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Harri Mattila

Appropriate Management of On-Site Sanitation

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Appropriate Management of On-Site Sanitation

Thesis for the degree of Doctor of Technology to be presented with due permission for public examination and criticism in Festia Building, Auditorium Pieni Sali 1, at Tampere University of Technology, on the 10th of June 2005, at 12 noon.

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Supervisor and Custos: Adjunct Professor, Dr. Tapio S. Katko
Institute of Environmental Engineering and Biotechnology
Tampere University of Technology
Tampere, Finland

Preliminary assessors: Professor, Dr. Pertti Seuna
Tuusula, Finland

Professor, Dr.-Ing. Ralph Otterpohl
Institute of Municipal and Industrial Wastewater Management
Technical University Hamburg-Harburg
Hamburg, Germany

Opponents: Professor, Dr. Pertti Seuna
Tuusula, Finland

Adjunct Professor, Dr. Jan-Olof Drangert
Department of Water and Environmental Studies
Linköping University
Linköping, Sweden

As Mahatma Gandhi once said:

"Sanitation is more important than independence."

PREFACE AND ACKNOWLEDGEMENTS

This dissertation was prepared and defended at Tampere University of Technology (TUT), Institute of Environmental Engineering and Biotechnology (IEEB), Finland. I collected most of the major part of the empirical research and case study material while working in the Lake Pyhäjärvi Protection Project in 1995-2000 and while supervising the B.Sc. theses of some would-be environmental engineers at Häme Polytechnic in 2000-2004. My warm thanks go to all the co-operative people working with, or living around the Lake Pyhäjärvi area and to all my students who have studied on-site sanitation in Häme Polytechnic.

The topic of this dissertation was derived from discussions within the CADWES research group at TUT/IEEB, which is doing its best to solve the most complicated water and sanitation matters in the world. I thank the entire group. Our inspiring meetings pushed me onwards and gave me new ideas for solving problems related to this research. I am especially grateful to my supervisor, Dr. Tapio Katko for his continuous and tireless interest in my research and Dr. Jarmo Hukka for his valuable advices.

I wish to express my warmest thanks to the following persons who greatly contributed to the completion of the research:

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* The opponents, Dr. Jan-Olof Drangert and Professor Pertti Seuna
* The pre-examiners, Professor Ralph Otterpohl and Professor Pertti Seuna
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I am also indebted to my family Heli, Heini, Hannes and Hasse. They have been long suffering with the busy and sometimes tired and strained husband and father. They have also left the “toilet researcher” in peace when necessary. Hopefully, I can spend more time with them in future. Also my mother in law, Aila deserves my gratitude for helping the family during these busy years.

Last but not least, I would like to thank my parents to whom I also dedicate my dissertation. It is always relaxing and encouraging to visit home and to see their positive attitude towards life.

To my parents,

Tampere, 10th of June 2005,

Harri Mattila

Mattila, H. 2005. Appropriate management of on-site sanitation, Tampere University of Technology, Publications 537. 151 p.

ABSTRACT

The world is facing an enormous sanitation crisis: about 2.6 billion people lack of appropriate sanitation. Together with the lack of clean drinking water, it is causing 10 000 - 30 000 deaths daily. Roughly 6 000 children die every day from diarrhoeal diseases alone. And 88 per cent of those diseases are caused by unsafe water and inappropriate sanitation.

In Finland, the lack of proper sanitation is not jeopardizing people's lives, but it causes deterioration of the environment, especially eutrophication of surface waters and in some cases also pollution of groundwater. There are more than 700 000 residential properties - either summer cottages or year-round houses - outside sewerage networks in the country. The wastewaters of these properties were mainly treated in septic tanks until the end of the 20th century.

Since the beginning of the new millennium, the legislation concerning on-site sanitation has changed completely. For it to operate as planned, research on the proper management of on-site sanitation is required. The main objective of this research is to find answers to the questions: How to put the new laws and regulations into practice without major friction? What will the consequences of the new legislation be? What main topics should be researched further to avoid the deterioration of the environment due to wastewaters from sparsely populated areas?

After collecting empirical data from different sanitation projects in Finland and a number of international conferences, as well as studying the theory of Social Construction of Technology (SCOT), path dependence theory, stakeholders theories and futures research methods, the author makes comparisons, analyses and reviews of the findings and gives his conclusions and recommendations concerning the research topics. Action research, which aims at interaction between practise and theories, is used as the strategy of the research.

The main findings can be condensed into the following conclusions. Finland has enough up-to-date laws and regulations concerning on-site sanitation. The most important thing is that the legislation is interpreted with equal strictness all over the country to uphold respect for it. The quality of all activities taken must be first rate, availability of professional sector people is to be secured and product development - especially in dry toilet technology - must continue. We should apply the methods of futures research more seriously in the water and sanitation sector to ensure that we are moving in the preferred direction.

There are also a couple of recommendations for future actions and research topics given. The research implies the question whether the dominating trend toward larger sewer networks and larger centralised wastewater treatment plants in Finland is desirable or should we also study the decentralised alternatives? Should we totally eliminate the concept of non-point source pollution to highlight the individual's responsibility for the environment?

Finnish research, experiences and product development of on-site sanitation could help in solving the world's sanitation crisis if only given enough resources. It would support the country's own environmental protection, employment and economy as well.

Key words: sanitation, on-site sanitation, decentralised sanitation, wastewater treatment, management options, environmental legislation, SCOT, non-point source pollution, water services, DESAR

Mattila, H. 2005. Haja-asutusalueiden jätevesihuollon järjestäminen. (Appropriate management of on-site sanitation). Tampereen teknillinen yliopisto, Julkaisu 537. 151 s. (Alkuperäinen englanniksi).

TIIVISTELMÄ

Maailman sanitaatiokriisi on valtaisa. Noin 2,6 miljardilta ihmiseltä puuttuu kunnollinen jätevesihuolto. Yhdessä puhtaan juomaveden puutteen kanssa tämä aiheuttaa päivittäin 10 000 - 30 000 ihmishengen menetyksen. Yksistään ripulitauteihin kuolee joka päivä noin 6 000 lasta. Ripulitaudeista 88 prosenttia johtuu likaisesta vedestä tai puutteellisesta sanitaatiosta.

Suomessa asianmukaisen sanitaation puute ei uhkaa ihmishenkiä mutta heikentää ympäristön tilaa, etenkin vesistöjen rehevöitymistä, mutta joissakin tapauksissa myös pohjaveden pilaantumista. Suomessa on viemärilaitosten ulkopuolella yli 700 000 asuinkiinteistöä – joko kesä- tai vakituisia asuntoja. Pääosaltaan näiden kiinteistöjen jätevedet on käsitelty ainoastaan saostussäiliössä aina vuosituhannen vaihtumiseen saakka.

Haja-asutusalueiden jätevesihuoltoa koskeva lainsäädäntö on kokonaisuudessaan muuttunut Suomessa 2000-luvun alusta lähtien. Tämän tutkimuksen tavoitteena on löytää vastauksia kysymyksiin: Miten uudet lait ja määräykset laitetaan täytäntöön ilman suurempaa kitkaa? Mitä uusi lainsäädäntö tulee muuttamaan? Mihin suuntaan tutkimustyötä tulisi kohdistaa, jotta haja-asutusalueiden jätevesien aiheuttamaa kuormitusta saataisiin tehokkaimmin vähennetyksi?

Perehdyttyään kentällä usean vuoden ajan tutkimuksen problematiikkaan, kerättyään runsaasti käytäntöön liittyvää tietoutta lukuisista alan kansainvälisistä konferensseista ja Suomessa toteutetuista jätevesihankkeista, opiskeltuaan tekniikan sosiaalisen rakentumisen teoriaa, polkuteoriaa, osallistujateorioita ja tulevaisuuden tutkimusmetodeja kirjoittaja tekee havaintojen vertailuja, analyysejä ja arviointeja ja antaa johtopäätöksiä ja suosituksia yllä esitettyihin kysymyksiin. Tutkimusstrategiana käytetään toimintatutkimusta, joka pyrkii käytännön ja teoreettisen tutkimuksen vuorovaikutukseen.

Tutkimuksen tärkeimmät tulokset voidaan tiivistää seuraaviin johtopäätöksiin. Suomessa on riittävästi ajanmukaisia haja-asutuksen jätevesiä koskevia lakeja ja määräyksiä. Tärkeintä on tulkita lainsäädäntöä kaikkialla Suomessa yhtä tiukasti, jotta sen merkitys ei heikkenisi. Haja-asutuksen jätevesihuollon laadusta on huolehdittava, ammattitaitoisen henkilöstön saanti pitää varmistaa ja tuotekehityksen - etenkin kuivakäymäläteknologian - pitää jatkua. Tulevaisuuden tutkimus pitää ottaa nykyistä vakavammin vesi- ja sanitaatiosektorilla halutun kehityssuunnan varmistamiseksi.

Tutkimuksessa annetaan myös joitakin suosituksia toimenpiteiksi ja jatkotutkimuksen aiheiksi. Väitöstyön pohjalta voidaan kysyä, onko Suomessa vallalla oleva kehitys kohti yhä suurempia viemärilaitoksia aina paras, vai pitäisikö selvittää myös mahdollisuudet hajautettuun järjestelmään? Pitääkö hajakuormitus käsitteenä unohtaa kokonaan, jotta yksilön vastuu ympäristöstä tulisi konkreettisemmaksi.

Suomalainen tutkimus, kokemus ja tuotekehitys voisivat auttaa maailman sanitaatiokriisin ratkaisemisessa, mikäli niille vaan suunnattaisiin riittävästi resursseja. Kehitys tukisi samalla myös kotimaista ympäristönsuojelua, työllisyyttä ja taloutta.

Avainsanat: sanitaatio, kiinteistökohtainen jätevesihuolto, hajautettu jätevesien käsittely, jätevesien käsittely, ympäristölainsäädäntö, vesiensuojelu, hajakuormitus, vesihuoltopalvelut

APPROPRIATE MANAGEMENT OF ON-SITE SANITATION

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LIST OF ORIGINAL PUBLICATIONS

The dissertation is based on the following peer-reviewed, internationally published articles and conference papers, referred to in the text by their Roman numerals:

I Mattila, H. The role of public acceptance in the application of DESAR technology, The chapter 27 (pp. 517-533) in the book Decentralised Sanitation and Reuse – concepts, systems and implementation, edited by Lens, P. Zeeman, G. And Lettinga, G., IWA Publishing, 2001, London, UK

II Mattila, H. Management of Wastewater Treatment in Rural Areas, Conference paper proceedings, an oral presentation, 9th International Conference on the Conservation and Management of Lakes, November 11-16, 2001, Shiga, Japan.

III Mattila, **H**., Santala, E. and Aho, J. Consumer Managed Co-operative – A Solution for Progressing Wastewater Management in Rural Areas, Journal Water Science & Technology Vol 48 No 11 pp 385–391, IWA Publishing 2004

IV Mattila, H. New legislation for on-site sanitation in Finland, Conference proceedings, an oral presentation, in peer review for consideration to Journal Water Science & Technology, 2nd International Symposium on ecological sanitation, April 7-11, 2003, Lübeck, Germany

THE AUTHOR'S CONTRIBUTION

Paper I:
Harri Mattila wrote the paper independently and is the corresponding author. The paper was based on a conference paper prepared together with Dr Osmo Seppälä.

Paper II:
Harri Mattila wrote the paper independently and is the corresponding author.

Paper III:
Harri Mattila wrote the paper almost entirely and is the corresponding author. The co-authors brought in their valuable experiences from practical on-site sanitation projects.

Paper IV:
Harri Mattila wrote the paper independently and is the corresponding author.

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KEY DEFINITIONS
(note: Definitions might vary from one country to another. Like deep pits can be considered conventional systems in a number of developing countries.)

On-site sanitation	Wastewater plus toilet waste treatment on site (includes all possible alternatives of on-site systems) for a maximum of three to five households
Centralised wastewater treatment	Collection of wastewater plus toilet waste into a sewerage network and treatment in a big treatment plant (population equivalent > 100), a so-called end-of-pipe system which does not work according to the principle of ecological sanitation
Conventional wastewater treatment	Centralised wastewater treatment
Centralised sanitation	Centralised wastewater treatment, which includes also the possibility of breaking wastes into different components and collection and treatment of them separately
Decentralised sanitation	On-site sanitation involving small sewerage networks with wastewater treatment plants (population equivalent < 100)
Ecological sanitation	Allows all possible technical alternatives of wastewater and toilet waste treatment as long as the nutrients are recovered and used as fertilizers in food production
Ecosanitation, ecosan	Ecological sanitation which also incorporates the idea of economical sanitation, i.e. sanitation at the lowest appropriate cost
DESAR technology	DEcentralised SAnitation and Reuse technology = decentralised sanitation + ecological sanitation

ABBREVIATIONS AND ACRONYMS

BAT	Best available technology
CADWES	Capacity Development of Water and Environmental Services
DESAR	Decentralised Sanitation and Reuse
EU	European Union
FAEP	Finnish Agri-Environmental Programme
FEI	Finnish Environment Institute
GPS	Global Positioning System
HAMK	Häme Polytechnic
IEEB	Istitute of Environmental Engineering and Biotechnology
IWA	International Water Association
LPPF	Lake Pyhäjärvi Protection Fund
MOAF	Ministry of Agriculture and Forestry
MOE	Ministry of the Environment
MDGs	Millennium Development Goals
PREC	Pirkanmaa Regional Environmental Centre
RIL	Finnish Association of Civil Engineers
SCOT	Social Construction of Technology
SWFREC	South-West Finland Regional Environmental Centre
TEKES	National Technology Agency of Finland
TUT	Tampere University of Technology
UK	United Kingdom
USEPA	United States Environmental Protection Authority

1 INTRODUCTION

About 2.6 billion people lack appropriate sanitation in the world today. This combined with the lack of clean dinking water - which is faced by about 1 billion people - causes 10 000 - 30 000 deaths daily. It is estimated that roughly 6 000 children die every day from diarrhoeal diseases only. And 88 per cent of diarrhoeal diseases are caused by unsafe water and inappropriate sanitation. (Rosemarin 2004 a, http://www.who.int and http://www.wsscc.org)

It was estimated that the tsunami in the Far-East in the beginning of 2005 claimed some 300 000 lives. It is quite understandable that this tremendous loss received a lot of attention all over the world. The stricken areas and their inhabitants got unparalleled sums of money in relief and for reconstruction of infrastructure – all of it desperately needed and well justified. Yet, one might wonder, where are the intensive relief campaigns for alleviating the water and sanitation crises? They are causing the same number of deaths every ten days that the tsunami did once.

