Module 4.10
Ecosan versus conventional sanitation

How can dry UD ecosan system be compared with a conventional systems (open defecation, latrine pit, water-borne)?

This module will give a comparison of different sanitation systems using a systems analysis approach. For further understanding of environmental systems analysis the reader is recommended to look at chapter 4 module 9 where the description of the systems analysis and different factors for comparison are included.

After studying the module the student should be able to understand the effects on eutrophication, global warming, water resource use, non-renewable resource use, renewable resource use.

Acknowledgment; Professor Håkan Jönsson have supported this presentation with material regarding the systems analysis comparing different sanitation systems.

4 Swedish systems with nutrient recovery compared

1. **Reference**. Conventional system. N & P removal in WWTP. Effluent: 8 mg N & 0.24 mg P/l. Sludge incinerated, ash landfilled.
2. **Urine**. 80% of urine diverted & recycled as fertiliser. Rest = reference
3. **Blackwater**. Vacuum toilets. Collected blackwater anaerobically digested, sanitised & recycled as fertiliser. Rest = reference
4. **Sludge**. Sludge recycled as fertiliser. Rest = reference

To start with we look upon the comparison of four different systems that is fairly advanced.

The first system is a reference system to which all other systems are compared with. It is important to have a reference system to start the comparison with as the numbers given by an environmental systems analysis will not be exact numbers of the impact from the system but rather a evaluation of one system compared to another. The reason to this is that in all analysis some estimations and assumptions are needed to get the full comparison. Without this, there will never be possible to perform a full comparison, but it also lead to that the study is very specific regarding the numbers. However, the order between the systems in the evaluation is possible to use in other comparisons.

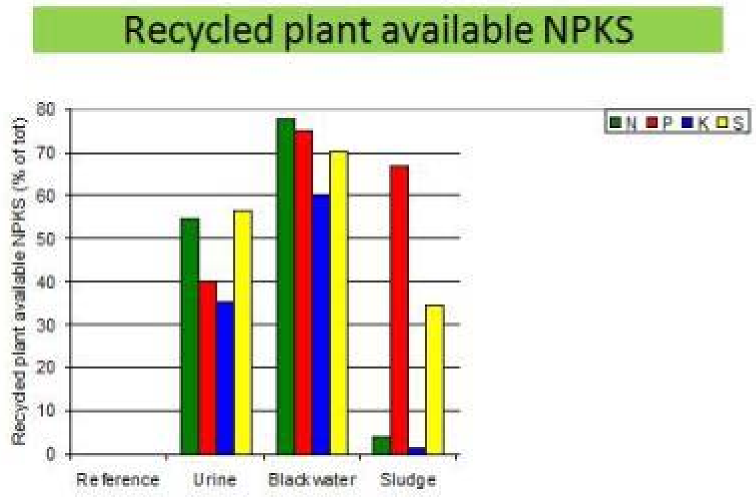
The reference system is a conventional system such as the one found in Sweden, an Active sludge system including nitrogen and phosphorus removal. The effluent is fairly low in N and P and the sludge is incinerated and the ash is land filled.

System number two is a similar system as the reference, the difference is that the urine is collected to a rate of 80%, and then recycled as fertiliser. The remaining system is the same as the conventional system.

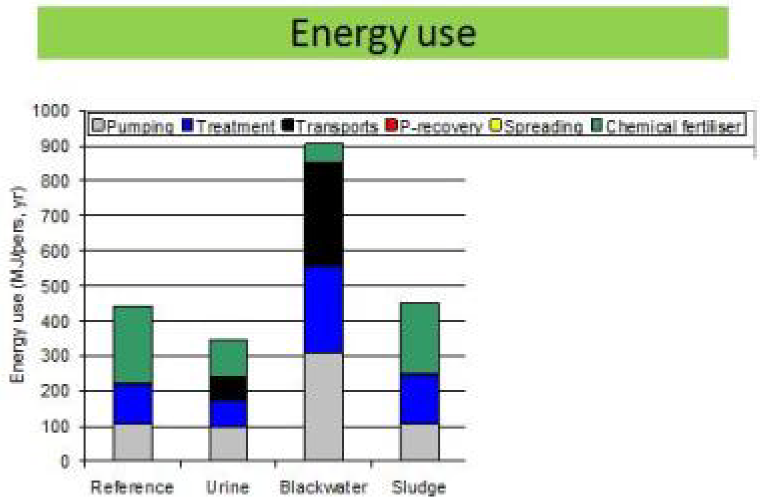
System number three is still using the wastewater treatment plant for the greywater while the toilet water (blackwater) is collected anaerobically digested, sanitised by heat 70’C for one hour and then recycled as fertiliser.

