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Dry Toilets Can Offer a Sustainable Wastewater Treatment System in Rural Areas

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Kautiala is rural area in Kangasala municipality, where homeowners need to meet the requirements of the new Finnish decree concerning wastewater treatment outside sewer network. The new decree stipulates minimum requirements for wastewater treatment as well as for designing, construction, operation, maintenance and data monitoring of onsite wastewater treatment. The technical and ecomonic feasibility of four different systems was evaluated: (1) Upgrading failing septic systems by constructing sand filters with a phosphorus adsorption material. 2) Connecting to the Kautiala cooperative sewer network (3) Using biochemical package plants which require constant power supply. (4) Using dry toilets (DT) and treating greywater separately. In terms of economic feasibility the best option is dry toilet with separate grey water treatment. The acquisition costs are maximum of 2000 euros. The operation and maintenance (O&M) costs of these systems is also the lowest, only 200-300 euros/year. Most expensive alternative is to connect to the sewer system, which would cost 10 000-12 000 euros depending on the distance to the network. The O&M costs of centralized sewer system are about 500 euros/year. In long-term use (15 years time-frame) the biochemical package plants are the most expensive, since their annual O&M costs are quite high, about 800 euros. DTs need careful planning to suit household conditions and commitment in the maintenance. They suit best in environmentally sensitive areas and islands. Large-scale use of DTs necessitates storage, transportation and disposal of excess compost. From the environment point of view, dry toilets are the safest way of managing excreta. However the legal use of dry toilet compost and source separated urine is not yet solved in Finland, thus significant political and technical decisions need to be made before that is possible.

Keywords: *Onsite wastewater treatment, effluent, sand filters, greywater, sludge, activated sludge, dry toilets*

Introduction

Kautiala is a rural area located about 15 Km Northeast of Kangasala municipality found in the Pirkanmaa region in Southwestern Finland (Figure 1). Kautiala is the area where the cooperative main sewer trunk begins. The study geographical area in this report is generally referred to as Kautiala but also includes all the areas along the cooperative sewer trunk. The study focuses on unconnected properties particularly on the Eastern side of the cooperative sewer network. There are in total about 185 unconnected properties: 144 summer dwellings and 41 permanent houses. These properties currently use onsite wastewater treatment systems and water supply facilities. About 68% of the unconnected properties are summer dwellings located on the environmentally sensitive shores of lake Vesijärvi in the West of Kautiala

where the obligation to meet the requirements of the new wastewater legislation is urgent. The properties are typical Finnish rural residential houses characterized by 3-5 persons households.

