

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**

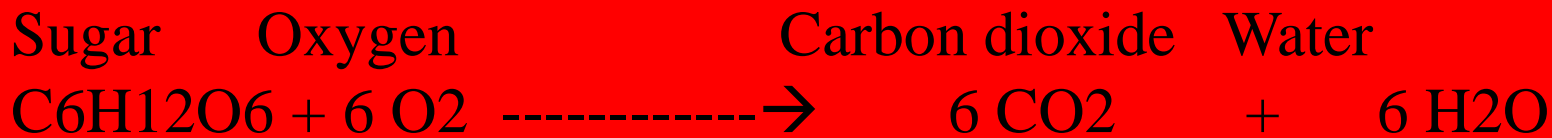
Humans

Human basics for living:

**Breathing, sugar and other energy sources,
water and nutrients,
space, sanitation...**



Energy transformation
e.g. for
muscle work



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 **sunshine** they **produce new energy storages** (sugar, starch etc) via fotosynthesis.

Fotosynthesis



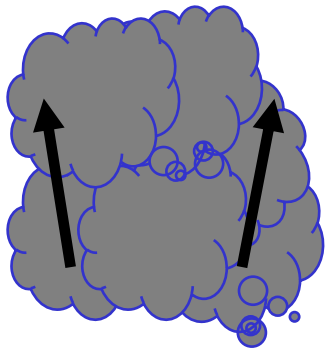
https://www.youtube.com/watch?v=C1_uez5WX1o

Basics for growing: NPK+H₂O



<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”?

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period 1	1 H																	2 He
Period 2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
Period 3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
Period 4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
Period 5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
Period 6	55 Cs	56 Ba	57 La	* 72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
Period 7	87 Fr	88 Ra	89 Ac	* 104 Rf	* 105 Db	* 106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
				* 58 Ce	* 59 Pr	* 60 Nd	* 61 Pm	* 62 Sm	* 63 Eu	* 64 Gd	* 65 Tb	* 66 Dy	* 67 Ho	* 68 Er	* 69 Tm	* 70 Yb	* 71 Lu	
				* 90 Th	* 91 Pa	* 92 U	* 93 Np	* 94 Pu	* 95 Am	* 96 Cm	* 97 Bk	* 98 Cf	* 99 Es	* 100 Fm	* 101 Md	* 102 No	* 103 Lr	