The fourth system is a mixed wastewater system treated as the reference with the difference that the sludge is collected and recycled as fertiliser.

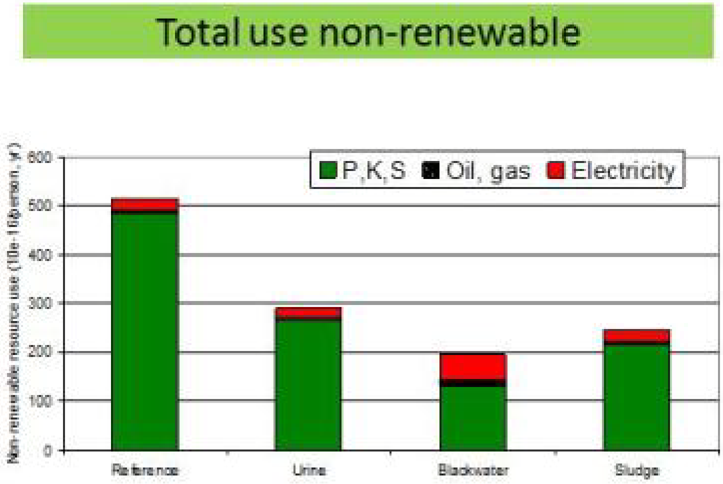
The compensatory systems here will be systems for producing, heat and electricity from the incineration and the anaerobic processes. System for producing compensation for the fertiliser production will also be included, i.e. mineral fertiliser to compensate for the fertilisers recycled in the sludge, the urine and the treated blackwater.



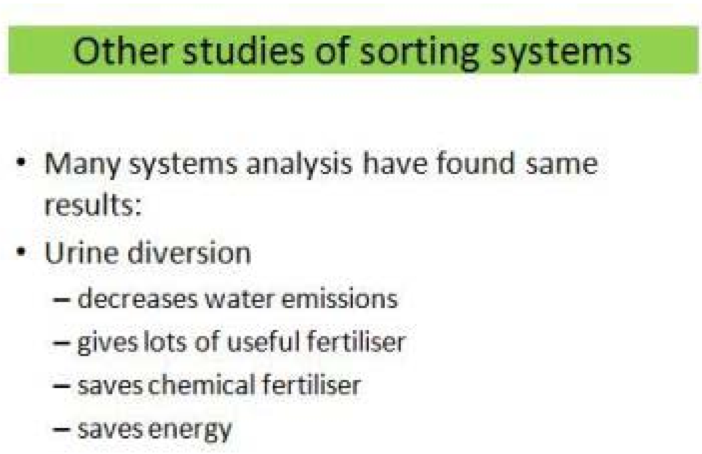
Looking at the plant nutrients recycled, the blackwater system is the one producing the most fertiliser, followed by the urine systems. This is presented as percentage of the total flow of nutrients from the household. The flow is based on assumptions and the flows will be affected by the habits of the people living there, e.g. the P in the greywater would increase if P based detergents are used in the household.



When we look at the energy case the table will turn as the blackwater system is the one that will be the major user. The large volumes of blackwater and the advanced treatment will lead to larger energy consumption due to the pumping and treatment and transport. For the non-sorting systems the major energy consumption will be for producing compensatory fertilisers that are recycled with the other systems. The compensatory consumption of mineral fertiliser in the urine and blackwater system is from higher recycling of phosphorus in the system that recycle sewage sludge, the systems of urine and faeces sorting are the sewage sludge incinerated and no nutrients recycled.