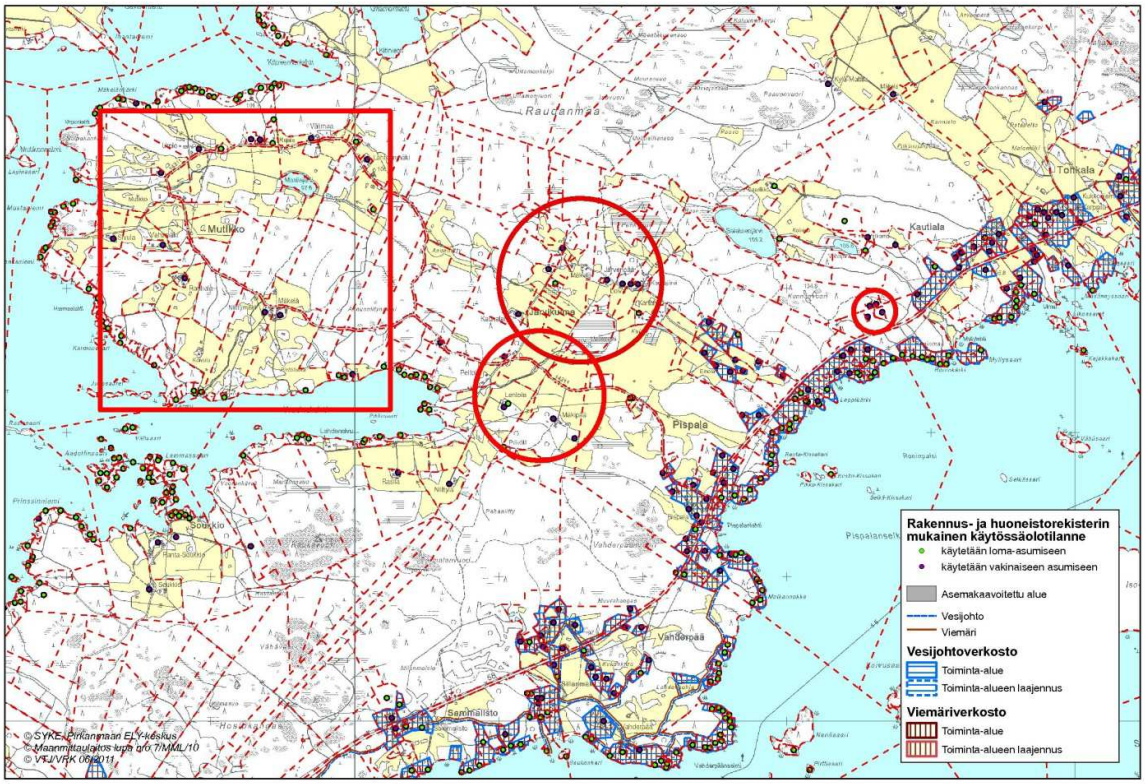

Figure 1. Map of Kautiala showing sewer operational and non-operational areas. (SYKE, Pirkanmaan ELY-Keskus)

Background and aim of the study

Unconnected homeowners in Kautiala have a common challenge to sustainably meet the requirements of the new onsite wastewater treatment decree (Finnish Government Decree 2011). The available alternatives have different benefits, opportunities and limitations that require critical analysis. The centralized sewer system is socially considered as the most conventional solution but is unreasonably expensive due to long distances or physical barriers. It is also impossible to extend it in some environmentally sensitive locations where it poses a high risk of pollution. Where it is technically feasible to extend, some households already have systems that meet the new requirements or require relatively cheaper renovations and connecting to the sewer is unnecessary.

The connection fees grow annually making it cheaper to connect now but the high connection costs require a substantially large connecting party that has limitations to form. This situation makes onsite solutions less complicated to implement but with caution because of their interim nature for some locations and therefore require minimal capital expenditure. The anticipated eventual arrival of the sewer to the currently unconnected areas and the possibility of load treatment requirements being raised in the future make onsite systems to be

considered as interim solutions. In locations where onsite systems are most suitable and feasible, implementation is limited by liabilities associated with sludge management, separate greywater treatment and clean water supply. Currently the trend is towards designing and building the expensive sewer systems to rural areas. Another major trend is to invest on expensive onsite wastewater treatment plants, which do not necessarily fulfill the requirements in wastewater treatment (Rakennusmaailma 2009, 2011). Dry toilets and other decentralized alternatives are not main stream in the current discussion concerning onsite wastewater treatment and it seems that there is not enough information and research about the feasibility of the different alternatives. This study aims at comparing and evaluating the feasibility of three onsite wastewater treatment systems as alternatives to the cooperative sewer in the area.

Methods

This study was carried out to investigate four alternative wastewater treatment systems that can enable unconnected properties in Kautiala area to meet the requirements of the new wastewater legislation. The alternatives were chosen due to their implementation feasibility and availability given the location and local conditions of Kautiala. They include:

1) The first alternative is upgrading the current wastewater treatment systems. Unconnected homeowners already have some sort of wastewater filtration facility that may need minor or major renovations to meet the requirements of the new legislation.
2) The second alternative is connecting to the already existing and operational Kautiala cooperative sewer network. This network has both the capacity and plans to expand provided that there are a substantial number of interested homeowners.
3) The third alternative is using biochemical package plants. Package plants support flushing toilets and other modern home water facilities.
4) The forth alternative is changing from flushing toilets to DTs and treating large amounts of GW separately. DTs particularly offer a reliable and sustainable non-flushing system in areas where flushing toilets are forbidden, in locations with low accessibility and in households with temporary occupancy or not connected to the national electricity grid.

