Lecture 9

Water use and management - Agriculture and Sanitation

April 17, 2023, 14.30 – 16.00 (Sw time 11.30 – 12.00 – 13)

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Disposition

Basics for CULTIVATION

Basics for SANITATION

Basics for IRRIGATION

*** Conclusions**

Humans

Human basics for living:

Breathing, sugar and other energy sources,

water and nutrients,

space, sanitation…

Energy transformation
e.g.for
muscle work

Sugar Oxygen Carbon dioxide Water

$C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O$

Note that energy cannot be destroyed but transformed between different forms: electricity, light, heat, muscle/mechanical work etc.

Resembles the needs of plants

- They are also respiring and are using energy sources when it is dark.
- But in **sun**shine they **produce new energy storages** (sugar, starch etc) via fotosynthesis.

Fotosynthesis

Carbon dioxide Water **Sunlight** Sugar Oxygen

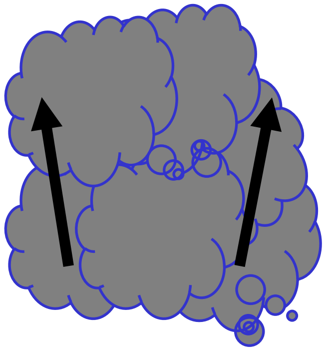
$6\ CO_2 + 6\ H_2O$ -------------→ $C_6H_{12}O_6 + 6\ O_2$