It is important to notice the international context of the sanitation crisis. It means that even if the sanitation-related unsolved questions definitely need to be researched in Finland, the results might be – and most probably are – also applicable globally. We should remember that Europe alone has are some 120 million people without access to safe drinking-water, and even more lack access to sanitation (http://www.euro.who.int), which results in basically the same health problems as the water and sanitation crises in the developing world. Better health care saves the lives of the Europeans though.

The international society is working with the water and sanitation crisis through different world wide programmes, declarations and targets agreed in international conferences and official meetings arranged in the same connection by heads or ministers of states. The issue has been discussed thoroughly on this level for example at the Johannesburg Summit in 2002 (http://www.johannesburgsummit.org/):

> *"It is hard to imagine how we can implement sustainable development when two billion people lack proper sanitation facilities,"* said Johannesburg Summit Secretary-General Nitin Desai. *"These new commitments show that the Johannesburg Summit has moved the international community to take action on an essential element in the fight to reduce poverty, promote human dignity, and protect and improve the environment."*

These types of events are important to keep the issue on the agenda of international politics and in the media to generate public interest. We should also ensure that action is taken, and that not only speeches and declarations are made. One action taken in Johannesburg was the reaffirming Millennium Development Goals (MDGs). The new commitment for sanitation is a companion target for the previously agreed upon goal of halving the proportion of people who lack access to clean water by the year 2015. The new commitments agreed to in Johannesburg also call on countries to provide the resources and technical assistance needed to embark on action programmes to meet the goals.

In several international comparisons of the water and environmental sector Finland has been placed at the top or at least close to it. These include, the "water quality index" (www.unesco.org/water/wwap), which emphasises water protection and quality; the "water

poverty index" (www.nwl.ac.uk/research/WPI), which focuses on the availability and management of water resources; the "transparency index" (www.gwdg.de/~uwvw/icr.htm), which assesses transparency and level of corruption; the "environmental sustainability index" (www.ciesin.columbia.edu/indicators/ESI) concerned with environmental protection and sustainability as well as the European comparison of water pollution control efforts called "name, shame and fame" (www.europa.eu.int/comm./environment/nsf/index.htm). Thus, Finland could be even more active in finding solutions to the global sanitation crisis together with other industrialised countries.

Of course, national legislation plays a major role in the management of on-site sanitation. That is why the management of systems cannot be copied from one country to another like the technology itself.

There are several reasons why the research on on-site sanitation is very up-to-date and prominent in Finland.

Various changes and recent developments in environmental legislation are creating new challenges and needs for good practises to implement the spirit and the word of the new laws and other regulations. The amended The Constitution of Finland (1.3.2000) makes everyone responsible for preserving nature and protecting the environment.

The Constitution of Finland (731/1999), Section 20:

> *"Nature and its biodiversity, the environment and national heritage are the responsibility of everyone."*

This is a very important section of the Constitution in relation to on-site sanitation and the related detailed legislation. It forms the first part the wider framevork of this research. The European Union Water Framework Directive (2000/60/EC) forms another part of the frames (Figure 1). The directive aims at providing good quality water resources by 2015 and seeks to guide national legislation in that direction.

The decision-in-principle of the Finnish Council of State on Water Protection Targets to 2005 has provided the general water protection targets which have guided actions in water environment protection during the late 1990's and early 2000's. The Water Protection Targets to the year 2005 set by the Ministry of the Environment and the agreements concerning water protection among the Baltic Sea Countries deal more directly also with waste water treatment but are nevertheless very general. The mentioned documents have influenced the detailed legislation concerning on-site sanitation in Finland. The actual targets to 2005 concerning diffuse pollution will not be met, but the decision-in-principle has been the basis for preparation and approval of amendments to legislation.

There are many detailed stipulations on on-site sanitation in some new Finnish laws. The changes in the legislation made this research necessary and formed the real field of research within the above described operational framework (Figure 1). The most important new laws are the Environmental Protection Act (86/2000), the Land Use and Building Act (132/1999) and the Act on Water Services (119/2001). All of them were enacted around the turn of the millennium and have resulted in many actions but questions and sometimes even confusion as

well. The older laws, the Waste Act (1072/1993) and the Health Protection Act (763/1994), which also deal with on-site sanitation are still in force and also play their important role in the management of on-site sanitation.

This dissertation answers some of the questions asked and clarifies the implementation of the new laws, rules and regulations. It also gives recommendations for further action to make the spirit of the new legislation reality.

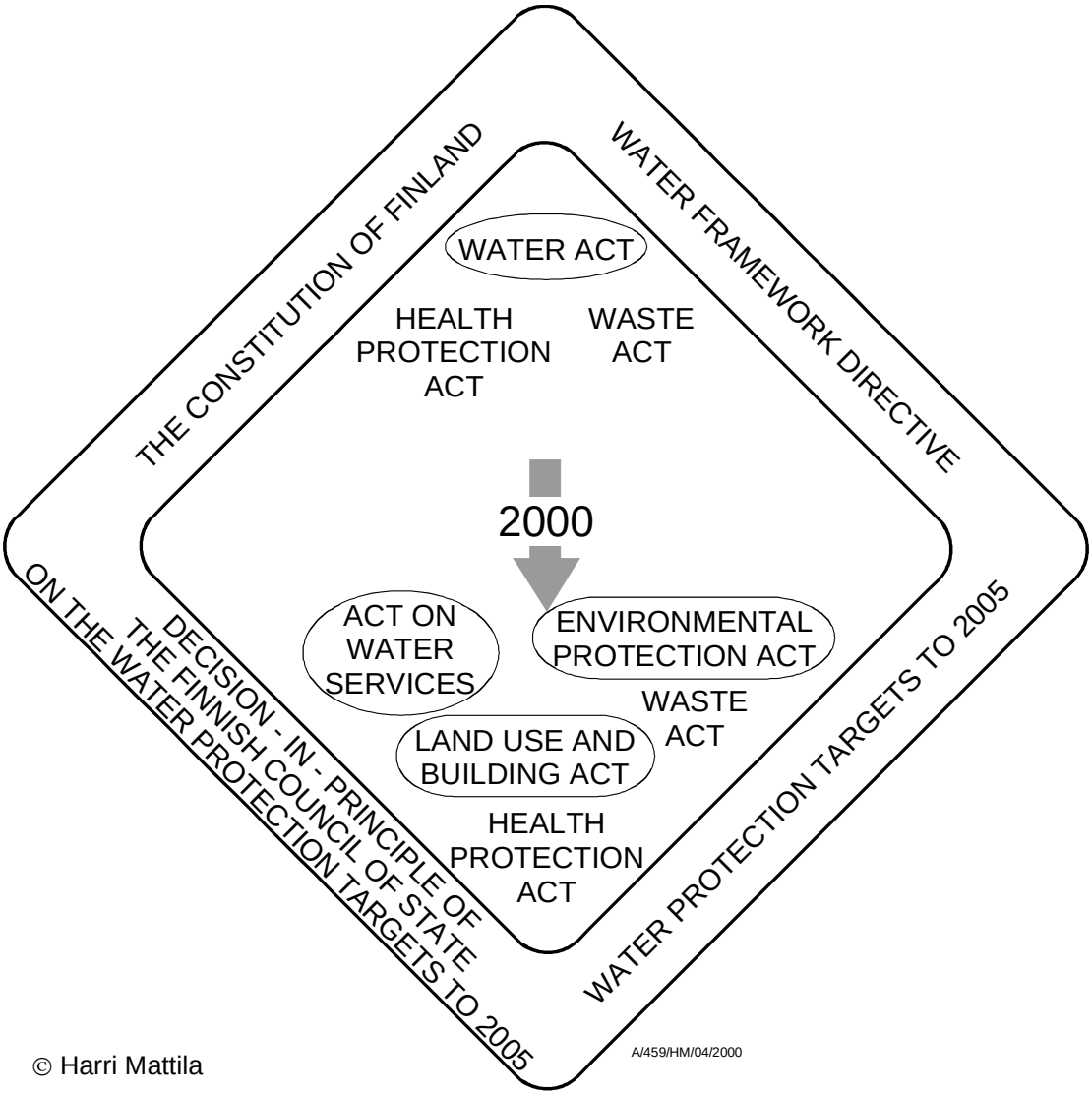


Figure 1. The operational framework of the research. The Constitution of Finland, EU Water Framework Directive and the Water Protection Targets to 2005 in Finland form the outer framework while the changes in specific laws form the actual research field.

This work is an example of so called "pracademic" research. According to Price (2001) pracademic means that research for a practicing field demands a research strategy based on the participation of both academics and practitioners. This is very much the case in the field of the management of on-site sanitation, where the final decisions and responsibility for sanitation systems lies with house owners, where there is a great risk of technologically problematic systems because of unskilled designers or contractors, and where insufficient operation and maintenance often spoil even the most sophisticated wastewater treatment unit. The smallest details of the legislation and the smartest theories are, however, also researched to make things work properly.

The pracademic approach of the research is possible since the author has participated in several on-site sanitation projects in the field while at the same time getting acquainted with the theories appropriate to the subject.

The subject was not been studied in Finland until the last years of the 20th century. There are very few published papers dealing with the management aspect of on-site sanitation because the requirements of earlier legislation were not as detailed as those of more recent laws. The author views practical experiences from several projects in the light of the new laws and regulations to find out the most appropriate modes for on-site sanitation.

Lake Pyhäjärvi Restoration Project

The need for this research became clear during the Lake Pyhäjärvi Restoration Project in Southwest Finland in 1995 - 1999 (Sarvala and Sarvala, 2001). The author worked as a project manager in the project and dealt with on-site sanitation matters daily. Soil filtration and soil infiltration were the known wastewater treatment methods, and development of other systems was just beginning.

The project implemented an on-site sanitation investigation in 1995. There are about 2 500 houses (including more than 1 000 summer cottages for recreational use) without a connection to a sewerage network in the drainage area of Lake Pyhäjärvi. The investigation covered some 2 000 of them (80 per cent) and showed that most of the year round houses are equipped with flush toilets. Wastewaters are treated in septic tanks, and the outlet is in most cases in an open drain. Summer cottages are mostly (65 per cent) equipped with dry toilets, but out only about 10 per cent of them are modern toilets that compost faeces. According to the investigation, about 15 per cent of the total phosphorous load into the lake comes from household wastewaters. (Elomaa, Mattila and Reko 2001)

Even if the share of the phosphorous load into water courses from rural households is relatively small compared with, for example, agriculture, it is vitally important to implement all possible measures to diminish it. Swedish researches have found that even the smallest nutrient leaks into the Baltic Sea need to be stopped to save the sea from eutrophication (Anon 2005).

The regional municipalities and Lake Pyhäjärvi Protection Fund, which are implementing the Lake Pyhäjärvi Restoration Project, supported house owners in implementing improved on-site sanitation. Improved and, often, also more complicated systems increased the need to manage the systems properly. (Paper I and Figure 2)

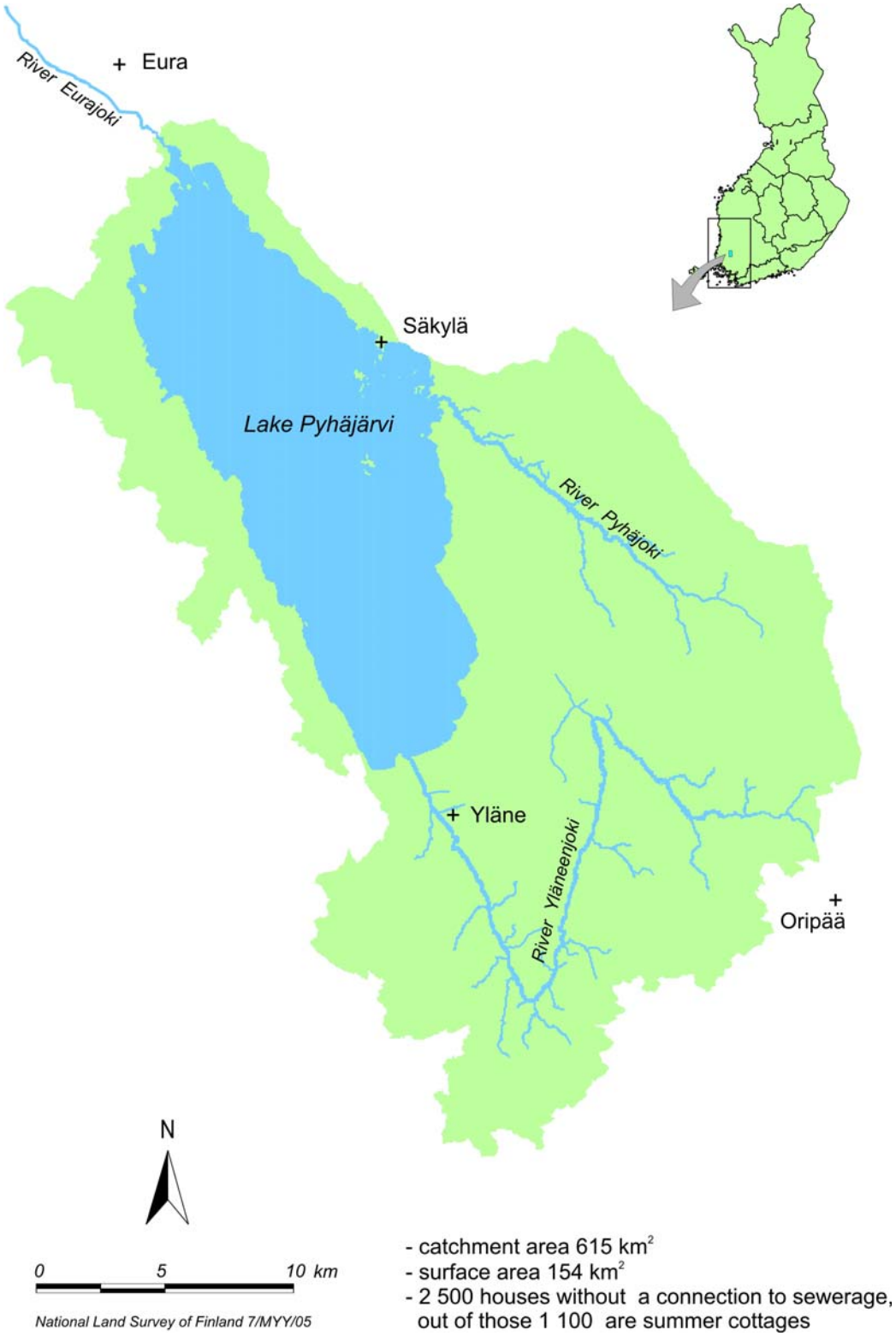


Figure 2. The area of Lake Pyhäjärvi Restoration Project (the map made by South-West Finland Regional Environment Centre 2005).

