
- With an understanding of natural processes on the river we can also influence on environmentally aware of pupils, teachers and parents.

Teaching goals include:

- The pupils visit pond, gravel deposit, reed bed and as last visiting point constructed wetland.
- They get to know all the types where self-protective capacities is imitated.
- Besides they visit a site with harmful impact and learn about people who don't realize the importance, structure and function of water biotope.

LIST OF MATERIAL AND OBSERVATION ACTIVITIES

1.1.1 Observation, measurements	1.1.2 Material, equipment
1.1.3 Water's depth	**1.1.4 Stick, boots, meter**
1.1.5 Water temperature and dissolved oxygen	**1.1.6 Thermometer, boots, paper, pencil, dissolved oxygen probe, tumblers**
1.1.7 Water's pH	**1.1.8 pH meter, tumbler**
1.1.9 Nitric compounds	**1.1.10 Indicatory paper for nitrates, tumbler**
1.1.11 Colour of water and electroconductance	1.1.12 **Tumblers, white paper, pencil, boots, distillatory water, instrument for measuring of electroconductance**
1.1.13 Speed of stream	**1.1.14 Rottenstone, rope, stopwatch**
1.1.15 Aquatic animals	**1.1.16 Animal net, small tub, manual magnifying glass, key for determination water non-vertebrate, brushes**
1.1.17 Waterside plants	**1.1.18 Different keys for determination plants**
1.1.19 Smell of water	**1.1.20 Plastic bottle with the stopper, Ball's scale of smells**
1.1.21 Hight of plants	**1.1.22 Boots, meter, pencil**

WORK SHEETS

LOCATION

- **Worksheet: ORIENTATION AND STONEWARE COMPOSITION**

NATURAL ECOREMEDIATION METHODS (pond, gravel deposit, reed bed)

- **Worksheet: THE WATER'S DEPTH**
- **Worksheet: MEASURING THE WATER TEMPERATURE AND DISSOLVED OXYGEN**
- **Worksheet: MEASURING OF WATER'S pH**
- **Worksheet: MEASURING OF NITRIC COMPOUNDS**
- **Worksheet: DETERMINATION THE COLOUR OF THE WATER AND EI. COND.**
- **Worksheet: MEASURING THE SPEED OF STREAM**
- **Worksheet: OBSERVATION OF AQUATIC ANIMALS**
- **Worksheet: LIST OF WATERSIDE PLANTS**
- **Worksheet: HEIGHT AND DENSITY OF THE PLANTS IN THE REED BED**

CONSTRUCTED WETLAND (CW)

- **Worksheet: MEASURING OF NITRIC COMPOUNDS IN CW**
- **Worksheet: MEASURING OF WATER'S pH**
- **Worksheet: MEASURING THE WATER TEMPERATURE AND DISS.OXYGEN**
- **Worksheet: DETERMINATION THE SMELL OF WATER IN CW**
- **Worksheet: HEIGHT AND DENSITY OF THE PLANTS IN CW**
- **Worksheet: DETERMINATION THE COLOUR OF WATER AND EL.COND.**
- **Worksheet: LIST OF PLANTS AND ANIMALS IN CW**





Learning about organic waste and the global cycle of nutrients

Daniel Todt, Petter Jenssen, Birgitte Bjønnes

Why should we reflect about wastes?

Play With Water

- The amount of household waste increased on 60 percent during the last 11 years in Norway
- So far only a small minority of Norwegian households separate organic litter such as kitchen wastes
- Organic waste dumped into landfills cause problems with water pollution and greenhouse gas emissions
- **There is a need to educate young people about opportunities for separating recycling organic waste**

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Classroom Compost Box

Play With Water

What are the goals?

- Create a compost system that can be established in a classroom
- Observe natural decomposition processes
- Get an idea on what type of wastes can be decomposed by nature and what could disturb ecosystems

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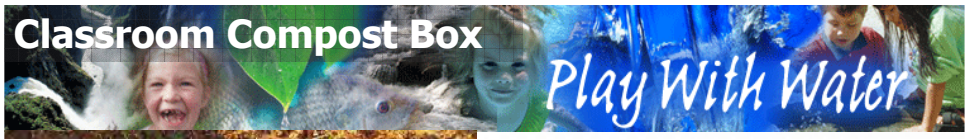

How to do the classroom compost box works?

- kitchen wastes
- leaves as structure material
- forest soil for inoculation
- sawdust as drain layer
- digital thermometer to monitor the temperature

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Ideas for compost box experiments

- Add different type of household wastes into the box and observe what is happen with this stuff over time
- Contaminate one box with dish washer
- Add earth worms to one of the box and try to gather if there are some difference to the box without worms

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Classroom Compost Box

Play With Water

Demonstrate how compost can be reused as a fertilizer for plants

- Try different substrate mixtures with compost, sand and peat
- Let the pupils observe the effects on the growth and health state of the plants

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What is the link to water?