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

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

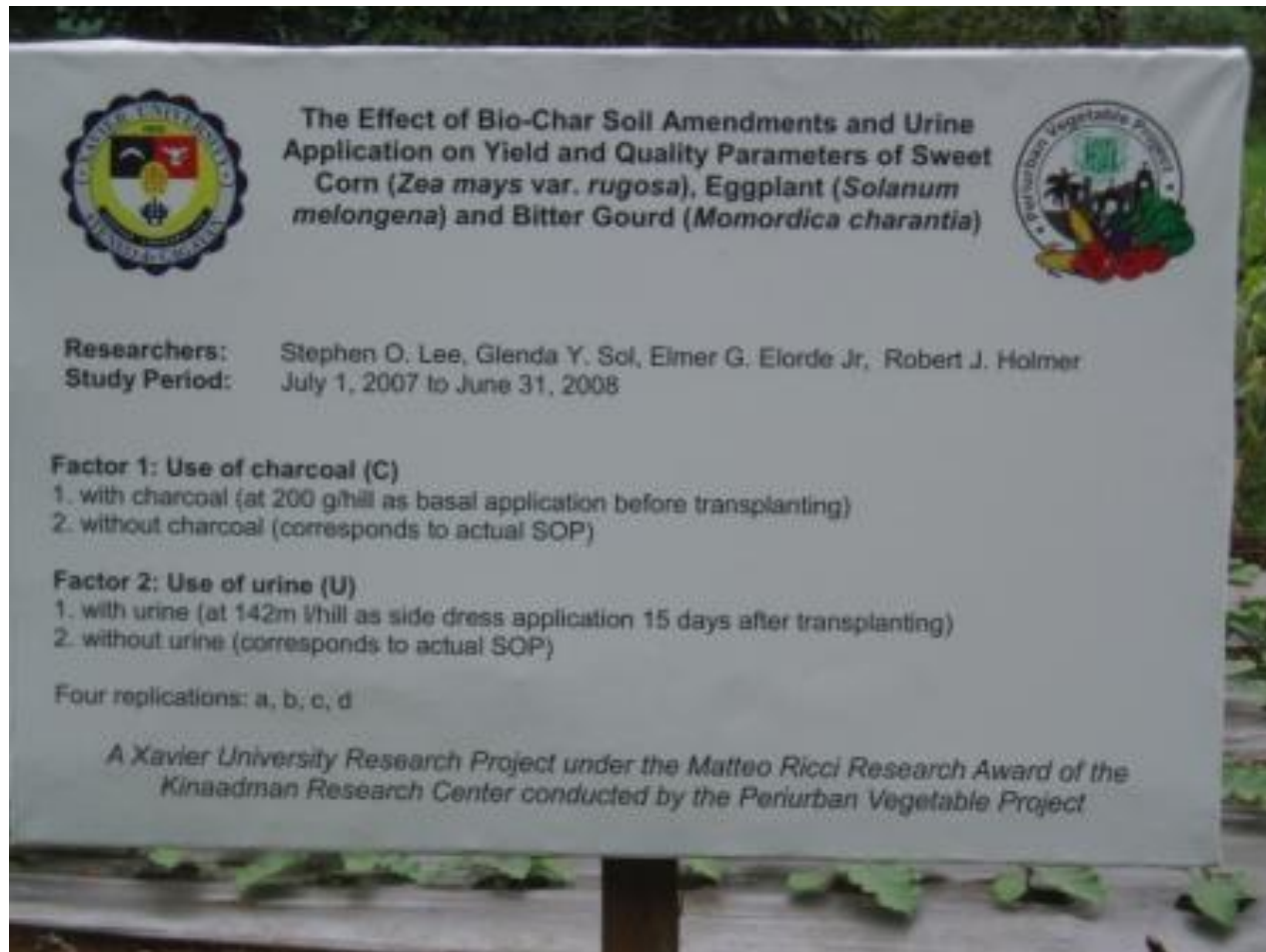
K: in liquids, electrolyte balance, function of membrane, muscle, nerve

N: Widely used in fertilisers, explosives 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.



The sign features two circular logos. The left logo is the seal of Xavier University, featuring a shield with a cross and a book, surrounded by the text 'XAVIER UNIVERSITY' and '1963'. The right logo is for the 'Penurban Vegetable Project', showing various vegetables like tomatoes, eggplants, and leafy greens, with the text 'A Penurban Vegetable Project' around the perimeter.

The Effect of Bio-Char Soil Amendments and Urine Application on Yield and Quality Parameters of Sweet Corn (*Zea mays* var. *rugosa*), Eggplant (*Solanum melongena*) and Bitter Gourd (*Momordica charantia*)

Researchers: Stephen O. Lee, Glenda Y. Sol, Elmer G. Elorde Jr, Robert J. Holmer
Study Period: July 1, 2007 to June 31, 2008

Factor 1: Use of charcoal (C)
1. with charcoal (at 200 g/hill as basal application before transplanting)
2. without charcoal (corresponds to actual SOP)

Factor 2: Use of urine (U)
1. with urine (at 142m l/hill as side dress application 15 days after transplanting)
2. without urine (corresponds to actual SOP)

Four replications: a, b, c, d

A Xavier University Research Project under the Matteo Ricci Research Award of the Kinaadman Research Center conducted by the Penurban Vegetable Project

Nutrient recycling without any poisons!
Gold water (urine) is gold worth for your plants.



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 persistent
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.