Hajasampo and other on-site sanitation projects

Due to the many on-site sanitation activities in the Lake Pyhäjärvi catchment area, the very practical oriented Hajasampo Research and Product Development Project was implemented mainly there in 1998-2000 (Kujala-Räty and Santala 2001). The structure of the Hajasampo Project is given in Figure 3. The author was involved in it in many ways:

- as a member of the project implementation group,
- participated in the implementation of the on-site systems as Project Manager of Lake Pyhäjärvi Protection Fund (LPPF),
- researched in Finnish Environment Institute (FEI) the possibilities of starting centralised operation and maintenance activities among the on-site sanitation systems
- participated intensively in the process of establishing the Varsinais-Suomi Water Services Co-operative (founded 18th December 1999),
- participated in the creation of the full on-site sanitation service package offered by the private specialist LVI-Helin Oy Ltd and
- participated in the dissemination activities performed by the project.

Material for Paper I was derived mainly from the Lake Pyhäjärvi area and the Hajasampo Project.

The Hajasampo-Project was a pioneering project (with its wide scope and large number of stakeholders) in the field of on-site sanitation in Finland. Several theses were also written during and after the project utilising the results of the project (number 1 stands for a licentiate's (pre-doctoral), 2 for a master's and 3 for a bachelor's thesis in Figure 3). They are also listed below, and the ones supervised by the author, are marked with an asterisk.

1) On-site Wastewater Treatment Plants' Functionality Study, Hajasampo Project, Licentiate's thesis by Katriina Kujala-Räty (Kujala-Räty 2004 a)

2) Responsibilities and Control in Wastewater Treatment in Rural Areas, M.Sc. thesis by Jami Aho (Aho 2002)

3) A Co-operative as an Organisation to Take Care of On-Site Wastewater Treatment – Varsinais-Suomen Vesihuolto-osuuskunta as an example, B.Sc. thesis by Katriina Jokinen (Jokinen 2003) *

3) Questionnaire study about experiences of using composting toilets, B.Sc. thesis by Mari Ruuska (Ruuska 2001)*

3) The Full Service Package for WasteWater Treatment of Rural Areas – Business Strategy, B.Sc. thesis by Kai Saralehto (Saralehto 2001) *

3) Improvement of Wastewater Treatment in Rural Areas, B.Sc. thesis by Jukka Palonperä

Research activities under the Hajasampo Project were funded by National Technology Agency of Finland (TEKES), Ministry of the Environment (MOE), Ministry of Agriculture and Forestry (MOAF) and Finnish Environment Institute (FEI). Regional Environment Centres of Southwest Finland (SWFREC) and Pirkanmaa (PREC), Lake Pyhäjärvi Potection Fund (LPPF), the five municipalities and the four enterprises named in Figure 3 made the

implementation of the sites possible. More over, the project had three co-operation projects in the country.

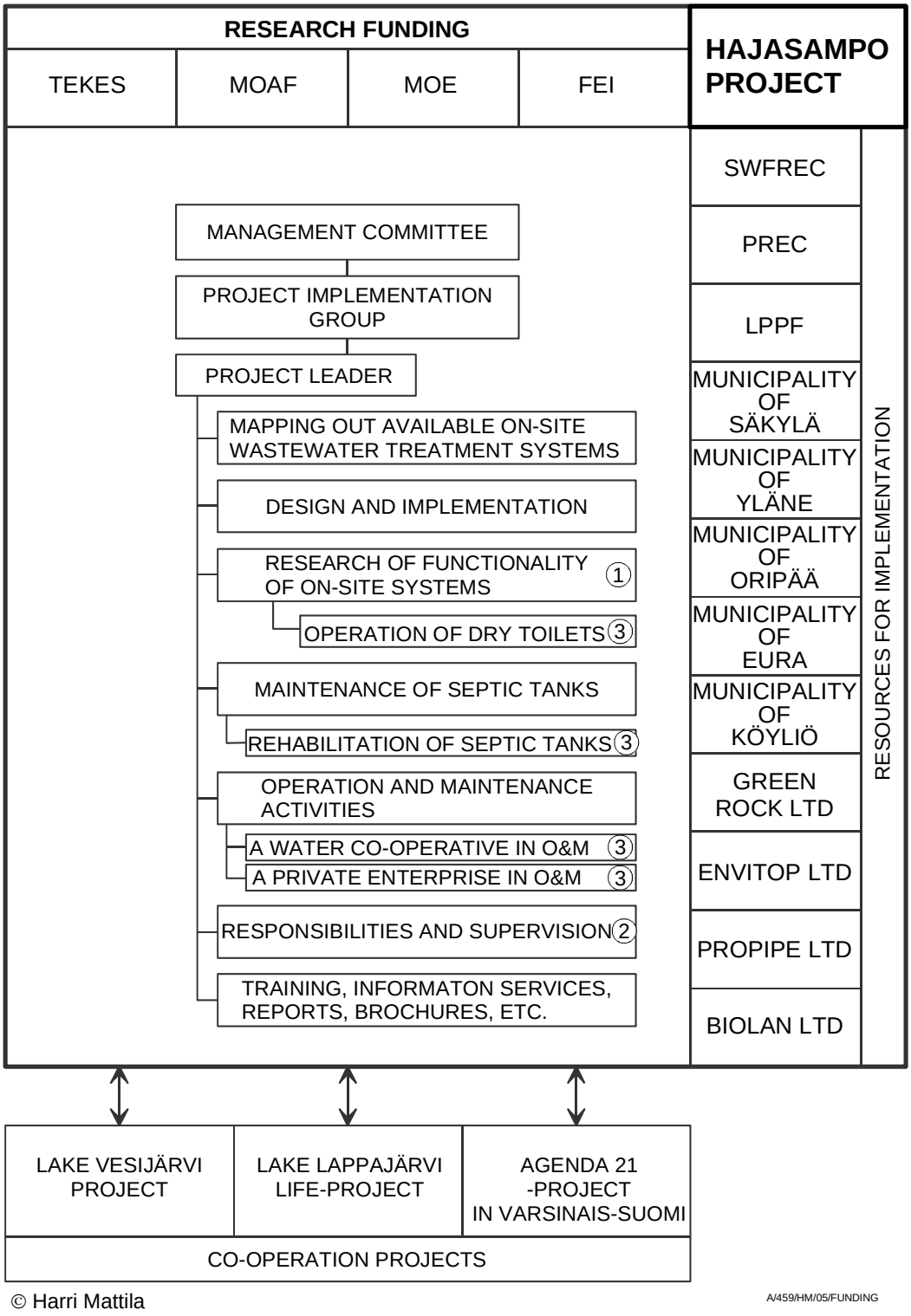


Figure 3. The structure of the Hajasampo-Project 1998 – 2001. The author worked as Project Manager in Lake Pyhäjärvi Protection Fund (LPPF) during the project, and because the major part of the project was implemented in Lake Pyhäjärvi area, the author was involved in several activities of the project.

During 2000 - 2004 the author had the opportunity to act as supervisor of 12 B.Sc. theses all related to on-site sanitation. These projects have provided a lot of valid information for this research. (Nikkari 2001, Ruuska 2001, Viitala 2001, Saralehto 2001, Lehtovuori 2002, Soininen 2002, Tammi, 2003, Ekola 2003, Jokinen 2003, Vienonen 2003, Rannisto 2003, Heikkilä 2004)

Conferences

The author has participated in several international conferences dealing with on-site sanitation. These conferences were extremely important for gathering data for the research. Because the subject has not been dealt by Finnish researchers, and even practical experiences are from quite a short period, international contacts are highly valuable.

One part of the research worth mentioning is the study tour in Germany, Denmark and Sweden in the spring of 2003 during which several actual on-site sanitation projects and involved persons were visited. A list of the sites is presented below:

- Møn Museum in Denmark, separation toilets
- The Svanholm Collective in Denmark, a community aim at sustainable living
- Munkesögaard Ecovillage in Denmark, decentralised wastewater treatment system
- Hyldespjaeldet in Denmark, a suburb experimenting several ideas of sustainable living
- Universeum in Gothenburg, Sweden, separation toilets and decentralised wastewater treatment
- Volvo leisure time and conference village at Bokenäs, Sweden, decentralised wastewater treatment system
- Henriksdal wastewater treatment plant in Stockholm, Sweden
- Understenhöjden ecovillage in Stockholm, Sweden, separation toilets and urine utilisation
- Gebers Housing project in Sweden, a renovated block house in Stockholm, Sweden, dry toilet system
- Rica City Hotel in Stockholm, Sweden, vacuum toilets
- Bra små avlopp, on-site wastewater treatment testing project in Stockholm, Sweden
- Ekoporten, a new eco-house in Norrköping, Sweden, composting toilets
- Toarp- eco-village in Sweden, dry toilets and decentralised grey wastewater treatment system.

Description of the tour is available at http://www2.gtz.de/ecosan/english/symposium2.htm#7.

Some research material was also acquired from the 1st International Dry Toilet Conference held in Tampere Finland in August 2003. (Kiukas and Repka 2003) The researcher was a member of the Organising Committee and Secretary of the Scientific Committee of the conference and got additional data for the research. There were 163 participants from 30 countries at this pioneering conference.

All stages of the research, the structure and the progress of the research are presented in Figure 4. The publications forming the basis for the theoretical analysis and discussion of the research are framed and numbered from I to IV, while the others are supporting the research.

Mattila, H. Treatment of waste water in rural areas must be improved. Finnish Journal of Water Economy, Water Technology, Hydraulic and Agricultural Engineering and Environmental Protection, Vol.38 (1997), 3: 6-8. Original in Finnish, abstract in English.

Mattila, H. Onsite treatment of wastewaters: Technology and solutions used in the Lake Pyhäjärvi catchment area, Finland; Conference paper, 4th International Conference, Managing the Wastewater Resource, Ecological Engineering for Wastewater Treatment, June 7-11, 1999, Ås, Norway.

Mattila, H. and Seppälä, O. Decentralised Sanitation and Reuse, Institutional and Public Acceptance Aspects of DESAR, the Lake Pyhäjärvi area as a pilot case in Finland, Conference paper, EURO Summer School DESAR, June 18-23, 2000, WICC, Wageningen, The Netherlands.

I
Mattila, H. The role of public acceptance in the application of DESAR technology, Chapter 27 (pp. 517-533) of the book Decentralised Sanitation and Reuse – concepts, systems and implementation, edited by Lens, P. Zeeman, G. And Lettinga, G., IWA Publishing, 2001, London, UK

Mattila, H. Chapter 10 of Operation and Maintenance Activities in the book Improvement of Wastewater Treatment in Rural Areas, the final report of the Hajasampo Project, edited by Katriina Kujala-Räty and Erkki Santala, Finnish Environment Institute publications, theme Environmental protection, The Finnish Environment No. 491, 2001, Tummavuoren Kirjapaino Oy, Vantaa, Finland. Original in Finnish, summary in English.

II
Mattila, H. Management of Wastewater Treatment in Rural Areas, Conference paper proceedings, an oral presentation, 9th International Conference on the Conservation and Management of Lakes, November 11-16, 2001, Shiga, Japan.

III
Mattila, **H**., Santala, E. and Aho, J. Consumer Managed Co-operative – A Solution for Progressing Wastewater Management in Rural Areas, Journal Water Science & Technology Vol 48 No 11 pp 385–391, IWA Publishing 2004

IV
Mattila, H. New legislation for on-site sanitation in Finland, Conference proceedings, an oral presentation, in peer review for consideration to WST, 2nd International Symposium on ecological sanitation, April 7-11, 2003, Lübeck, Germany

Mattila, H. Dry toilet - a solution to meet new requirements for on-site sanitation in Finland, conference proceedings, an oral presentation, 1st International Dry Toilet Conference, August 20-23, 2003, Tampere, Finland

Secretary of the Scientific Committee in the 1st International Dry Toilet Conference, August 20-23, 2003, Tampere, Finland

Dissertation: **Appropriate management of on-site sanitation**

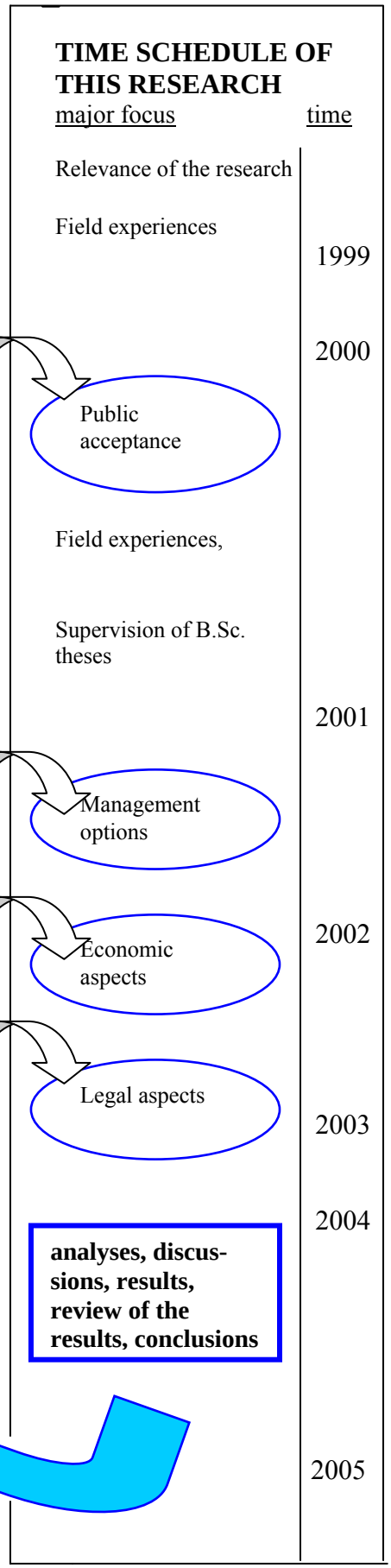


Figure 4. The structure and time schedule of the research

The relevance of the research was made apparent through the projects the author was involved in the late 1990's. The accumulating knowledge on the subject area was recorded in Papers I to IV and presented in the international forums indicated in the figure. The main subject of the papers is given in the circle in research schedule on the right hand side of the figure. There are also other publications besides the ones included in the dissertation in the figure to show the author's intensive involvement in matters related to on-site sanitation during the research.