The study investigates the implementation practicalities of each alternative in terms of system acquisition, operation and maintenance costs and the legal and site requirements. It assesses the potential of each system in terms of load treatment and water conservation. It further looks at the tied responsibilities related to separate GW treatment and clean water supply. Different approaches to acquiring and maintaining the systems are described and their limitations discussed. Finally the study compares the four alternatives and their associated investment costs looking at the 15 years service life.

Results

Qualitative and quantitative comparison of the four options

In Table 1. the qualitative comparison of the four alternatives is presented.

Table 1. Qualitative comparison of important aspects of the four wastewater treatment options assuming the extreme case scenario of each option

Factors	**Dry toilets**	**Sand filters**	**Sewer network**	**Bio-chemical plants**
Limited compliance to new legislation (load treatment)	Limited capacity	Limited capacity	Relatively Unlimited capacity	Limited capacity
Social acceptability	Misconceptions Environmental consciousness is the major driving force	Relatively acceptable	Highly convenient & acceptable	Relatively acceptable
Availability of the system	Local, national & foreign markets	Locally and nationally	Monopolized by the co-operative	Locally & nationally
Land requirements	Low	Very high	Low	Relatively high
Labor requirements (Installation)	Few hours or days Skilled & semi-skilled	Can take days More skilled labor	Only skilled labor	Only skilled labor
Water requirements (as transport medium)	Very low	Low	High	Low
Energy requirements (in the property)	Very low	Very low	Very low	Very high
Range of services provided by the system	Treats only black water	Treats all wastewater (BW + GW)	Treats all wastewater Supplies clean water	Treats all wastewater
Material reusability (at the property)	Recovered and utilized onsite	Recovered offsite Expensive to treat onsite	Recovered offsite	Recovered and utilized onsite (some models)

It is important that homeowners are aware of all the costs associated with each of the four options. Onsite systems in particular have tied financial costs associated with the sludge management, separate greywater treatment and clean water supply. The investment and O&M costs of the different alternatives are presented in Table 2. In Figure 2 the maximum investment and O&M costs are presented.

Table 2. Initial investment and the annual O&M costs of the four alternative solutions.

Cost type	1. Sand filters with improved P-adsorption	2. Cooperative sewer network	3. Dry toilets	Biochemical package plants
Initial Capital	7000€	12,000€	200-2000€	6200- 8300€
O& M costs	260€	480€	240€	800€

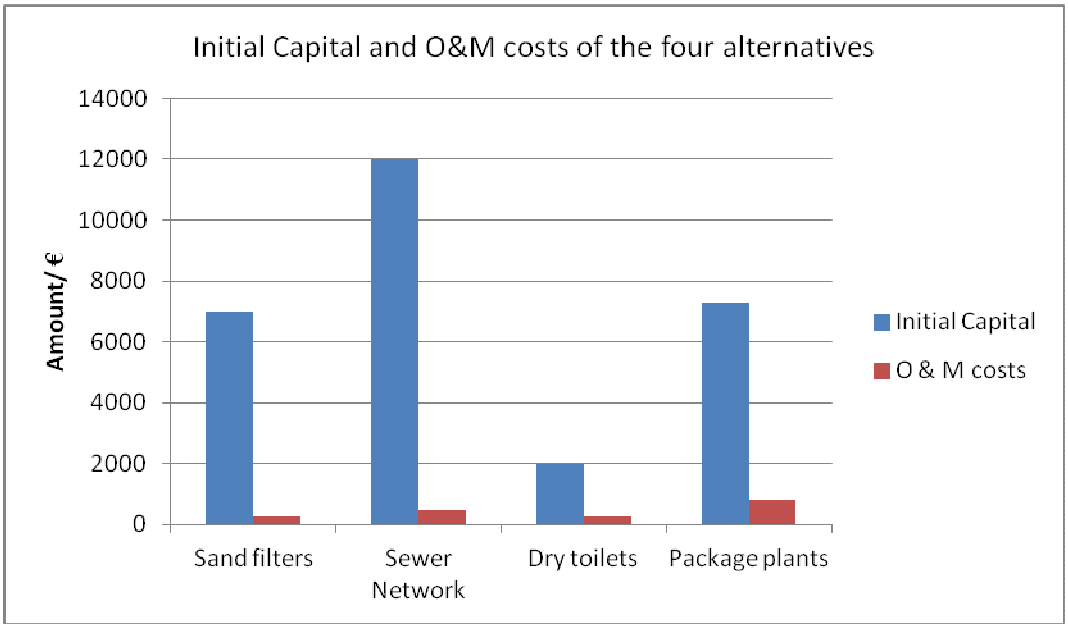

Figure 2. Initial capital and O& M costs for the four alternatives (at highest)

The O&M costs for 15 years are calculated using a simple method basing on the current average price and assuming a constant average inflation rate in Finland of 4%. The 15 years O&M costs are shown Table 3.