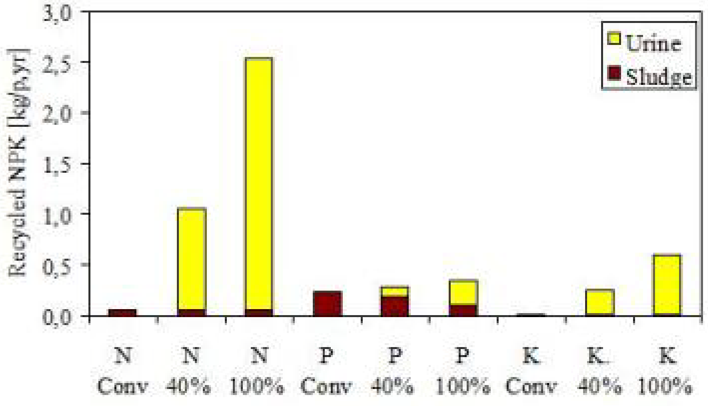
When we add these two parts together and compare it as total non-renewable resources the major resource consumption is from mineral fertilisers while the oil and gas and electricity is considerably less, even in the blackwater system that consumed the largest amount of energy.



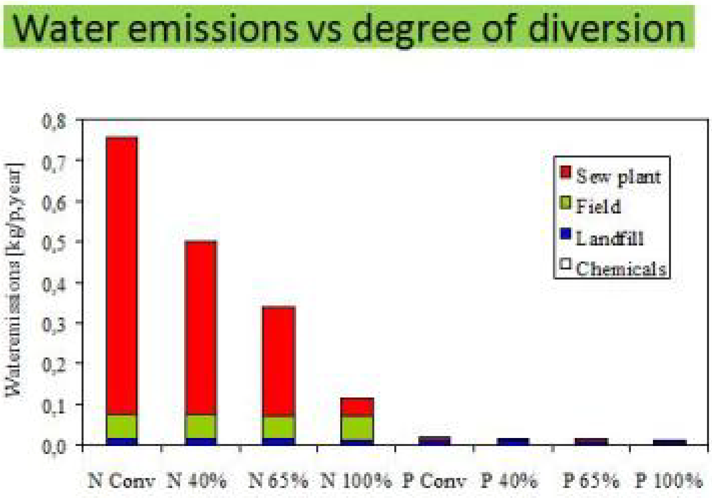
There has been a large number of systems analysis, both in Sweden and international, that have looked upon the environmental effects when comparing conventional wastewater and sorting wastewater systems, all these have shown similar results that the sorting system have major environmental and resource consumption gains compared to the conventional system.

The urine diversion system mainly gain in the fact that the water emissions of nutrients decreases, especially if the wastewater is not treated at all. There is produced a large amount of fertiliser in the sorting system, that compared with increased energy consumption in the sorting system is a larger consumer of resources.

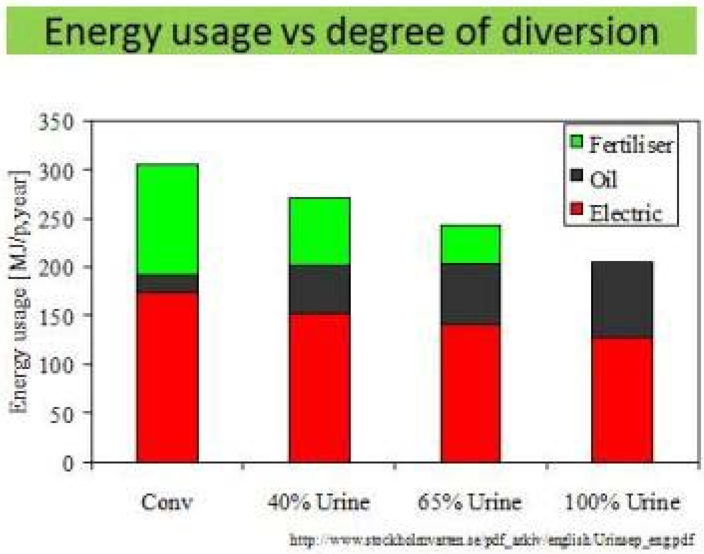
Recycled NPK vs degree of diversion



When comparing the proportion of NPK that is recycled in comparison with degree of diversion of urine. When 100% is source separated recycled plant available N increases to 42 times conventional P to 1.5 times conventional K to 35 times conventional. So the recycling effects is very large when including sorting systems. The major effects is in the nitrogen and the potassium as the wastewater treatment plant do not sort these into the sludge at all. Additionally there are several trace elements that are included in the recycling and improving the quality of the soil that is not included in this comparison.