https://www.youtube.com/watch?v=C1_uez5WX1o

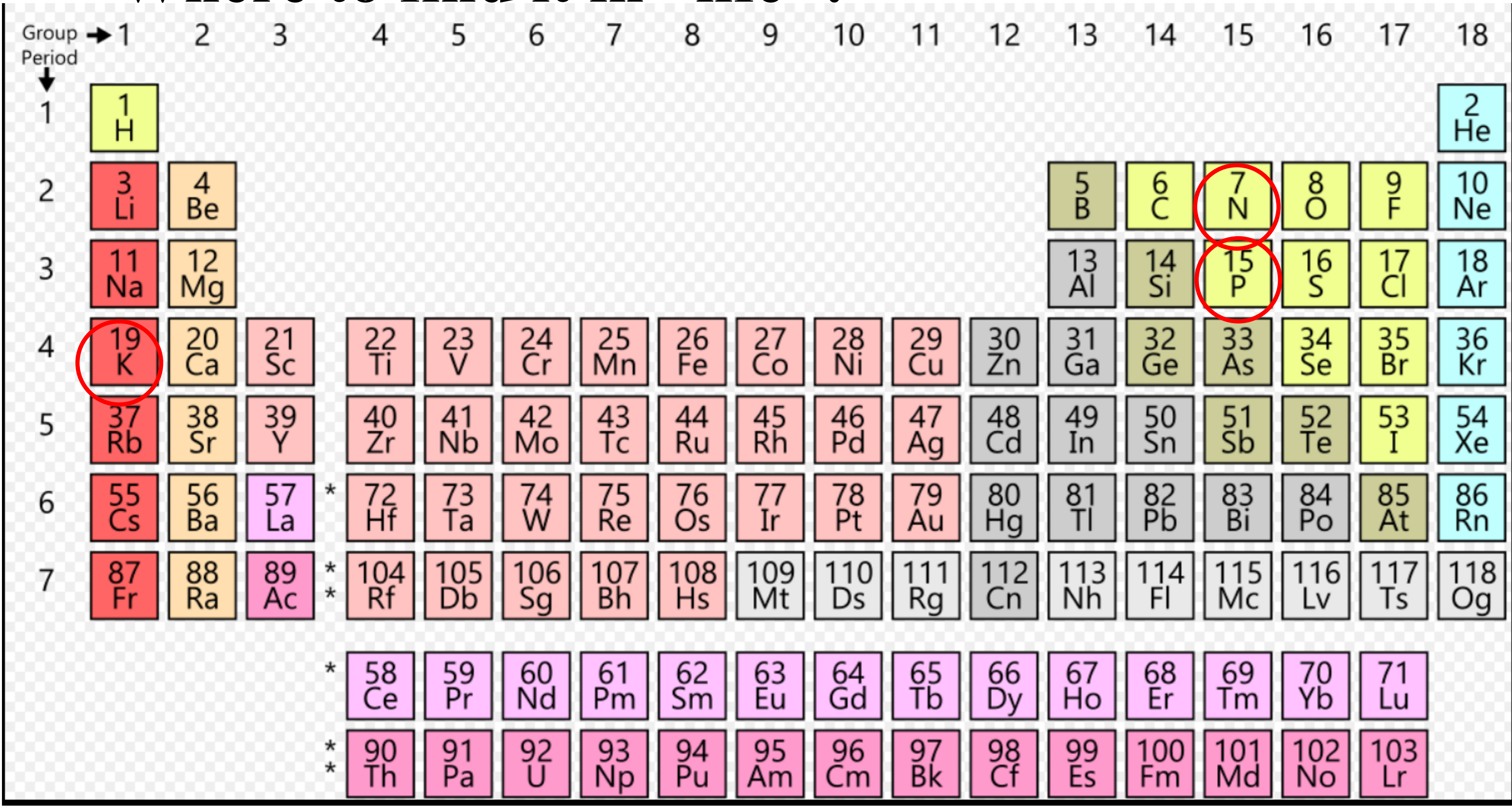
Basics for growing: NPK+H_2O

https://www.hydrogarden.se/odlingssystemkrukor/bevattning-pumpar/droppbevattning/

Certainly also CO2, accessed freely from the air.



What is nitrogen, phosphorus, and potassium? Where to find it in "life"?



P: DNA, RNA, ATP, phospholipids + teeth and bones.

N: air, DNA, RNA, amino acids (proteins in beans,peas,milk,muscles)

K: in liquids, electrolyte balance, function of membrane,muscle,nerve

N: Widely used in fertilisers, eplosives etc

P: Widely used in fertilisers, detergents, pesticides, Coca Cola etc

K: Widely used in fertilisers, soaps, salt, also in match heads, etc

Urine is perfect as a fertiliser. Supplies N, P, K and micro nutrients.

Nutrient recycling without any poisons!

Gold water (urine) is gold worth for your plants.

Foto: Lars Hylander   Kungsgarden@telia.com

Soil improvement

- In sandy soils, water soluble nutrients are leached away when raining.
- This can be counteracted by adding charcoal, called biochar.

Charred wood is persistant against degradation.

Will remain in the soil for thousands of years.

It is a safe carbon sink.

Mycel of fungus and plant roots love biochar

Richard Haard, February 12, 2007

Retaining nutrients in soil c.f. Terra Preta in rain forests.

Photo of charcoal of pine.