Play With Water

- More than half of the world population is living in areas with insufficient water supply
- This water shortage problem is complex and not only limited to the lack of fresh water sources

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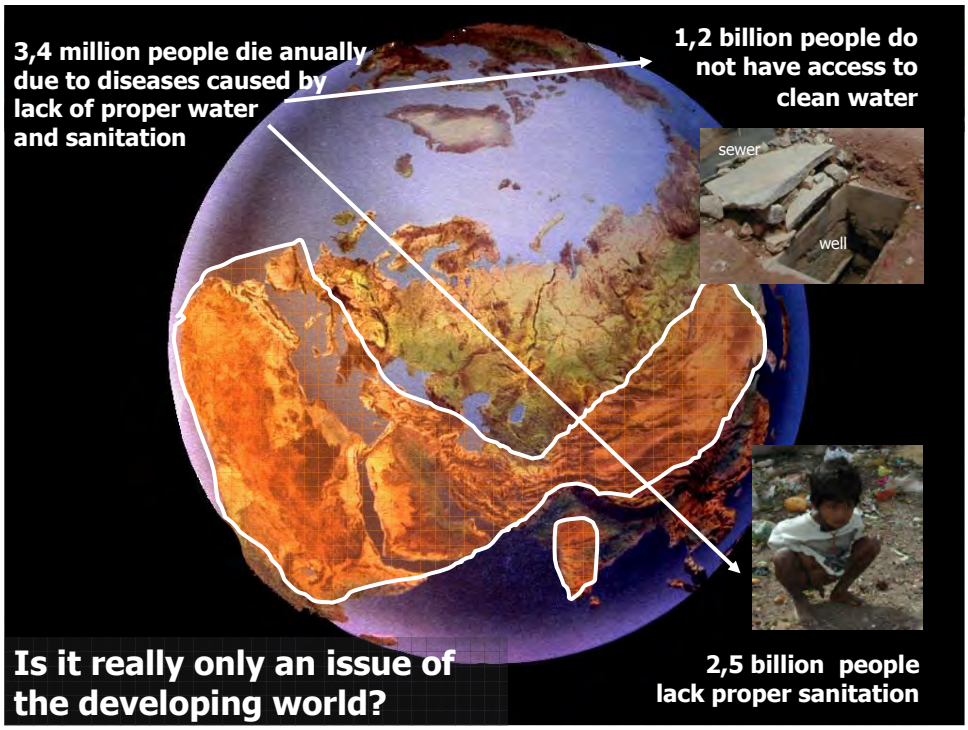

20 - 40 % of the water consumption in sewered cities is due to the water toilet*

dner, G. 1997. Recycling organic waste: From urban pollutant to farm resource. Worldwatch Institute, 135, 58 p

We consume amazing amounts of water to flush the toilet

Play With Water

roughly 50 kg of faecal matter (per person/year)

50 kg

roughly 500 l of urine (per person/year)

500 L

with roughly 20'000l of ***clean*** flushwater* (11), based on a volume of 8l per flush

20'000 L

We thus produce more than 20'000 L of highly polluted, pathogenic wastewater.

If this wastewater is discharged untreated into rivers, an even higher amount of water is polluted.

* Based on the European average for a toilet that uses about 8 L of Water per flush.

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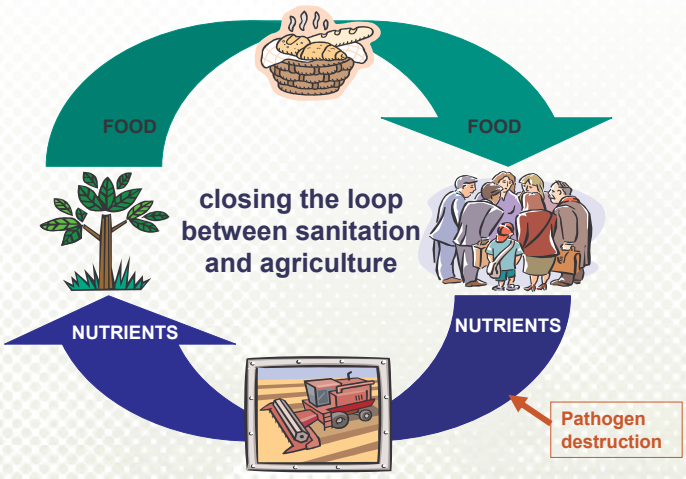
Ecological sanitation – closing the loop

Play With Water



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Play With Water
Sewer
Well
sewer


Ecosan Toilet Centre
Bangalore: Collection
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Faeces
Urin
Washing
water
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Ecosan Toilet Centre
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Door
Window
Wastewater
Urine
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