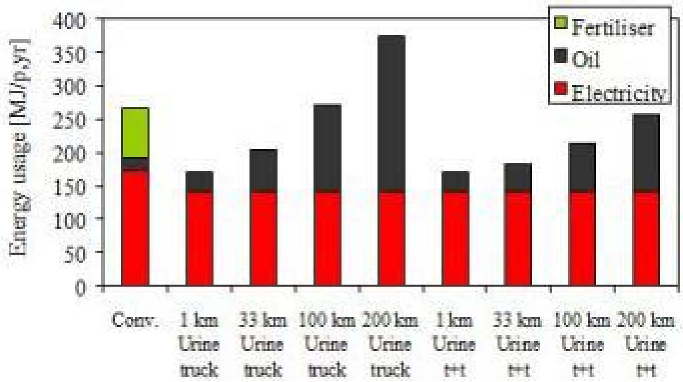


When 65% of the urine is sorted the total N-emissions decreases 55%, sewage plant emissions decreases 60% and Total P-emissions decreases 25%. The effect of nitrogen and phosphorus are different considering that the sludge is recycled. For nitrogen the main effect is that the sorted urine carries the nitrogen so less enters the wastewater and follows the treated wastewater as emission. For the phosphorus the main difference is that the decrease is mainly based upon less water into the treatment plant and as the treatment is a percentage removal there will be less P emitted to the environment



Comparing the energy usage, the sorting system will decrease energy for wastewater treatment and pumping as well as for production of mineral fertilizer while the transportation, oil consumption, will increase. Here it is important to have in mind that the environmental effect on local level will increase, with increased sorting, due to larger number of local transports but the global effects will decrease.

Energy usage vs transport distance



One of the major issues discussed with sorting system is that they will increase the cost, and energy consumption, for local transports. When adding the electricity, oil and fertilizer consumption. The conventional system consume fertilizer compared to the sorting system and there is less electricity consumption in the sorting system. When adding these factors it is possible to transport and spread the urine 100km when using a truck and over 200 km using truck and trailer, without consuming larger quantities of energy compared to the conventional system.

When doing the comparison of two different systems it is important to decide what should be included in the comparison.

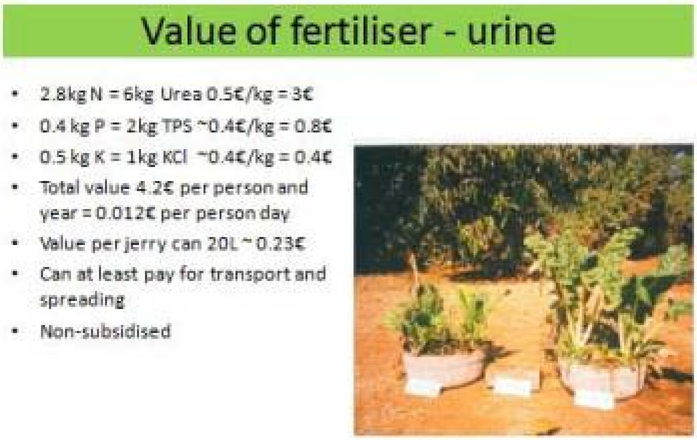
For the example of dry urine diversion toilet. Should the management of solid organic waste be included? In the case of co-composting of faeces and solid organic waste it should be included but if the material is not co-composted there is no need of including the solid organic waste in the comparison.

Energy production, should be included if any of the systems compared is generating energy, the best example hear would be if the faeces and organic waste is anaerobically digested. The compensation for the energy gain of the biogas needs to be included. If the material is composted, there will as well be energy production in the form of heat, but as long as the heat is not recovered in the system there will be no need to include the heat in the comparison.