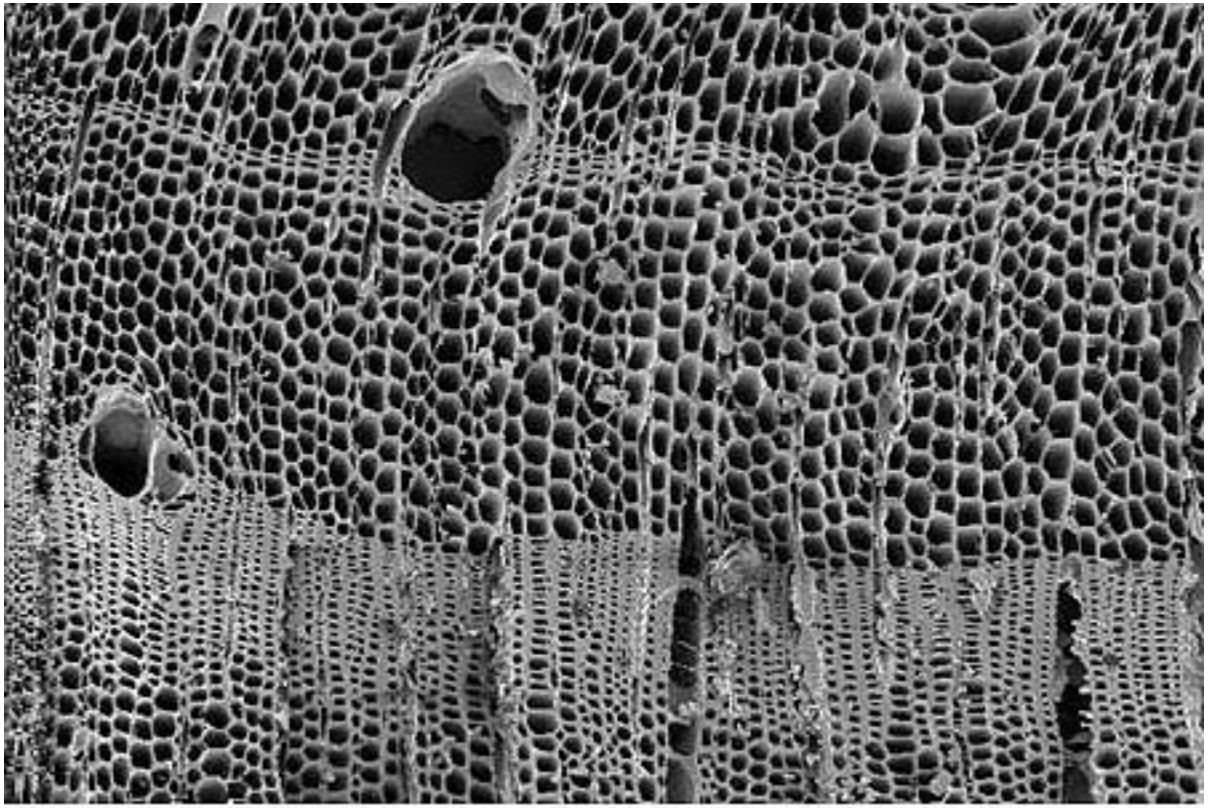


Figure 13. Scanning electron micrograph of pine (*Pinus* sp.) charcoal from Barton Creek Cave.

Similarities with a honey comb thanks to the cell walls.

Biochar in a Swedish compost.

Effectively reducing emissions and losses of nitrogen.

Sustainable sanitation

Dry toilets are optimal

Recovering 99 % of all plant nutrients

Foto: Lars.Hylander

The function may be improved by separating the urine. Char coal will remove odors and reduce N-emissions.

Photo: Lars Hylander of his dry toilet.
Kungsgarden@telia.com

Insertion for dry toilet to separate urine (in the bowl to the left) from feces (falling down into a container to the right).
View from above.
A tube is connected in the bottom of the urine bowl and led to a container (and stored a few weeks before used as a fertiliser).

A urinal is easy to install

Portable urinal for women

Many fabricates of composting toilets

e.g. CompostEra

http://www.compostera.se/compostera.se/CompostEra.html

- Mullis, http://www.mullis.se/http___mullis.se_eng_home.html/Home.html

- Clivus multrum, http://www.clivusmultrum.com/

- Wostman has a porcelain chair. http://www.wostman.se/en/ecodry

A vacuumtoilet with a separate tank (fabricates: Wostman, Jets etc) gives a better possibility to recycle the nutrients in an environment-frienldy way than a WC (water closett) connected to the municipal sewage system.

Why using a dry toilet system?

Hinders spreading of infections from the toilet waste.

Drastically reducing the water consumption.

No smell. Hardly any work (emptying every 20th year if the container is big enough.)

Hinders eutrophication of surface waters (rivers, lakes, seas).

Produces fertilisers to a sustainable agriculture.

Does not damage our important provision – drinking water.

Drinking water is scarce

- Water covers 71 % of the Earth’s surface.
- 97 % of water on Earth is in the Oceans. Too salty to drink for humans.

- Only 3 % of water on Earth is fresh, of which 2.5 % is unavailable (locked up as ice, highly polluted, too deep under the surface etc. or vapor in the atmosphere. (A tiny fraction may be extracted from air humity)

- So only 0.5 % is available fresh water.