The scope of the research is defined to include issues related to on-site sanitation. This is because the new legislation is creating problems for property owners in dispersed rural areas where proper sanitation must be organised either by individual houses or jointly with one or two neighbours. These problems are new to responsible authorities as well and require either common solutions or further research.

The new legislation concerns also small sewerage systems with some tens of households and a common wastewater treatment plant (population equivalent < 100). But because the management of these systems is easier to be solved similarly to centralised wastewater treatment systems it was reasonable to concentrate into the very small systems considered as on-site systems.

The concept of ecological sanitation is emerging in international research, conferences, symposiums and meetings (see, for example www.ecosanres.org, www.siwi.org and www.iwahq.org). Research and discussion about the concept need to be encouraged in Finland also. This is necessitated by our internal problem of eutrophication of water bodies and the global problem of some 2.6 billion people living without proper sanitation, most of them in the developing countries where the nutrients of especially toilet wastes could be put into beneficial use.

2 OBJECTIVES OF THE RESEARCH

This thesis has several objectives. Yet, almost all of them are in one way or another related to the new legislation concerning on-site sanitation in Finland.

The first objective is to find methods to avoid situations where people living in different parts of the country are treated differently. This matter is approached by clarifying some points of the new legislation so that sector people will read and understand it in approximately the same way. Some examples for the implementation of the new laws, rules and regulations are given as well. New legislation always requires new interpretations for it to be applied effectively.

The second objective is to give ideas for improving the efficiency of on-site sanitation. Practical problems of on-site sanitation are tackled in many ways. One is the discussion about the weakest points of the management chain of on-site sanitation. If these weak points or stakeholders are not recognised, efforts to improve on-site sanitation will certainly be ineffective at least to some extent. Due to the practical background of the author examples are given to show how the weak points of the chain might ruin the spirit of the new legislation.

The third objective is to create deep discussions about best practices in managing on-site sanitation appropriately. The research gives recommendations of practices to avoid common problems noticed in implementation of on-site sanitation in Finland. These modes of practices will really be needed in the coming years. Otherwise the eutrophication of water courses will continue and our limited ground water resources will be in danger of pollution.

The fourth objective is to create awareness of some special matters. Firstly, considering the existing legislation, one can seriously ask, whether the concept of non-point source (or diffuse) pollution is needed at all in connection with water protection. Would the concepts of point source pollution, natural leaching and deposition from air suffice?

The other matter is related to the word *responsibility*. The new legislation underlines the individual's responsibility towards the environment in many ways. Thus, is the Finnish policy of collecting wastewaters into long sewers and treating them far away in large treatment plants really the right one? Do people realise their responsibility for the impact they have on the water bodies when their wastewaters are treated tens of kilometres downstream?

The third matter is the global sanitation crisis, which is much more serious than the Finnish national one. Still, research done in Finland concentrating on the circumstances existing in this country, especially the analysis concerning the development of ecosanitation, can be applicable also globally.

And fourthly, the author will make recommendations for further research and on areas which are in urgent need of development to secure appropriate management of on-site sanitation in Finland.

3 THEORETICAL APPROACH

The theoretical background of research is mainly drawn from the theory of **Social Construction of Technology (SCOT)** and s**takeholder theories**. This is due the nature of on-site sanitation: the entire context and problems of the management of on-site sanitation is strongly related to the social behaviour of people and the social and political atmosphere of a society. In on-site sanitation, number of stakeholders are struggling with the same issue, which is rather personal. Thus, the issue is very sensitive: each stakeholder has his or her own views about the issue, own experiences – whether positive or negative - about it and own social and educational background.

Some of the matters discussed can be approached through the **path dependence theory** while the nature of the research - there are only limited number of researches on the subject in Finland, and the effects of changes in the legislation are still to be experienced - guided the author to use also on **futures research** to some extent.

The theoretical framework of the research is shown by Figure 5. SCOT plays a major role in the research. It is the process on-site sanitation system is selected in a certain site. The selection is affected by all kinds of factors related to environmental protection and circumstances on the site, expected operations and maintenance activities, investment and running costs, possibility of changing the system later on, local development, expected health consequences and security of the system.

SCOT is present also when stakeholder theories are applied. Naturally, stakeholders interact, and their ability to co-operate greatly affects the successfulness of the management of on-site sanitation. No matter, what kind of technological solution is selected.

The connection between path dependence and on-site sanitation is a bit more complicated. But SCOT is involved in that process as well: it explains why the path of sanitation in urban areas has affected on-site sanitation as well.

SCOT can also be used in the future research. The persons constructing futures maps with possible scenarios are making their own judgements on the basis of their own considerations about the possible and plausible paths of development.

All these theories deal with institutional and management arrangements in sanitation. Research of these matters linked to practical actions in the field is still inadequate, according to Seppälä (2004). This research adds to the knowledge about the link between theoretical management arrangements and practical on-site sanitation arrangements.

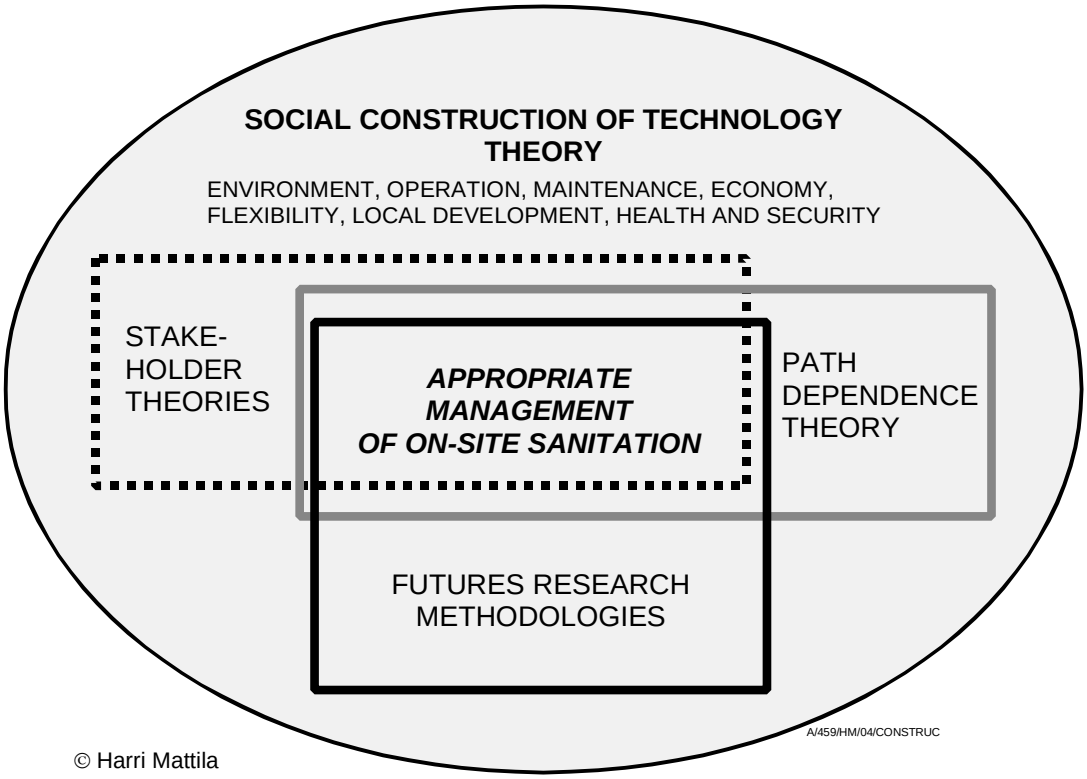


Figure 5. Theoretical framework of the research. The social construction of technology – theory applies well to issues related to on-site sanitation. Yet, because there are number of stakeholders involved, stakeholder theories were also utilised in the research. The path dependence theory is applied especially to some of the technology involved while some issues are tested by futures research.

Social Construction of Technology (SCOT)

The theory of social construction of technology (SCOT) builds on the concepts that technological products or solutions develop through discussions, interference and problem setting by different relevant social groups (Bijker, Hughes and Pinch 1987). According to SCOT the problems to be solved are defined through discussions by different groups, which means that, for example, earlier the only problem in sanitation was the smell and sight of faeces, and a flush toilet was a good enough solution to eliminate this problem. As long as the pollution of water courses or ground water was not seen as a problem, the flush toilet and septic tanks only, or any other limited treatment of wastewater was a good enough technical solution for on-site sanitation. There was no need for further discussion.

Awareness of the negative environmental effects of wastewater and the increasing interest in recreational use of water courses have now, however, restarted discussion and new solutions to the problems are sought. If only technical factors need to be considered, solutions for on-site sanitation are not too difficult to find. But according to SCOT, acceptable solutions can

only be arrived at through negotiations, discussions and considerations by different social groups. Therefore, a basically simple matter becomes complicated and the final solution is always a compromise as shown in Figure 6.

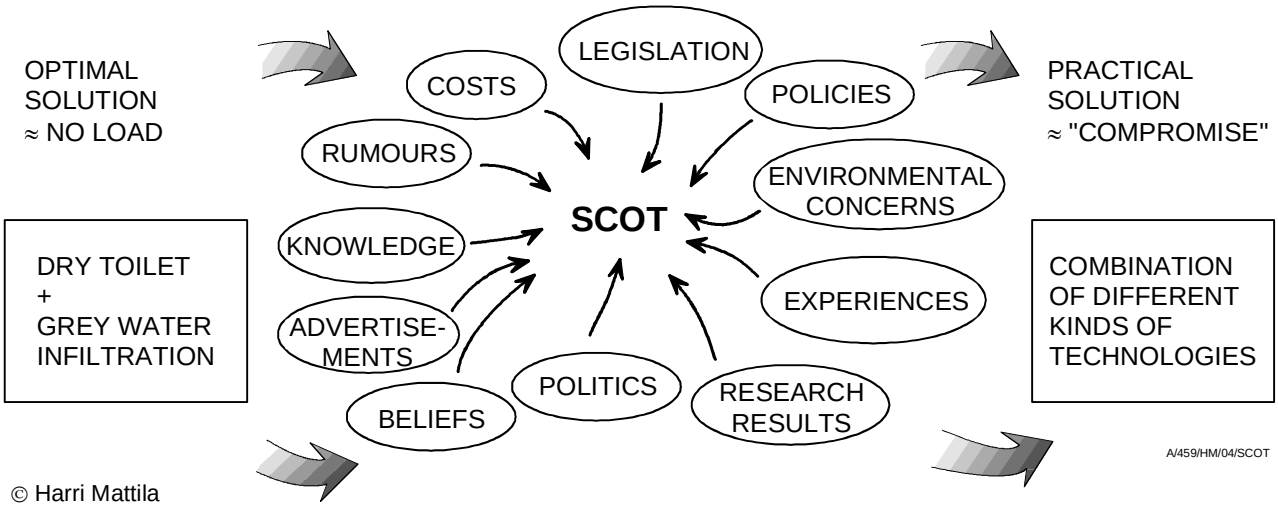


Figure 6. The effect of social construction of technology (SCOT) on the selection of solutions for on-site sanitation. An optimal solution, either for the environment or the house owner or for both (e.g., dry toilet plus infiltration) is rarely implemented because of the various elements affecting the decision-making process. The final solution to be implemented is a compromise between different alternatives which is often not the best one, not even for the house owner.

The phenomenon is described also in economics by North (2005). According to North logical operations determine only a small proportion of human decision making. The decision rules determined by the society play a critical role in the process of making choices. This adds some complications to people's decision making process.

An example of the effect of SCOT is described also in an article by Katko and Nygård (2000) where the "second best solution" is selected in solid waste management. It implies a situation where the optimal solution is not implemented for economical, technical or social reasons.

In many international meetings and conferences arranged in the late 1990's and early 2000's conventional (also called waterborne or traditional) sanitation systems are dealt as opposite alternatives to the principle of ecological sanitation. However, the President of IWA, Michael Rouse recommended that the term ecosan should (also called ecosanitation, which incorporates the ideas of ecological and economical sanitation) never be used to avoid the conflict with the conventional options. Instead, the phrase "appropriate sanitation" should be used to make it clear that all technological alternatives could and should be used to meet sanitation standards; the fact is that certain technology is appropriate in one place while it might not suit another. (Rouse 2004)

Actually, the idea of ecosan is just what Rouse proposes. Ecosan does not rely on any single technology. Conventional sewerage is criticised because it wastes a valuable raw material, which could otherwise be used for food production, by discharging it into water courses. (Werner, Fall, Schlick and Mang 2003)

The dry sanitation alternative can be as inappropriate as the wet one if not properly implemented. For example, traditional pit latrines waste the nutrients and organic material of urine and faeces which stay in the ground or leach into groundwater. That is why the title of this research is Appropriate management of on-site sanitation. It discusses not only all the possible technological alternatives from wet to dry systems, but also SCOT, which cannot be avoided as long as private house owners themselves are responsible for on-site sanitation as is the case in Finland in accordance with the Environmental Protection Act and the Act on Water Services.