Fertiliser production need to be included when the excreta nutrients are recycled, either should the same amount of nutrients be included or the same amount food produced. The later comparison factor is mainly based upon that the systems compared cannot include mineral fertilizers, e.g. mineral nutrients are not available/affordable or not a alternative to consider.

The final comparison factor is the delivered sanitation function, here will other factors such as greywater treatment, drinkingwater production and management of other waste.

The productive sanitation is based on that the nutririents coming out from the households. The concentrations of nutrients differs between regions and in the western high income world the food consumption is higher and thereby also the excreta based fertilizer production. The example here is based on the data for excretion in India that can be considered to be mid income country and for low income countries the food consumption and the fertilizer production is less.



When we look at the fertilizer production for one person based on excreta and compare this to the price of the same amount of mineral fertilizer. The price will differ over the year and between years due to differences in production, consumption and price of the substances that is used for production, e.g. the price of fossil gas have a direct effect of the price of urea.

The total value for the fertilizer from one person collected during one year corresponds to just over €4. And if this is distributed into what the fertilizer price of the urine collected in one 20L jerry can will it correspond to 0,23€. Even if the farmer is not interested in paying with money for the product it can at least pay for the transport of the material from the toilet to the field.

Important to have in mind here is that this calculation is based upon a non-subsidised fertilizer. Many countries are though subsidizing the fertilizer making it hard to compare the prices of organic and mineral fertilizers as the organic fertilizer will not carry the same subsidies.

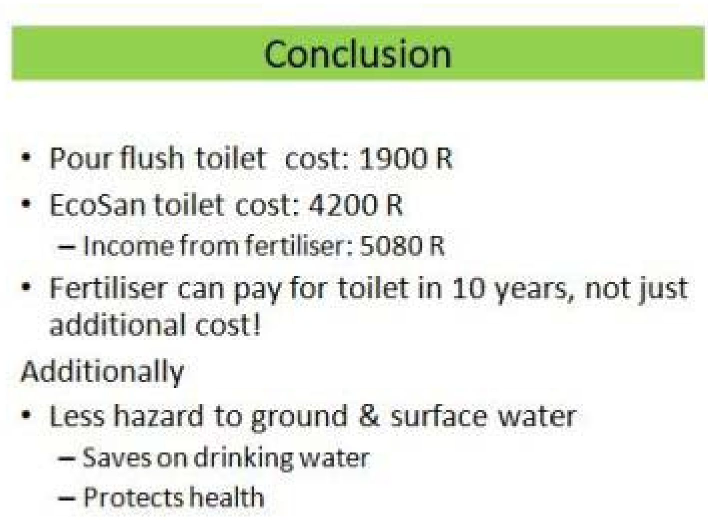
To compare the price of producing Ecosan, we use an example first presented by Professor Dunkan Mara. The price of the Ecosan toilet is almost the double compared to the conventional system.

Fertiliser per family

	Nutrients	Fertiliser	Amount, kg	Difference
	4 persons	NPK 10-5-20	160	kg
N	18,2	10,0%	16,0	2,2
P	2,32	2,2%	3,6	-1,2

- NPK 10-5-20 Indian, price 5.5 INR/kg (0.1€)
- Value 880 INR/year (16€)
- Present value years 2-10: 5070 INR! (93€)

The organic fertilizer is compared to similar concentration mineral fertilizer and the price of that fertilizer.



When comparing the produce fertilizer from one family and the non—subsidised fertilizer it shows that during a life span of ten years, the value of the fertilizer is higher compared to the cost of production.

In addition to the gain in decreased cost the toilet system will decrease the use of water for flushing the toilet, and lead to less pollution of the water recipients and thereby increased health.

To conclude this example, the cheapest solution is always not to have a toilet at all, just using the bush/curb/field-toilet.

It is only toilet system that sort the excreta from the total wastewater volume that result in a pay off from the investment.

The cost is in most cases covered by the single household. This leads to decreased risk for corruption and the cost acceptance is higher.

This will also give more private enterprices leading to more competition and thereby decreasing the prices and thereby both increasing the local employment and decreasing the cost for taxes.