- How to use the freshwater wisely?
- Is it wise to use it as transport medium of faeces?

Drinking water consumers in Sweden

	Per capita (l/p/d)	Relative use (%)
• Households	198	57
• Industries	35	10
• General services	35	10
• Losses and own use	79	23
• Total	347	100

- Source: VAV, 1995 from Rydén et al. (ed.) 2003. Environmental Science, ch. 17.

Water use Consumption

Relative use	(l/p/d)	(%)
• **Food and drink**	**10**	**5**
• Toilet flushing	40	20
• Laundry	30	15
• Dish washing	40	20
• Personal hygiene	70	35
• Miscellananeous	10	5
• Total	200	100

Source: Rydén et al. (ed.) 2003. Environmental Science, ch. 17.

Urin separating toilet should be compulsory at new installations!

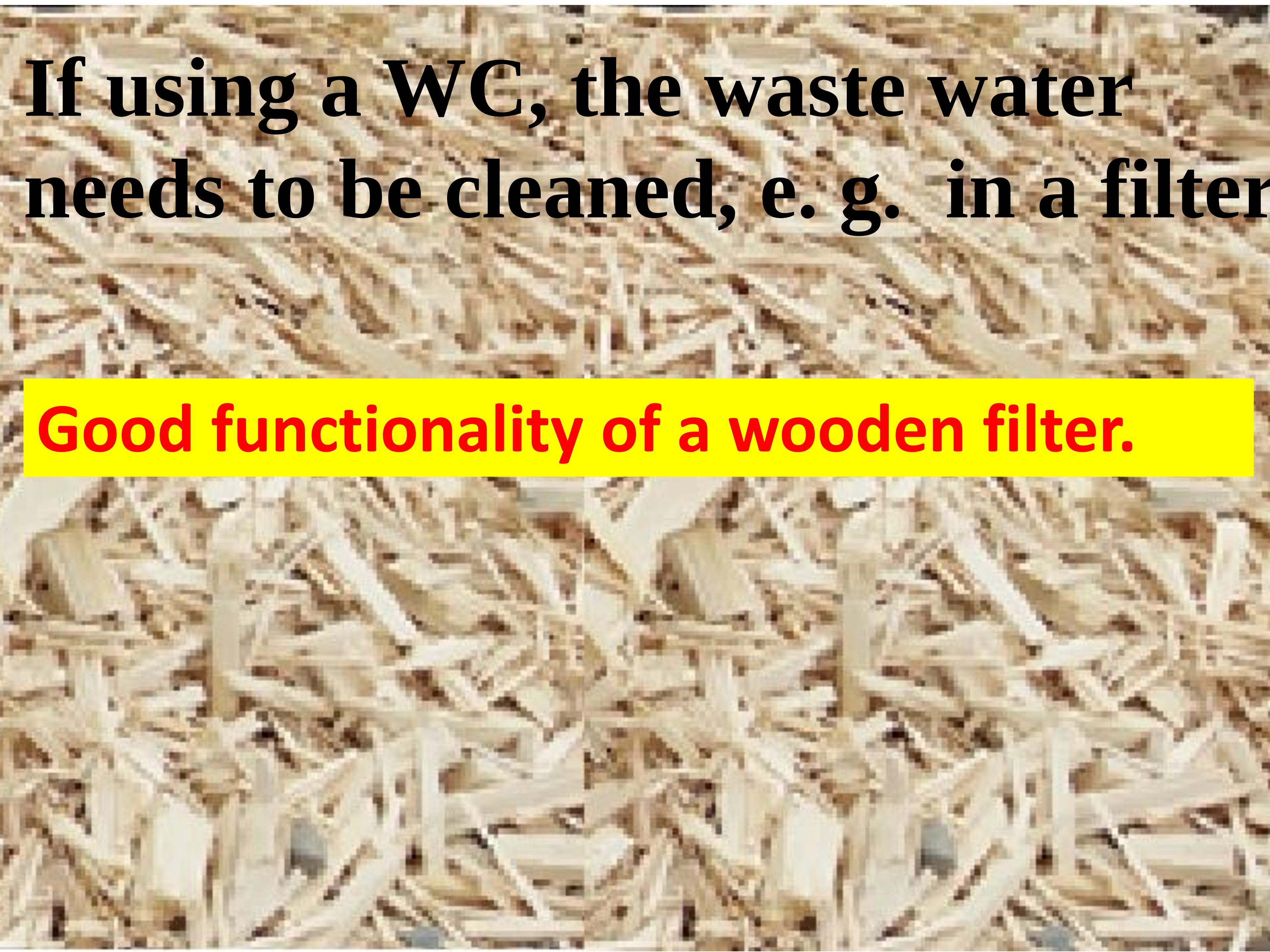
Separates
60% of P from the waste water,
80% of N and
90% of K.