Path dependence

The path dependence theory originated in economics but has lately been applied in other academic disciplines as well. According to David (2000) “The concept of path dependence refers to a property of contingent, non-reversible dynamical processes, including a wide array of biological and social processes that can properly be described as evolutionary.” The nature of the theory makes it worth discussing together with social construction of technology (SCOT).

According to the path dependence theory, the earlier decisions make us follow a certain path in development (David 2000). For example, when we constructed drainage canals in cities and towns we also made decisions concerning the type of toilets because the same drainage system (the infrastructure already invested in) could be used also for transporting wastes. While remembering the effects of SCOT in decision making when selecting on-site sanitation systems it should be noticed that SCOT can also lock-in a certain path of development.

When combining the two theories, SCOT and path dependence, we can say that the mentioned development led to the selection of flush toilet technology in rural areas as well. The social "pressure" from the cities and friends and relatives living in them introduced flush toilets to conditions where there that kind of technology makes no sense. The combining of the ideas behind the two theories is discussed in more detail in Chapter 6.2.

While path dependence contends that decisions made in the past are likely to have long-term impacts on water and sanitation systems, it should be noted that path dependence is linked to futures research as well. It is possible to change the path to a more favoured one by analysing the scenarios leading in the preferred direction.

Stakeholder theories

A stakeholder in an organisation is a group or an individual who can affect or is affected by the achievement of the objectives of the organisation. (Näsi and Näsi 2002). In the context of on-site sanitation, a management network or chain formed by number of stakeholders can be

considered the organisation. It is not a fixed network, but its composition varies from case to case.

Usually the stakeholders of on-site sanitation are considered to consist of the house owner and his/her family, a professional designer of on-site systems, entrepreneurs constructing and maintaining on-site systems, a sanitation and/or wastewater treatment unit manufacturer, a hardware store keeper retailing sanitation units and equipment, an engineer in charge of the construction site, municipal building and environmental authorities, and local and national politicians. SCOT makes the list even longer.

The management network for on-site sanitation can be considered to include also factors like legislation and municipal ordinances or persons indirectly involved in the on-site sanitation system in question. According to SCOT, many other issues besides pure facts also affect the solutions selected for on-site sanitation: different kinds of experiences, rumours, advertisements etc. in the media must also be taken into account.

Stakeholder theories analyse the structure between organisations and interactions in this structure and recognise the change toward complex networks (Seppälä 2004). In on-site sanitation this complexity is emphasised. The surprisingly large number of actors strengthened by the impact of SCOT form a challenging structure which is not stable. Stakeholder theories dealing with the relationships and co-operation of different stakeholders is why they are useful tools in the research concerning on-site sanitation.

Futures research

Futures research was utilised in the end when some of the key findings of the research were evaluated by some of the professionals in the field of water supply and sanitation in Finland. The purpose of this was to confirm the relevance of the results in the theoretical and also in the operational framework of the research. Futures research suits well with SCOT theory. For example, according to Kamppinen, Kuusi and Söderlund (2002), a futures researcher should be knowledgeable in matters related to physics, biology, psychology, economics and sociology. Otherwise it is difficult to make scenarios about the possible paths things might take.

The idea behind futures research is that people can affect the future by their actions today and selections for tomorrow. And here SCOT has a big role: each person has his or her own will and beliefs created in the SCOT process (Figure 6). And of course, the will and beliefs change with experience. Thus, when we take our experience from the past and present and combine them with our scenarios about the future, we thereby mould the future to our liking. It is worth noticing that a useful futures map does not necessarily include more than one scenario if that is the only clear. There is no sense in creating scenarios by force. (Kamppinen et al. 2002)

As part of this research, the facts known on the basis of the new legislation and a few possible scenarios on the futures map were given for evaluation to a number of professionals in the field of water supply and sanitation. The professionals made their considerations on the basis of their own knowledge and experience, they put the given scenarios in an order of probability. If the most probable one, according to their consideration, was not given they were asked to present it.

Futures research has been found to suit well the research of water supply and sanitation services because of their complexity as they involve a number of stakeholders and different human activities. It has been recommended that visionary processes integrating scenarios need further development when applied to the processes of water services organisations (Seppälä 2004). This research is one step forward in this development process.

4 METHODOLOGY

This research can be described as a study of participatory observation and personal involvement as a result of the large number of projects monitored and participated in by the author. The Lake Pyhäjärvi Restoration Project, the Hajasampo-Project and all the smaller projects the author was involved in gave their valuable input to the research and finally to the conclusions. Action research became as a natural choice as the research method due to this participatory nature of the research.

Actually, action research is more a research strategy aiming towards interaction between practise and theoretical research than a research method. It was taken in use by Kurt Lewin in the 1940's in USA. In action research the research topic is approached through actions, which are then monitored leading to reflections and future planning. The planning is made for next stage actions followed by monitoring, etc. Thus, this strategy aims to develop the actions in a certain field in cycles (Suojanen 2005). This is seen also in Figure 8 describing the strategy of this research.

This type of research where private homes are visited, their toilets and wastewater treatment units are observed and the wastewater disposal sites evaluated is undoubtedly very sensitive. When the legislation was amended and the new regulations had to be followed and people were more or less confused, it was necessary to create a positive atmosphere whenever the author was participating in appointments and meetings.

Even though the research was done in Finland and for Finnish conditions, it is interesting to notice the similarities with on-site sanitation development projects and processes elsewhere and especially in the developing world. There are many examples (e.g. Gomez and Graham 2004) of the importance of using the participatory approach in these types of projects. It was considered the only possible one also in Finland.

The problems identified in the installed on-site sanitation systems listed in Table 1 indicate the relevance of the research. The table is compiled from the experiences gained in several on-site sanitation projects in Finland and reported in seminar and workshop lectures during the first years of the 21st century (Mattila 2004). These problems also made the planning of actions to improve the situation obvious and they were the starting point of the projects like the Hajasampo project and this research.

Table 1. Examples of problems identified in the installed on-site sanitation systems (Mattila 2004).

Problems related to local circumstances or inadequate pre-investigations on the site	Problems related to unprofessional design or construction	Problems related to bad or lacking operation and maintenance
• There is no drainage for run-off waters. • Ground water level is too high. • The outlet is situated below the water level in the receiving water body. • There are possibly also other waters in the outlet but wastewater. • The unit could not be inspected (The unit was about 3 m below the ground level.) • The outlet is frozen. • There is no T-junction in the outlet of the septic tank.	• Inspection of the system is almost impossible. • Water distribution does not work. • The pipe slopes are not correct. • The ventilation system is not proper. • There are no possibilities for water sampling. • There is no water, the filter is completely dry. • The entire system is frozen. • There are no possibilities for maintenance work to be done. • Water is not running towards the direction wanted. • The cover could not be opened by one person. • The treatment unit could not be found! • The installation instructions had clogged the outlet!	• Pre-sedimentation is not functioning. • Septic tanks are not maintained. • There are no flow adjusters. • The caps of ventilation pipes are missing. • The pumps are not functioning properly. • The filter media is missing. • The aeration pump is not running. • The well covers are broken. • The filter media is wrongly installed.

 A/459/HM/05/TABLE1

Thus, no matter, how simple the technical solutions of on-site sanitation systems are, the operation of them can be disturbed by several means. The vulnerability of technology was noted also by Pacey as early as 1977. He concluded that technology alone is not enough, but in addition we need a variety of criteria for technical, social and economic appropriateness. Koskiaho (1990) put it in other words: Results in technology can be evaluated from certain values like economical, ecological, ethical and esthetical. Purely technical norms do not tell us what the world is like, but what the world should be like.

The question in this research is more of understanding of phenomena rather than just recognising them. And according to Heidegger cited by Radnor (2002) understanding is an

ontological condition, not an epistemological one. That is why this research is done on hermeneutical background instead of positivistic one. The difference is presented in Figure 7.

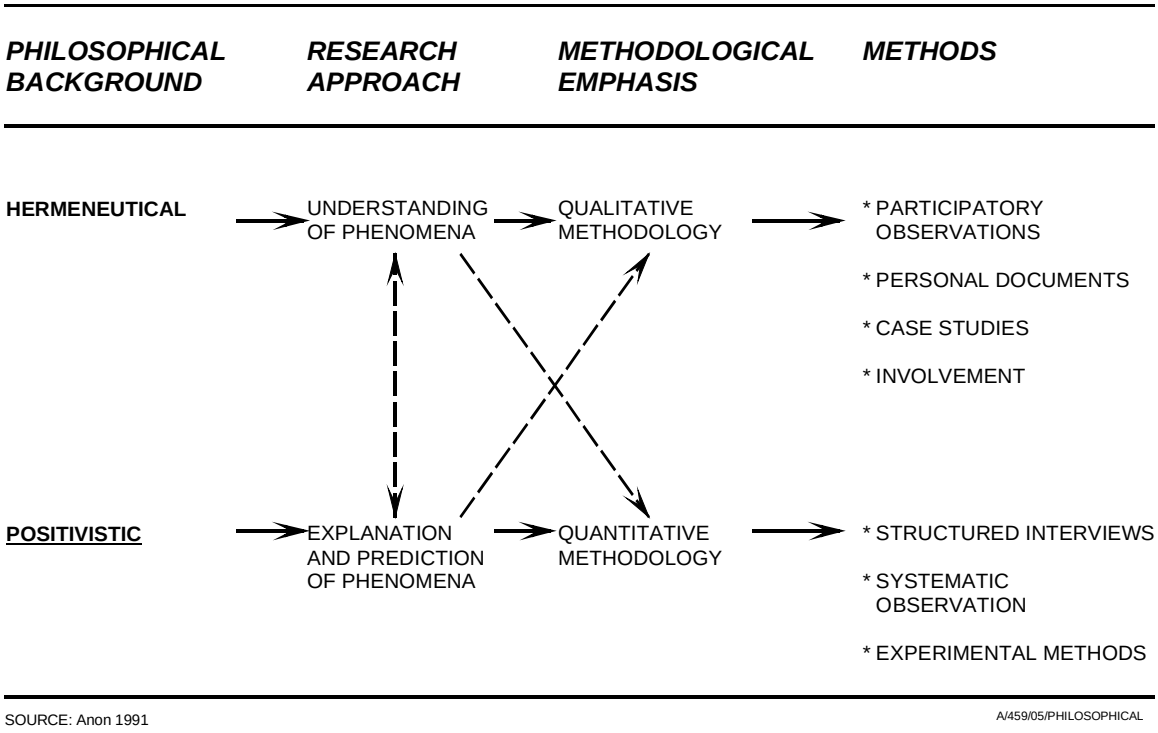


Figure 7. Hermeneutical and positivistic philosophical backgrounds and their connections (Anon 1991, modified by the author).

In spite of the hermeneutical background of the research, the nature of problems of on-site sanitation – new innovative solutions with the changed operational framework presented in Figure 1 on the page 19. – in Finland forced the author to carry on close follow up of researches done on the positivistic background. Just like the arrows show in Figure 7. In on-site sanitation, the question is more of new innovations than inventions. Innovation can be a totally new invention but most often it is a concept to apply or to use some resources (technological, human, knowledge, financial) in a new way in order to solve a problem (Järvinen 2004). Basically, inventions in centralised wastewater treatment can be utilised in decentralised systems. But the problem must be seen also from other resources' point of view.

Thus, the scope of this research is more on institutions than technology of on-site sanitation. Institutions are defined to be the rules of the game in a society, or the humanly devised constraints that shape human interaction (North 1990).

Differences in research approaches between the hermeneutical and positivistic philosophical backgrounds are presented in Table 2. There is partly positivistic approach used in this research: the author was deeply involved in the Hajasampo-Project which partly concentrated in researching the efficiency and treatment capacity of different on-site systems and later on the author supervised number of B.Sc. theses works, in which the positivistic approach was dominating. In these contexts the positivistic approach means observation of the operations of

the on-site sanitation systems objectively, description of the technology of the systems and the results obtained and, all in all, working only with pure facts. But most of the research was implemented utilising hermeneutical approach. In this research, the approach includes a high level of engagement and problemitisation of the observed facts, as well as trials to understand and make interpretations of the results gained, not just observing and reporting them.

Table 2. Positivistic and hermeneutic research approaches (Andersson 1982).

POSITIVISM	***HERMENEUTICS***
NATURAL SCIENCE TRADITION	SOCIAL SCIENCE TRADITION
SIMALARITY BETWEEN PHYSICAL AND SOCIAL PHENOMENA	DIFFERENCE BETWEEN PHYSICAL AND SOCIAL PHENOMENA
EXPLAINING	UNDERSTANDING
MATERIAL	SOCIOMATERIAL
UNIVERSALITY	TOTALITY
ABSTRACTION	CONCRETION
SIMPLIFICATION	PROBLEMITISATION
DESCRIPTION	INTERPRETATION
DIFFERENTIATION BETWEEN FACTS AND VALUES	SIMILARITY BETWEEN FACTS AND VALUES
DIFFERENTIATION BETWEEN EMOTION AND REASON	SIMILARITY BETWEEN EMOTION AND REASON
DISTANT OBSERVATION	ENGAGEMENT
OBJECTIVITY	SUBJECTIVITY
PREDICTABILITY	CHANGE
DIFFERENTIATION BETWEEN SCIENCE AND PERSONALITY	SIMILARITY BETWEEN SCIENCE AND PERSONALITY
DIFFERENTIATION BETWEEN SCIENTIFIC AND UNSCIENTIFIC KNOWLEDGE	SIMILARITY BETWEEN SCIENTIFIC AND UNSCIENTIFIC KNOWLEDGE

The relevance of the research was made evident not only by the detected practical sanitation needs but also by the revealed environmental protection needs. The eutrophication of lakes and rivers in Finland is worrying people across the southern and western parts of the country.

And this concern is also reflected in the national Water Protection Targets for the Year 2005 (Ministry of the Environment 1999).

The research methodology is described in Figure 8. The problems of on-site sanitation were recognised during the Lake Pyhäjärvi Restoration Project and from experiences in some other areas in Finland and that was the starting point of the research.