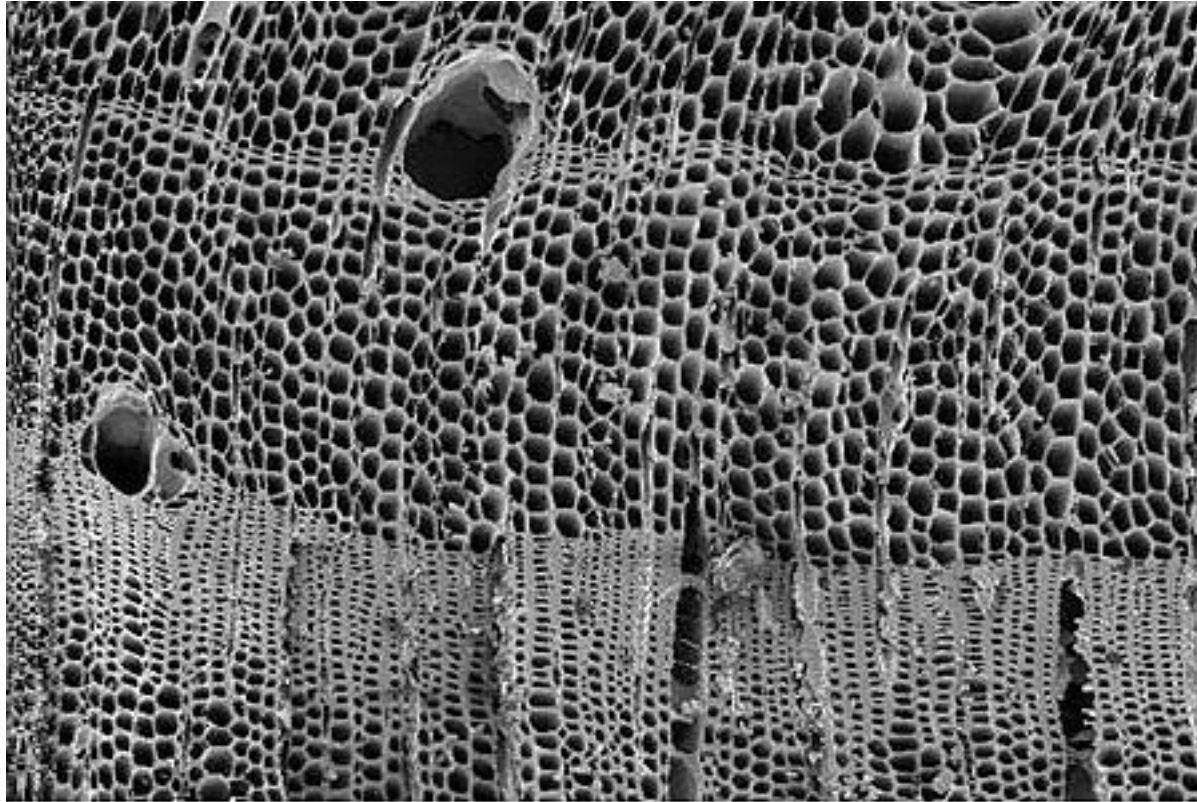


Figure 13. Scanning electron micrograph of pine (*Pinus* sp.) charcoal from Barton Creek Cave.

Similarities with a honey comb
thanks to the cell walls.



Biochar in a Swedish compost.



Effectively reducing emissions and losses of nitrogen.

The background of the image is a dense, textured surface of light-colored wood shavings or mulch. The shavings are irregular in shape and size, creating a complex, fibrous pattern. A bright yellow rectangular box is superimposed over the center of the image, containing the text "Sustainable sanitation" in a bold, red, sans-serif font.