Hylander, L. D. 2006. Släng inte fosforn i sjön! *Forskningsnytt om økologisk landbruk i Norden. Nr 3, 2006,* s. 4-6.

http://www.wost-man-ecology.se/assets/images/autogen/Dubbelspolande_System__WM_DS_NBanner.jpg

If using a WC, the waste water needs to be cleaned, e. g. in a filter

Good functionality of a wooden filter.



Easy to construct. 1. Dig a hole.

2. Put a bottom layer of chopped wood.

3. Build channels of logs and planks.

4. Cover the logs with a “roof”.

5. Fill with chopped wood.

6. Completed.

All can be built by wood to avoid concrete and plastic waste accumnulation.

Inspection well

Waste water at the bottom of the well before entering the filter.

Analytical results for waste water having passed a filter of chopped wood.

Date	**N_{tot}**	**P_{tot}**	**BOD_7**	**Esc. coli**
	(mg/L)	(mg/L)	(mg/L)	(cfu/100mL)
Incoming	>50	16.6		
March 2018	3.4	0.32	5.9	< 1
Limit value for Sweden	**< 15**	**< 1.3**	**< 10**	**< 1**

Can biochar and nutrient recycling of toilet waste benefit the Aral Sea region?

How to make your own biochar!

1. Fill a tin with firewood, organic waste etc. Punch a small hole in the part downwards as a gas exit.
Put the tin in a fire.