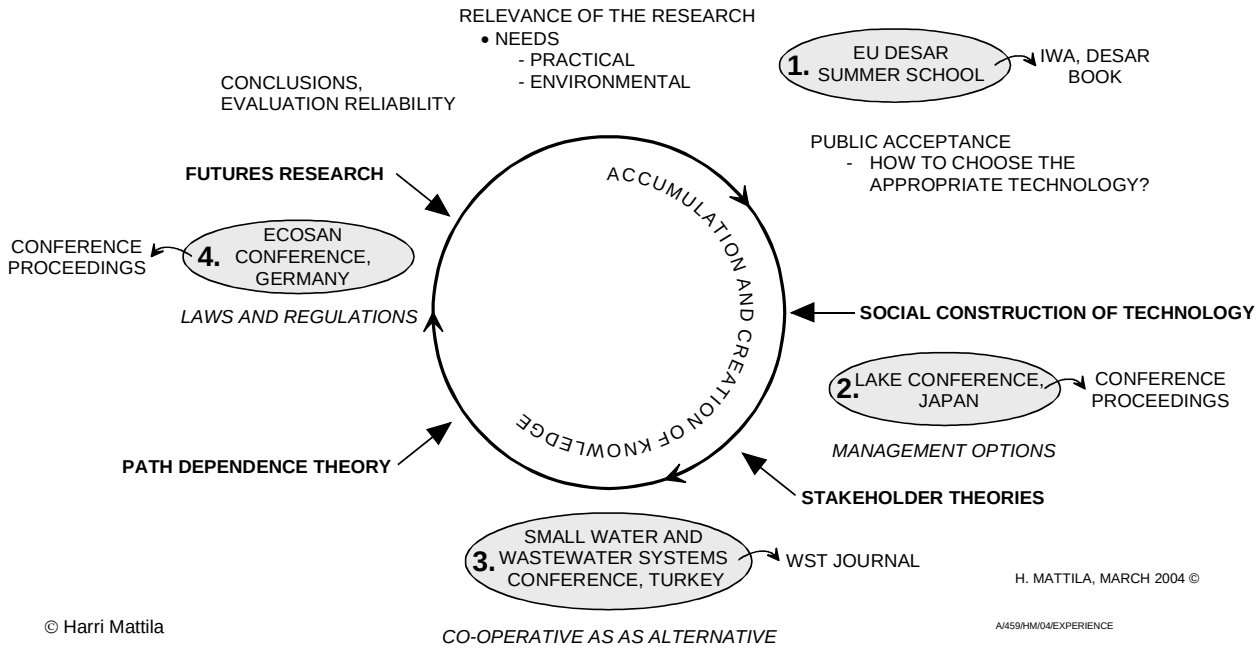


Figure 8. The research methodology. The participatory nature of the action research is shown by the inner circle: the author participated in several on-site sanitation projects during the research and the gained experiences were utilised in writing the attached Papers I-IV (see also the list on the p. 25) and presented at events 1 to 4. The subject has not been researched much while the existing legislation has been in force in Finland. That is why it is important to notice that the circle of accumulation and creation of knowledge is continuous. This research forms the basis for future efforts.

When working for the Lake Pyhäjärvi Restoration Project the author had the possibility to observe people's attitudes and opinions about improved on-site sanitation. These experiences were utilised when writing first the conference paper to The EU Summer School of Decentralised Sanitation and Reuse held in Wageningen, Netherlands in 2000. Later on the information was published in Paper I, which forms Chapter 27 in the DESAR handbook by IWA (Lens, Zeeman and Lettinga 2001).

During the Hajasampo-Project (Kujala-Räty and Santala 2001) different kinds of management options for on-site sanitation were considered. A M.Sc. thesis was also written on the subject (Aho 2002) and the author was in a position to follow the preparation of this paper quite closely. The author wrote Paper II based on these two sources.

One interesting and in the Finnish conditions quite promising way of managing on-site sanitation, - especially from the economical point of view - is to support house owners in establishing co-operatives. There are a lot of positive experiences from co-operatives, especially in the water sector, in the country. The author acted as a catalyst when the pioneer co-operative for this purpose, Varsinais-Suomi Water Services Co-operative, was created. Later on a B.Sc. thesis evaluating the first operational years of the co-operative was also written (Jokinen 2003). A co-operative as the solution for managing on-site sanitation is presented in Paper III.

When supervising the other B.Sc. thesis projects (2001 – 2003), the author became increasingly familiar with the details of the new legislation. At the same time he was also involved in a project which prepared guidelines for municipal authorities in implementing the new legislation concerning on-site sanitation organised by the Association of Finnish Municipalities. (Mattila 2003 a) When the final version of the decree on on-site sanitation was under preparation in spring 2003, the new legislation was ready for presentation at the 2nd International Symposium on Ecological Sanitation (Paper IV).

The new legislation was evaluated also from the dry toilet technology point of view. This was done at the 1st International Dry Toilet Conference held in Tampere, Finland in August 2003, where the author acted as the Secretary of the Scientific Committee and also gave an oral presentation on the appropriateness of dry toilets in implementing the new legislation on on-site sanitation in Finland (Mattila 2003 b).

All the mentioned steps of this action research have accumulated knowledge about managing on-site sanitation. This knowledge has been evaluated within the frameworks of the described theories and together with other identified research results reported. Finally conclusions have been drawn and proposals made. The study has also brought up fundamental questions for consideration concerning the technology of on-site sanitation - like dry versus wet toilets, and questions concerning the term “diffuse pollution”.

5 DEVELOPMENT OF ON-SITE SANITATION

> *"Where did we relieve ourselves in the beginning when there were no toilets? Everyone understands where Adam and Eve did it, even in Paradise. But let's not go that far back in time. As soon as there were back yards in Finland, we went there to sit on a rod. Women relieved themselves in cowsheds as much as their work was done with cattle or just used a bucket.. Men did not bother walking too far - they usually peed from the front steps often into a pile of straw or hay which was then eaten by the cattle."* (Kero and Seppovaara 1994, translated by the author)

The above concerns mainly residents and housing outside towns and village centres, but some city dwellers also practised animal husbandry in Finland not so long ago (e.g. in the town of Hämeenlinna pigs and other animals were quite common in the 19th century (Juuti, Rajala, and Katko 2001) and the described sanitation practices were existing also followed there.

Both the SCOT and path dependence –theories, or at least their key ideas, have affected the development of sanitation systems all over the world. Cooper (2001) describes how the clay pipes and brick-lined sewers laid by the Romans in London were used to drain latrines even though they were originally intended to lead run-off waters out of the city. Separate sewerage for wastewater and storm water was introduced in Britain in the late 19th century (Barty-King 1992).

Sir Edwin Chadwick was one of the most important persons as regards the development of sanitation technology in the 19th century. Chadwick was a lawyer and a reporter who was concerned about the dismal conditions in the slums of London. He published the *Report on Sanitary Conditions of the Labouring Population of Great Britain* in 1842. The report included several recommendations for water and waste management. One was to utilise wastewaters as fertiliser in agricultural areas instead of conveying them into natural water bodies.. That advice was largely adopted in Great Britain, even in big cities. The last land treatment plant operated until the 1980s. (Cooper 2001)

It would be interesting to know what kind of sanitation technology we would use today if the path of dry toilets had been selected as the main solution in the 19th century in the United Kingdom which was the most advanced country in this respect at that time. The success of the flush toilet is not as self-evident as one could imagine. Thomas Swinburne was the first one to get a patent for a dry toilet in 1838. Thereafter, for the rest of the century the merits of flush versus dry toilets were discussed at length (Esrey, Gough, Rapaport, Sawyer, Simpson-Hérbert, Vargas and Winblad 1998). Thus, the path of flush toilets was selected through the SCOT process. If the costs of efficient wastewater treatment and large sewerage networks had been taken into account already in these discussions, the selected path might have been different. Anyhow, the path of flush toilet technology practically ended the product development of dry toilet technology for over a hundred years (Juuti and Wallenius 2005).

There is quite interesting evidence of early dry toilet development in Finland as well. The famous architect Engel designed the sanitation system of the multi-storey prison in Kuopio as a dry one in 1825. The drawings can be seen at Café Engel in Helsinki. Yet, when the prison was finally completed it had flush toilets.

After sewerage systems became more prevalent, the product development of dry toilets was almost non-existent for more than a hundred years in Finland also. For example, while Finns have been building VIP- or similar properly ventilated latrines in development cooperation projects, their own toilets at their summer cottages have been constructed without ventilation. That is one of the reasons why the reputation of dry toilets is not good among common the Finnish public.

Hundreds of patent applications concerning wastewater treatment were made in the United Kingdom already in the late 19th and early 20th century. (Cooper 2001). In spite of that, the principle of *the solution to pollution is dilution* was followed for a long time, not only in the United Kingdom, but everywhere else in Europe as well. Very large sewerage systems have been constructed without wastewater treatment plants. Wastes have been diluted into natural waters. That is the case in many big cities (e.g. Milan and Brussels) even today (Bärlund 2003).

The first flush toilet in Finland was installed in the Bank of Finland in Helsinki in 1882. There was a rather lively discussion about this "smelling nest of bacteria" going on in the City Council before the installation. The negative impacts of wastewater were soon visible in the close-by Töölönlahti bay and a treatment plant was soon constructed. (Ahola 2003)

The city of Tampere had about 11 000 inhabitants using flush toilets in 1920. That was about one quarter of the population which means that about 33 000 persons were using dry toilets. (Mitro 1921 cited by Juuti and Katko 1998) As the number of flush toilets increased and the sewer network got wider, water quality problems in the receiving water body Lake Pyhäjärvi became more visible. The general plans for a sewerage system and wastewater treatment were prepared in 1954. (Juuti and Katko 1998)

As flush toilets became more common in Finnish cities, they started appearing in rural areas as well. Social pressure made rural inhabitants follow the path selected by cities (this is discussed more detailed in Chapter 6.2). At the same time city dwellers also became interested in equipping their summer cottages with modern water systems. Of course, it is not merely a question of social pressure, but also technical and practical factors. Modern water technology with centralised distribution has been the solution to the unsatisfactory water wells of rural areas, and flush toilets have been seen as the self evident solution for sanitation as water is led into houses for drinking purposes anyway. The development has been promoted by state and municipal governments through the past decades. Construction of water distribution networks in rural villages has been supported financially. (Paper IV)

The policy concerning financial support by the government for water supply services has changed in the beginning of 21st century. Nowadays, construction of sewers along with the water distribution network is normally required for a grant. An example of this type of project is given, for example, by Yläjärvi (2004). This policy is rather pleasant also to house owners. Yet, one might ask whether it is reasonable to lead wastewater downstream to become someone else's nuisance instead of on-site treatment. Even with conventional systems this is a relevant question.

"Responsibility" will be discussed in several chapters of this research. Juuti and Wallenius (2005) wrote that the standard of sanitation is not as much bound to time and place as to the ability of society to take responsibility for developing individuals and their environment. And

in this context, one should remember what society is in the first place – it is a group of individuals (Edwards 2005).

5.1 Relevance of the research on on-site sanitation

When the wastewater load from industry and towns was not yet controlled to the extent it is today, the load from on-site sanitation facilities and other non-point sources was neglected. But as wastewater treatment plants and technology developed quite fast from 1970 onwards (Paper I), especially the phosphorous load from non-point sources became more visible in statistics as well as in water courses. Water quality in rivers and lakes downstream from major cities and industrial plants has been improving already for a couple of decades. Meanwhile, eutrophication of other waters has continued, especially in the southern and western parts of Finland where most of the people and active farms are situated. (Ministry of the Environment 1999)

Water protection activities with special focus on forestry, agriculture and animal husbandry have been going on for some fifteen years. Extra financial support has been received after 1995 when Finland joined the European Union and the Finnish Agri-Environmental Programme (FAEP) was introduced (Ministry of Agriculture and Forestry 2005). This development was bound to lead to activities to improve on-site sanitation. And these activities made this research even more relevant. The described development can be simplified as in Figure 9.

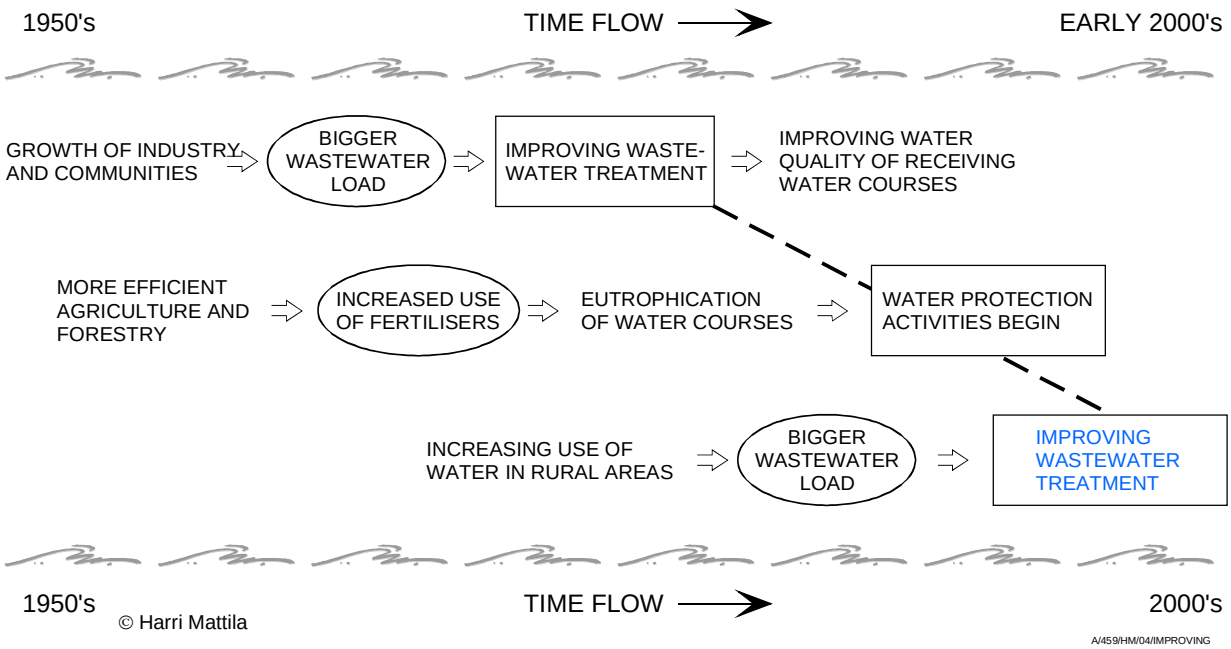


Figure 9. Simplified development of water deterioration and protection efforts in Finland. The figure illustrates how water protection efforts are implemented to reduce the number of sources of pollution as the turn of the century. The question is: Will this trend continue?