Table3. Average total O&M costs for 15 years

System	**O&M costs**
1) Sand filter	5 200€
2) Sewer Network	9 600€
3) Dry toilets	4 800€
4) Package plants	16 000€

Comparison of load treatment efficiencies of the onsite options

Onsite systems have limited load treatment efficiencies because their efficiencies depend on the design capacity, installation, operation and maintenance activities. All the three options are very efficient in BOD removal. DTs have the highest N and P removal efficiencies. Biochemical package plants have the lowest N removal efficiency. Sand filters have the

lowest P removal efficiency. If the current load treatment requirements are in the future raised by 10% for each load component, only DTs will be able to satisfy the new requirements without any system modifications. The load treatment efficiencies of the onsite systems are presented in Figure 3. The results mean that also from environmental point of view dry toilets would be the most viable option.

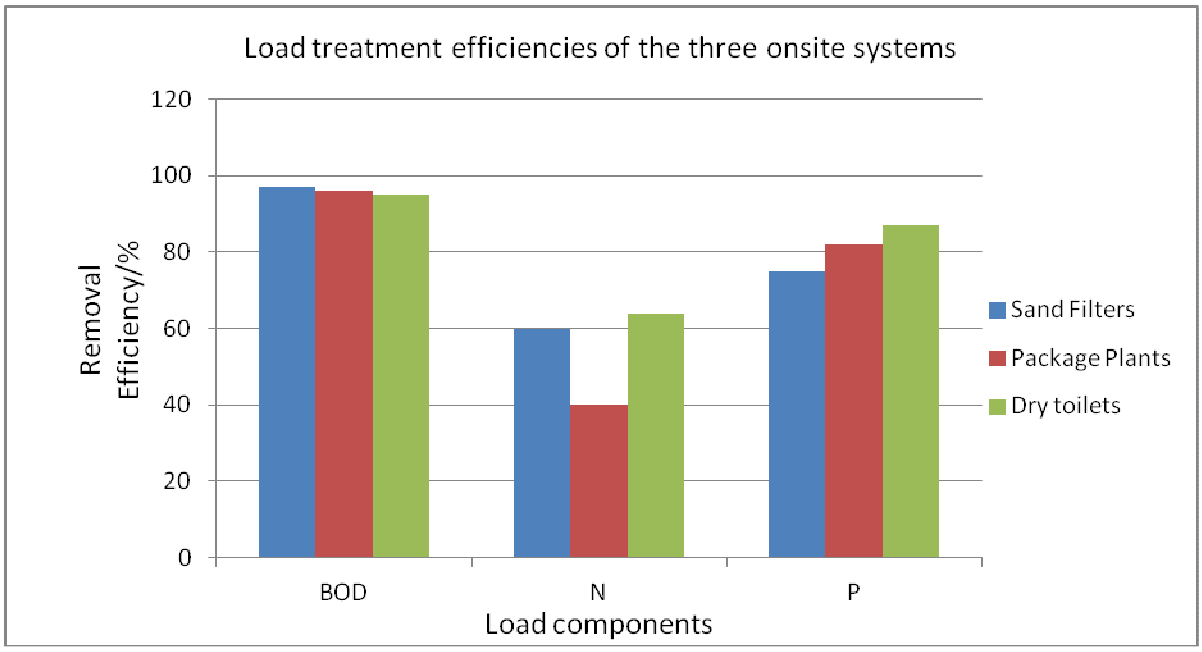

Figure3. Graph showing load treatment efficiencies of the three onsite systems.