Foto: Lars Hylander

2. The fire after 15 min.

Foto: Lars Hylander

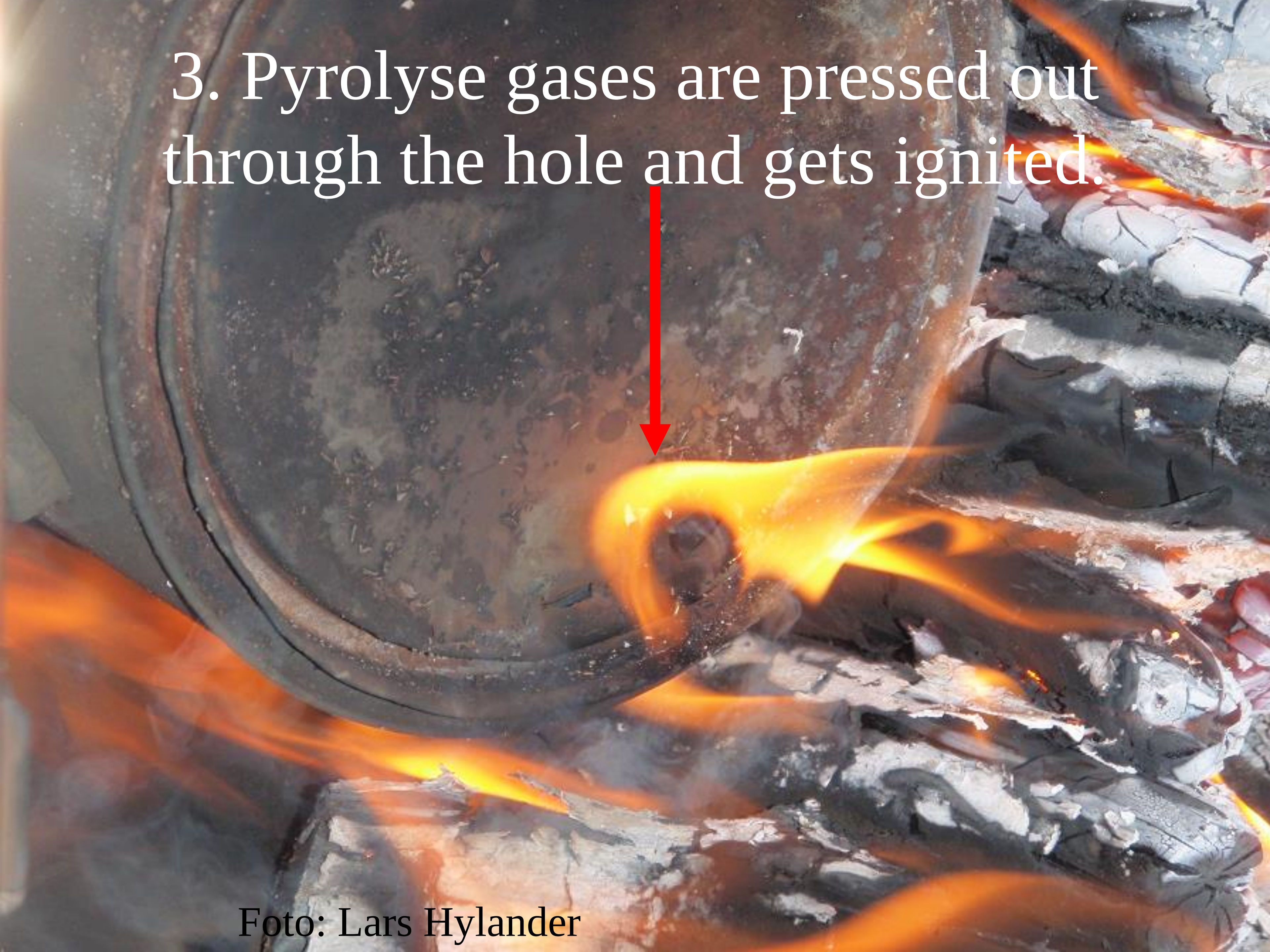


Foto: Lars Hylander

4. Allow to cool down and take out the char coal.

Spread on the fields or in the garden together with urine.

Foto: Aiko Nakano- Hylander

Irrigation

Irrigation techniques

* Ditch/furrows/**canals**

+ Low investment costs

- Inefficient use of water

* **Sprayers** of varying dimensions

+ High investment costs

- Inefficient use of water, especially when windy and sunny

* **Drip** irrigation

+ Low to medium investment costs

+ Efficient use of water

- More complex management

How to reduce water use at irrigation?

- reducing evaporation

Don’t irrigate when windy or sunny.

Use plastic films, mulching etc as evaporation barriers.

Create shadow and wind barriers, e.g. by trees.

Proper service and management of equipment.

Considerations!

- Necessary to apply more water than the plants need!
- This so that excess water can leach away salts from the soil to avoid a salt desert as in the Aral Sea basin.
- Using waste water for irrigation may be an option, but be observant to pollutants and too high salt content, burning green leaves.

Conclusions

- Nature can not be manipulated behind certain limits.
- Need to **prioritise sustainability**.
- Go for resource conserving technologies.
- Go for robust systems, minimising the need of rare/not available experts, expensive spares etc.

Questions

- **1. Could water flushed toilets be recommended** in the Aral Sea region?

State conditions needed of a toilet system to be sustainable.

Consider also chemicals at risk of entering in ecocycles and nutrient management.

- **2. Which alternative technical opportunities are there to generate more or less clean water in the Aral Sea region?**

Can reverse osmosis be used?

Or water harvesting from the air?

https://www.svt.se/nyheter/video/03c63d7722bfbf7c-uppsalaforskare-ska-losa-fragan-om-vattenbrist-sjalvforsorjande-stader?spellista=WyJhc3RyaWQtdmlkZW9wbGF5bGlzdCIsIjQ2YXhwbiJd