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-friendly 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 humidity)
- 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
• Miscellaneous	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 fosfor 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](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}	BOD₇	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

3. Pyrolyse gases are pressed out through the hole and gets ignited.

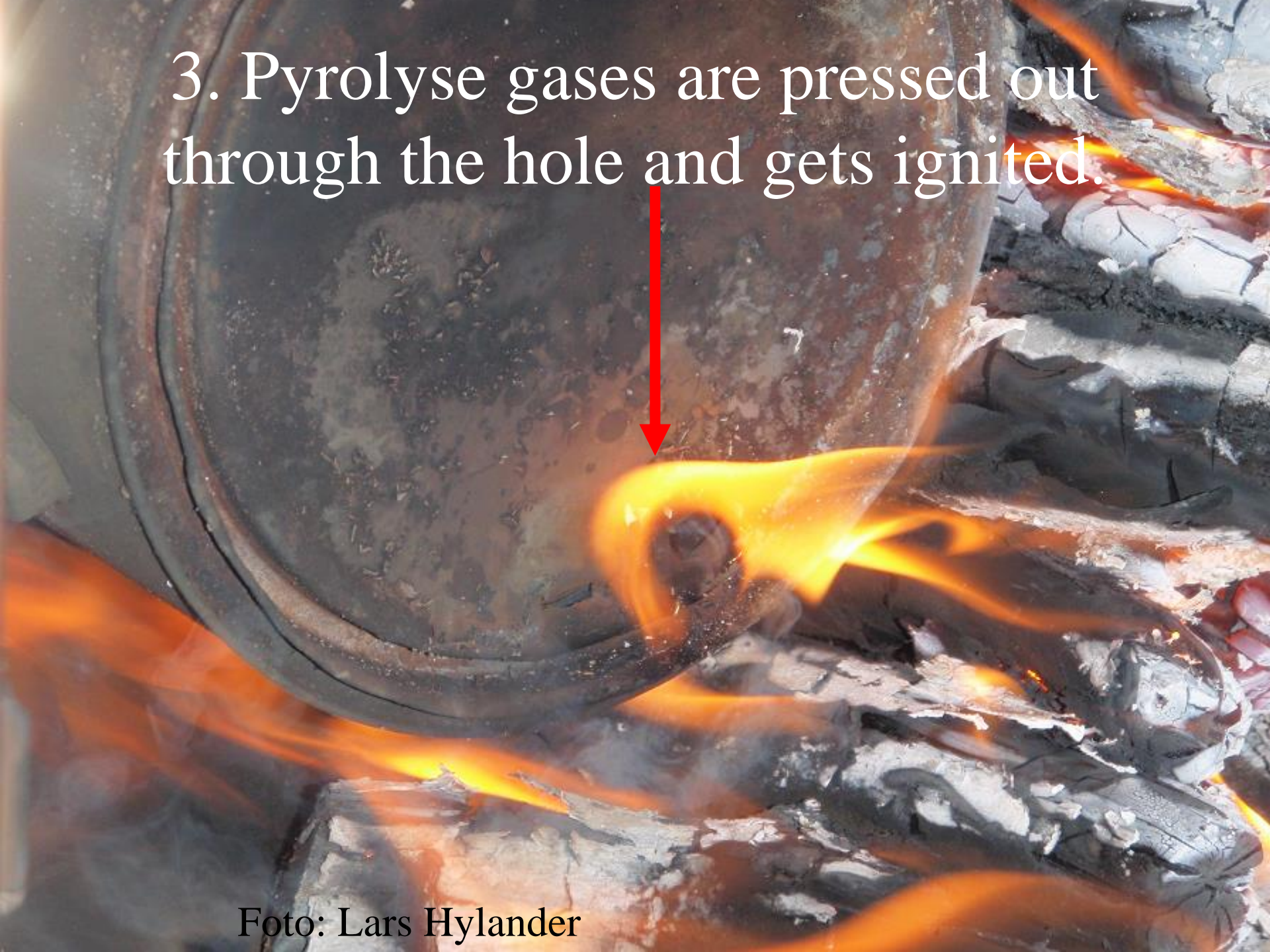


Foto: Lars Hylander



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=WyJhc3RyaWQtdmlkZW9wbGF5bGlzdClsljQ2YXhwbiJd>