5.1.1 Practical needs for research on on-site sanitation

First of all, the history of defecation is just as old as the history of mankind. It is a basic need just like eating even though defecation has not been researched nearly as intensively as taking food. Excrements spread diseases, pollute waters, cause eutrophication of water courses, look ugly, smell bad and spoil surroundings. Thus, there is a real need to get rid of them.

The more water is consumed, the more wastewater is produced. There are some 700 000 people without a connection to a water distribution network in Finland while less than 40 per cent of private wells fulfil all the quality and quantity criteria for potable water (Korkka-Niemi, Sipilä, Hatva, Hiisvirta, Lahti and Alfthan 1993). Most of those people are undoubtedly willing to acquire a connection as soon as it becomes feasible. At the same time some 5 000 new summer cottages are constructed and another 5 000 old ones are equipped with modern water facilities annually (Reijonen 2002). This means a quite radical increase in water consumption and wastewater production.

This development is further hastened by general development in agriculture and animal husbandry. The number of active farms is decreasing while their size is increasing (Uusi-Kämppä 2004). As, for example, cattle sizes are getting bigger the volume of wastewater from milk production is also growing. Many rural development projects are having the same effect. Increasing tourism, small scale wine, berry, jam etc. processing as well as horse stables are all activities that increase the wastewater load.

The new century brought along new laws and regulations concerning on-site sanitation (Paper IV and Chapter 8). It is obvious and absolutely necessary to research what kinds of management options are needed and acceptable to make on-site sanitation as successful as possible. This is especially true considering that totally new stakeholders are entering the field. Therefore, new rules for the game are needed.

One special problem waiting for a solution is appropriate sludge management. According to the Waste Act, sludge from septic tanks and wastewater containers is also considered waste generated by households and is thus to be collected and treated properly like any other household waste. There are several examples which clearly show that this does not happen in practise. Ekola (2003) found that only about 10 – 15 percent of all the sludge from on-site systems is collected and treated subject to proper monitoring and control.

> *Anon (2004 a) described in the 6th October 2004 issue of the Aamulehti newspaper a court case where some companies in the sludge transportation business in southern Finland were suspected of giving false information about the amount of sludge transported to wastewater treatment plants. According to the newspaper, the companies had kept no record of the amounts. The amount of the sludge in question is not small: over 40 000 m^3 of sludge in the nine year period of 1991-99. It is obvious that the cases described here are not the only ones in the country as was suspected in the article.*

Viitala (2001) studied the performance of small sewage treatment plants in the Pirkanmaa region. She noticed quite a few problems in the operations of the plants designed for 10 – 150 person equivalents. The problems were mainly caused by the selection of the wrong technological solution or by inadequate operations and maintenance. The same was true also

in the United States according to Wynn (2002): even commonly approved systems can fail if they are not properly maintained.

There are a number of examples about the implementation of the new legislation which show the relevance of the research. Because of the nature of on-site sanitation the final responsibility - both by law and in practice - for dealing with wastewater lies with house owners, and as long as the rules are unclear there is the danger of a lot of resources being wasted.

> *One example was given by Ojanperä (2003): a Finnish family first installed a poorly functioning treatment unit and struggled with it for about four years until they had to replace it. This happened because they were no given proper recommendations or advice on how to follow the principle of BAT (best available technology) when selecting the treatment method.*

Weather conditions are a factor that must always be considered in a northern country like Finland. Wastewater is also a big problem with summer cottages, not only year-round housing. The major difference between these two is that the former ones may be vacant for months. In winter conditions this brings the danger of the freezing of water equipment into the picture. Frozen piping, for example, bursts easily, and the whole building can suffer moisture damage. Thus, a totally different sanitation solution than flush toilet, should be developed for summer cottages (Reijonen 2002).

Different types of wastewaters generated in rural areas need different treatment solutions. The need for more advanced knowledge and information has given rise to a number of projects dealing with this issue. A recent project is called Waters in Food Chain. The project is aiming at securing and improving water quality in water courses by introducing more efficient wastewater treatment systems to all levels of small scale food stuff production. (Mäkelä 2004)

The more new types and modifications of on-site sanitation systems are developed and installed, the more requirements are set for the persons operating them. And even the simplest ones need regular maintenance (Wynn 2002).

Even though this research is done in and for an industrialised country like Finland, the need of the rest of the world are not forgotten. Most cities in the developing countries cannot afford the necessary resources, in terms of water, money and institutional capacity, to provide flush toilet systems with appropriate centralised wastewater treatment (Esrey et al 1998). There are more than two billion persons without proper sanitation facilities in the world (Millennium Project Task Force for Water and Sanitation 2004) and especially those who live in slums and rural areas are not able to utilise the flush-and discharge systems. They are bound to so-called drop-and-store devices (usually pit toilets) (Esrey et al 1998). This research will hopefully also be helpful in considering the appropriate solutions for those billions of people.

When discussing the sanitation services in the developing and the industrialised countries, it is often forgotten that the issue has not been completely solved in the latter, either. The official service coverage figures are estimated to have decreased by 2 per cent between 1990 and 2002 (Stedman 2004). This shows that the issue of appropriate sanitation must be kept on the agenda continuously. In a sparsely populated country like Finland, centralised wastewater treatment systems are not possible everywhere just because of great distances. The costs

would be too high: the costs of constructing water and wastewater pipes from main lines onwards can cost up to 100 euros/m (Kankaansydän-Lahtinen 2003).

There are also problems that are common to Finland and the developing world: pit toilets in the latter and poorly constructed wastewater infiltration systems or leaking wastewater containers in the former can both pollute groundwater and the water well of the household in question or that of its neighbour (Esrey et al 1998, Holm 1999). Therefore, each society needs to increase awareness of the link between contaminated water and disease. The effective dissemination of different research results and/or experiences from actual cases of contamination as well as the reasons for it could lead to remarkable results in diminishing the negative impacts of wastewaters (Holm 1999, McCann 2004 a).

5.1.2 Environmental need for research on on-site sanitation

Recreational activities are valued more as people's free time has increased. While in the past water courses were considered mainly from the transportation, electricity production and water supply points of view, today swimming, fishing, sailing, etc. recreational uses of water courses are seen as important. Good water quality plays an important role in satisfying these recreational needs. (Figure 10) Increasing water consumption and amounts of wastewater are causing increasing leaching of nutrients into water courses and are accelerating the process of eutrophication.

Figure 10. Blue green algae bloom can be poisonous, thus preventing recreational use of water. A peaceful beach at Lake Vanaja in the summer of 2003.

Different branches of the Finnish tourism industry also depend on a clean and wealthy environment nowadays. Travel agencies are selling refreshing moments in pure nature. (http://www.visitfinland.com) Actually, the need to improve on-site sanitation is based on the path dependence theory. After selecting clean nature as a marketing brand, we are forced to take care of the quality of water in rivers, lakes and the archipelago.

The eutrophication process of lakes and the Baltic Sea requires that we do our utmost to minimise the wastewater load independent of its origin. Figure 1 depicts this stage: National water protection targets and policies require the best possible rules and regulations and management practices in on-site sanitation to stop the deterioration of water courses.

One might think that on-site sanitation concerns mainly eastern and northern parts of Finland where distances between houses and villages are long and the population is small. Thus, it could be a surprise that there are some 116 000 persons outside sewerage networks within the operational area of Uusimaa Regional Environment Centre around Helsinki (Yli-Tolppa and Vaitomaa 2002). The wastewaters of these people are loading the Gulf of Finland together with other sources.

For an ordinary house and/or summer cottage owner the Baltic Sea can be a bit too "far away" to worry about. The quality of the nearby environment of their own yard or village and water wells and/or springs is much more important to them (Figure 10). Where on-site sanitation has earlier been managed badly, it has had unpleasant effects on small rivers and lakes, and even some wells.

Inadequately treated wastewater is also a danger to ground water resources. In Hausjärvi municipality in Finland it was observed that 20 per cent of private wells did not fulfil the bacteriological quality requirements for drinking water (Tapaninen 1997). Some of these wells might have been polluted by wastewaters, some by surface runoff water. Failed septic systems are the most often reported source of ground water contamination in the United States and about 50 per cent of all known waterborne disease outbreaks in the USA are attributed to contaminated groundwater (Wynn 2002).

When discussing on-site sanitation from the environmental point of view, a more global issue should be considered: phosphorous. It is one of the nutrients causing eutrophication and is a limited natural resource. It is estimated that phosphorous reserves will be exhausted in about 60 years at the present rate of consumption. (Werner, Fall, Schlick and Mang 2003). That is why a new way of thinking about wastewater treatment, ecological sanitation, has been emerged. One of the basic ideas of ecological sanitation is “closing the loop” –idea (Figure 11), which aims at utilising the nutrients in urine and faeces in food production instead of wasting them by allowing them to leach into water courses (Esrey, Andersson, Hillers and Sawyer 2001).

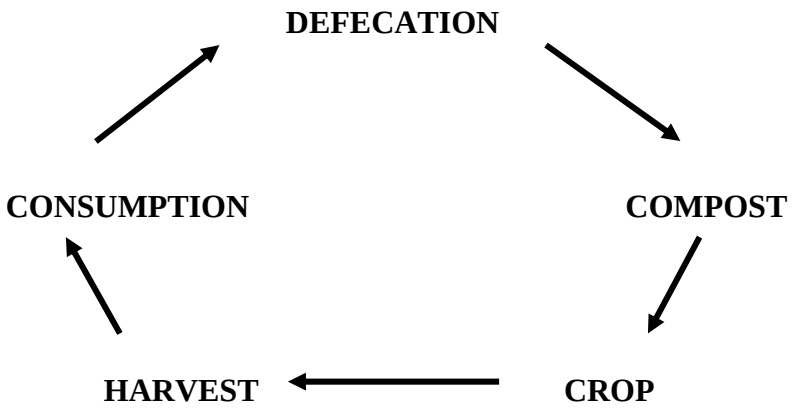


Figure 11. “Closing the loop” -principle of ecological sanitation (Esrey et al. 2001).

The principle of “closing the loop” is widely discussed in the sanitation sector today. In the developed world the matter is topical mainly due to the condition of the water bodies and in the developing world because of the ever increasing demand for fertilisers for food production and water for everyday living, irrigation and industrial purposes.

Actually, reuse of water and nutrients have been an important topic in many of major international water and wastewater related seminars and conferences as well as professional journals during the last years (Falkenmark 2004, Miller, Wert and Beaudoin 2004, MacCann 2004 c). Moreover, some countries like Sweden, the Netherlands and Germany have evaluated the possibilities of recovering phosphorous from wastewater and toilet wastes in food production. Sweden has set an intermediate target (under evaluation by the government) of restoring at least 60 per cent of the phosphorous in wastewater to productive soil, of which half should be returned to arable land (Stark, Levlin and Hultman 2004).

Tilman, Fargione, Wolff, D’Antonio, Dobson, Howarth, Schindler, Schleisinger, Simberloff and Swackhamer (2001) have calculated that if the past trends in population growth and food production continue, some 10^9 hectares of natural ecosystems will still be converted to agriculture by 2050 which would lead to a 2.4 - 2.7 fold increase in nitrogen- and phosphorous-driven eutrophication. This development could be stopped by implementing the “closing the loop” principle.

The importance of the subject is also indicated by recent textbooks on water management. For example, Matsui, Henze, Ho, and Otterpoohl (2001) present ecological sanitation as one important option for urban sanitation in “Frontiers in Urban Water Management, Deadlock or Hope”.

It is not only the need to reuse nutrients but also water, which forces rethinking the options for wastewater management. For example, in the Near East - Israel, Palestine and Jordan - there is a great need to meet water resource demands through effluent reuse (Scott 2003).

However, while the importance of recycling of water and nutrients in nature has to be recognised, one should not forget the spreading possible accumulation of different kinds of chemicals and drugs in faeces and especially in urine. This matter is under careful study by centralised wastewater treatment plants today. Certainly, it has to (and already has to some extent) be taken into account in decentralised systems as well (Ledin, Eriksson and Henze 2001, Matsui et al 2001, Vienonen 2003).

One important fact to be taken into consideration in Finnish conditions is the energy consumption of summer cottages equipped with "modern water equipment". According to Reijonen (2002) summer cottages that already have the equipment plus the ones under construction today (about 5000 annually) and the ones being renovated (about another 5000 annually) consume a significant amount of energy especially during the cold winter months January and February. Reijonen has estimated that it requires some 500 MWh peak power to keep the water equipment unfrozen in these summer cottages while most of them are uninhabited in winter time. The energy consumption is equal to about 35 -50 per cent of the output of the new nuclear power station to be constructed in the beginning of the new century in Finland. Thus there is a real need to develop sustainable sanitation technology and management practices also from this point of view. Reijonen has estimated that summer cottage owners will invest almost 500 million euros in the water supply systems in the coming 10 years.

5.2 Performance and costs of existing on-site sanitation systems

There are a few researches done on the performance of different on-site sanitation systems during the late 1990's and early 2000's. The latest one reported in Finland describes the existing stage of the development quite well. The results of the Ravinnesampo-Project (2002 – 2004) show that there are efficient enough on-site systems available. The requirements concerning BOD and nitrogen removal for decentralised sanitation given in the legislation, 90 per cent and 40 per cent respectively (more detailed in Paper IV), can be fulfilled by utilising almost any of the systems in the market. The more challenging requirement of 85 per cent is the one concerning phosphorous removal (Vilpas 2005). The results of the Ravinnesampo-Project are summarised in Figures 12 – 14.

Figures 12 – 14 show also quite well how big variety of technological solutions there are for on-site sanitation systems. The Ravinnesampo-Project could not include all the available systems in the research, but the most typical and popular ones are included. Only one of the most popular ones is missing: soil infiltration was not researched in this connection. The treatment efficiency of soil infiltration can be compared with the same of soil filtration due to the same operation principle the difference being disposal of treated wastewater: in a soil filter, treated water is collected into a inspection well via drainage pipes while in soil infiltration, treated wastewater ends in groundwater and that is why the treatment capacity of the system is rather difficult to measure.