Discussion

Although existing properties are given transitional period until 2016 to meet the requirements of the decree, it is important that homeowners start acting now. Considering factors such as inflation and the uncertain future of the Euro, acting in the future might be at much higher cost. The future of the current municipal and state subsidies and reimbursement programs is also uncertain.

Investing in onsite systems requires minimal capital expenditure. This is particularly to the inland properties. Consideration of the inevitable eventual arrival of the cooperative sewer to the currently non-operational areas is necessary. Any large investments in new expensive systems or renovations might be wasted as people might in the future be legally obligated to connect to the cooperative network and compelled to abandon their onsite systems. Unconnected properties located in close proximity to the sewer network even though the investment cost is high. Any future expansion programs of the network will most likely start in these areas as they are closest to the current operational areas. Connection in the future will be at a much higher cost than now.

Consultation and sensitization efforts to mobilize homeowners for a joint wastewater treatment facility should primarily focus on the cooperative sewer system. Communal biochemical package plants are cost effective but the sewer offers a less effort and energy demanding long term solution. Since the O&M costs of biochemical package plants are high, one household should not spent on those alone.

Kangasala municipality should do more to encourage homeowners to collectively connect to the cooperative sewer network for instance by being an active middle party between the unconnected properties and the Kautiala cooperative. This should involve identifying the interested homeowners and finding ways to address the constraints of the uninterested ones. It should further explore ways to promote DTs in areas where they are most suitable. Building a demonstration DT in the municipality office premises and other public places may help to sensitize people and reduce the negative attitude towards DTs.

Homeowners with functional septic systems should consider the option of upgrading their systems before exploring others. The systems may not need significant expansion or modifications because the new load treatment requirements are lower. This course of action should also be taken by homeowners with relatively new septic systems (less than 10 years old). This might be the most affordable immediate measure. It is more sustainable and economically viable, however, for permanent properties in environmentally sensitive areas and the summer dwellings on lake shores currently using septic systems to change from flushing toilets to DTs with the greywater and urine diverted to the functional septic systems. The load to the septic systems will be considerably reduced thereby extending their service life and avoiding expensive renovations. Maintenance costs will also be reduced due to the low rate of sludge accumulation.

Changing to DTs is the most economical and sustainable immediate option for property owners on the Eastern shores of Lake Vesijärvi and its islands. In the densely populated islands and other densely populated gulfs, a combination of DTs and greywater purifier systems is the best solution. The properties in these areas are predominantly summer dwellings and neighborhood wells can be the most efficient and affordable approach to obtaining clean water supply.

Policy makers need to acknowledge the full potential of composting DTs in wastewater treatment in sparsely populated areas. DTs could be one of the fastest growing onsite wastewater treatment technologies particularly in Scandinavia and there is need for clear guidelines on the usage of compost and separated urine. The current Finnish legislations are underestimating the potential of DTs in removing wastewater nutrients and conserving water. They further underestimate the potential of compost to supplement or replace inorganic fertilizers which have been attributed to the high levels of water and land pollution in rural areas. Policy makers have to work with DT manufacturers, local governments and users to streamline the issue of utilizing compost and look for ways to develop markets for compost.

Conclusions

It is possible for Kautiala residents to achieve sustainable sanitation with minimal impact on the environment and financial expenditure. The less stringent load treatment requirements of new legislation are an opportunity to homeowners if they can make informed decisions. It is the responsibility of homeowners to search for information on the available systems and exploit all the opportunities of sewer financing and system improvement reimbursement programs. Upgrading the current wastewater treatment systems is appropriate only if the upgraded system can affordably meet even more stringent load treatment requirements. Growing urbanization in Kautiala with eventually compel all properties to connect to the cooperative sewer network therefore active consultation of unconnected homeowners to connect to the sewer is urgent. Biochemical package plants are the least appropriate solution

given the large percentage of summer cottages in the area and difficult accessibility of island and isolated properties for regular maintenance. DTs are the most feasible alternative to sewer systems in areas where sewers cannot be extended. The question of negative attitude towards DTs can be solved by a sensitization campaign by the local government and other stakeholders. It is possible to implement DTs on a large scale if a procedure can be formulated to include compost in the waste collection program of the municipality and local waste collection companies. Further studies are necessary on sustainable collection and utilization of urine and compost.

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