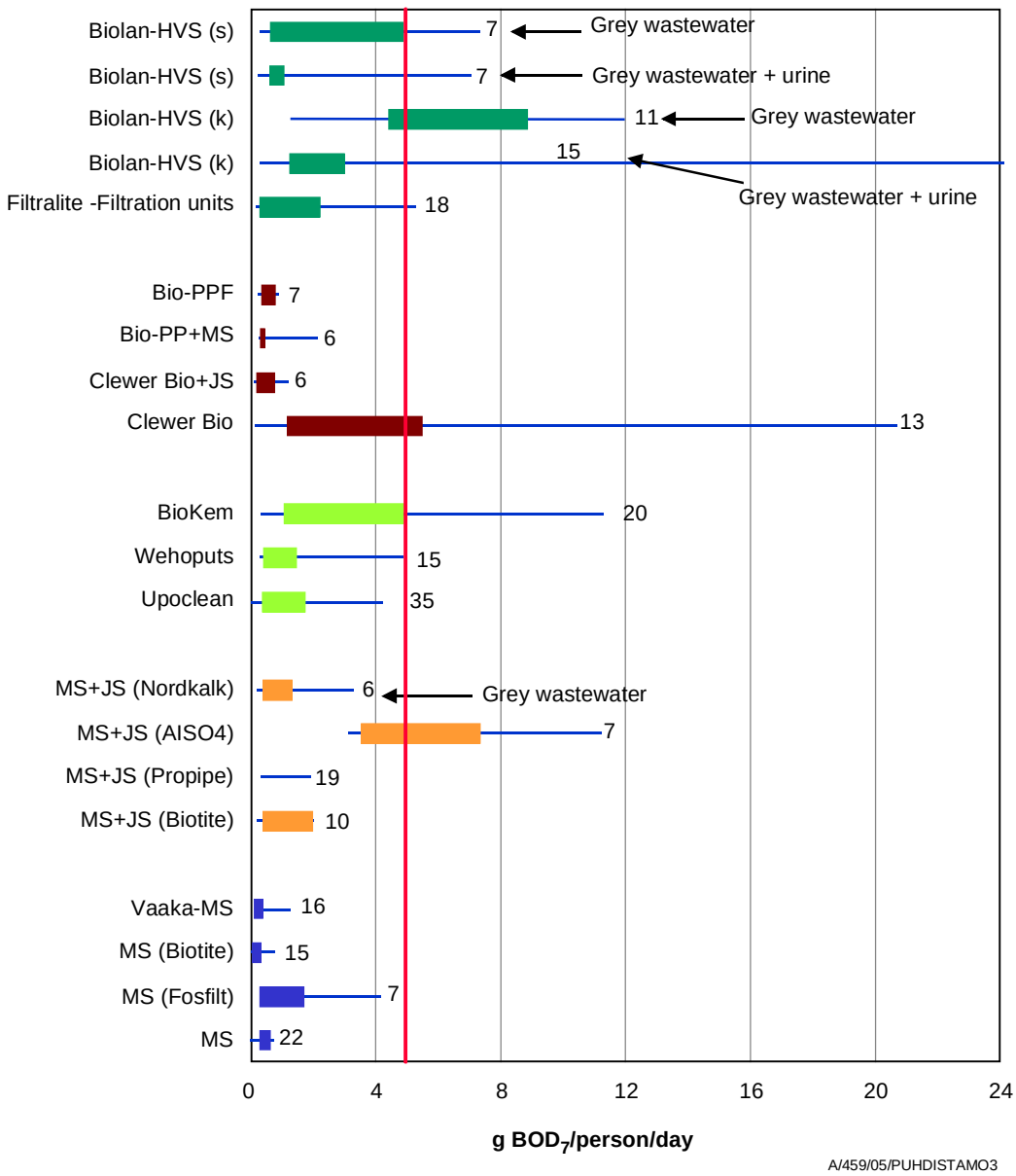


Figure 12. Organic matter (in BOD_7) in the effluent of the researched on-site wastewater treatment systems in the Ravinnesampo-Project. The coloured segment of a line describes the values of 50 percent of the water samples analysed. The highest 25 percent of the values are situated on the line right side of the coloured area and the lowest ones on the left respectively. The red line shows the allowed discharge by the decree (Paper IV) and the number at the right end of the line gives the number of water samples taken and analysed. (Vilpas 2005)

The researched wastewater treatment systems are as follows:

- Biolan HVS (s) grey wastewater filter utilising moss as filter media
- Biolan HVS (k) grey wastewater filter utilising coconut as filter media
- Filtralite filtration grey wastewater filter utilising Filtralite as filter media
- Bio-PPF biofilter with phosphorous precipitation
- Bio-PP + MS biofilter with phosphorous precipitation and soil filtration
- Clewer Bio + JS biofilter with phosphorous removal by filtration (Propipe 1400Filt)

- Biokem sequencing batch reactor system with chemical phosphorous removal
- Wehoputs sequencing batch reactor system with chemical phosphorous removal
- Upoclean sequencing batch reactor system with chemical phosphorous removal
- MS + JS soil filter with phosphorous removal by filtration (filter media or its producer in brackets)
- Vaaka-MS horizontal soil filter
- MS soil filter, if constructed with special filter media for phosphorous removal, the name of the media in brackets

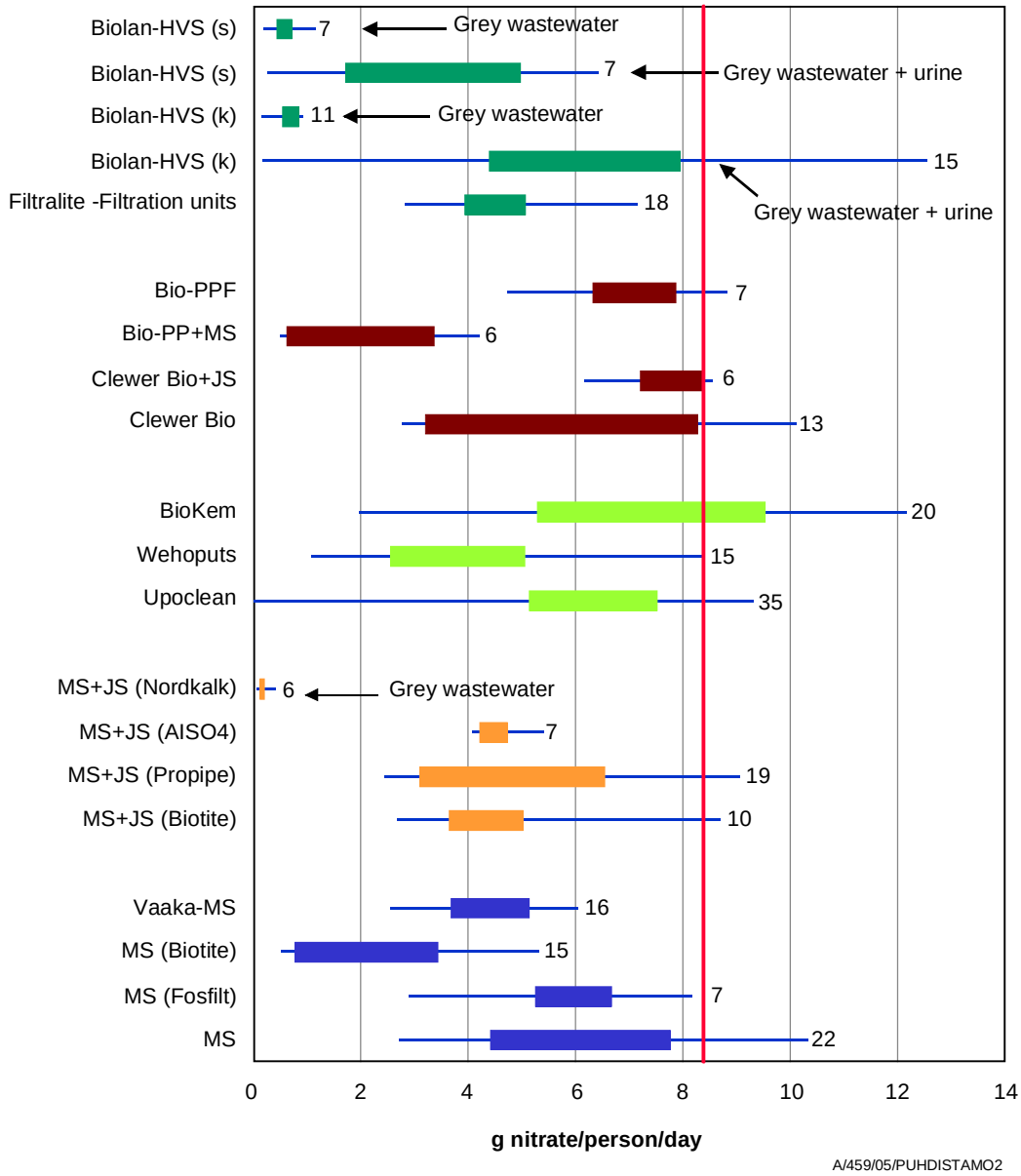


Figure 13. Total nitrate in the effluent of the researched on-site wastewater treatment systems in the Ravinnesampo-Project. The coloured segment of a line describes the values of 50 percent of the water samples analysed. The highest 25 percent of the values are situated on the line right side of the coloured area and the lowest ones on the left respectively. The red line shows the allowed discharge by the decree (Paper IV) and the number at the right end of the line gives the number of water samples taken and analysed. (Vilpas 2005)

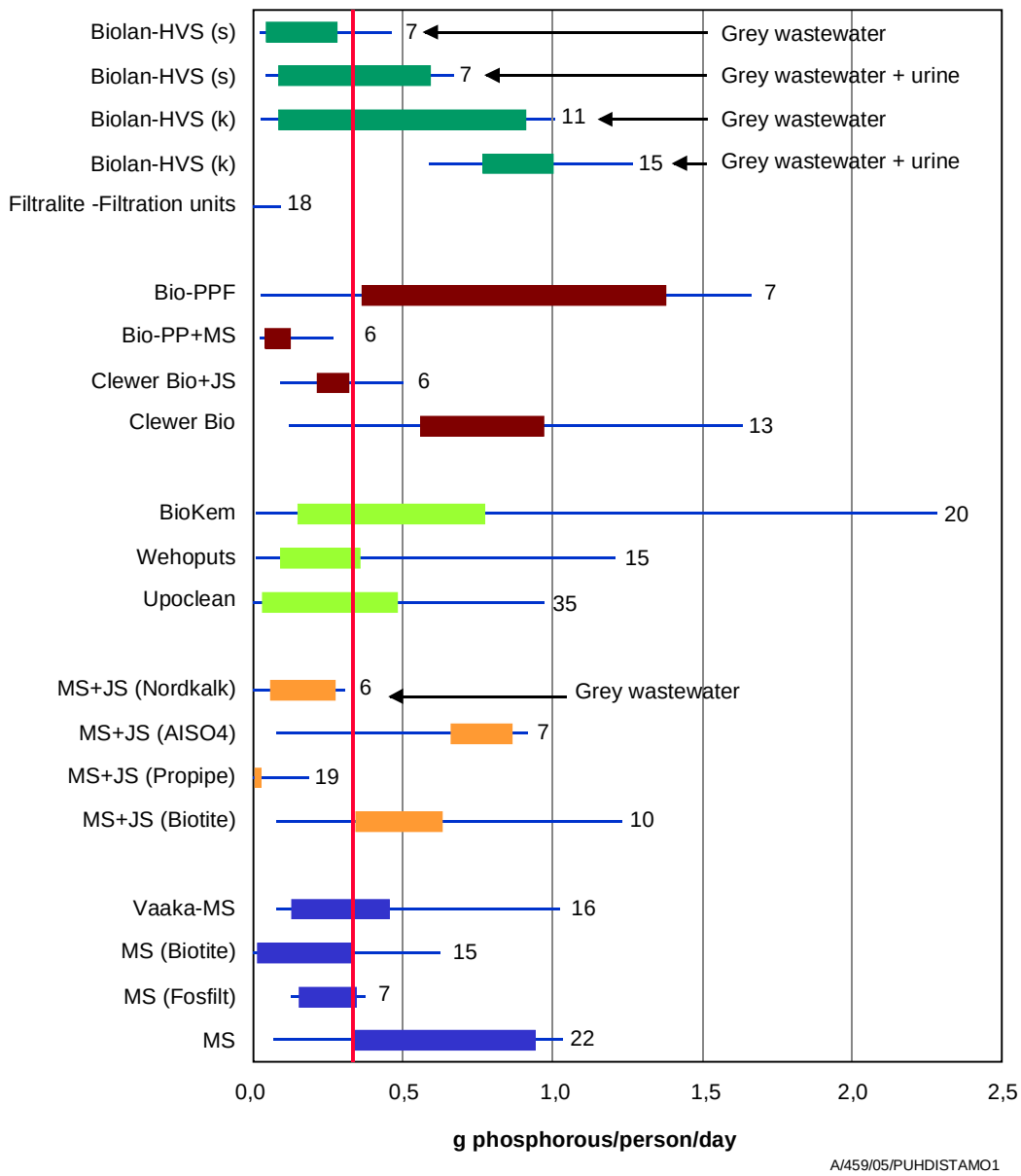


Figure 14. Total phosphorous in the effluent of the researched on-site wastewater treatment systems in the Ravinnesampo-Project. The coloured segment of a line describes the values of 50 percent of the water samples analysed. The highest 25 percent of the values are situated on the line right side of the coloured area and the lowest ones on the left respectively. The red line shows the allowed discharge by the decree (Paper IV) and the number at the right end of the line gives the number of water samples taken and analysed. (Vilpas 2005)

The final report of the Ravinnesampo-Project concludes that most of the on-site systems could meet the given requirements if only:

- the systems were selected and designed to fit the conditions on the sites,
- the systems were selected to fit the skills and interests of the house owners and
- the systems would be constructed, operated and maintained according to instructions. (Vilpas 2005)

In the Hajasampo Project, the average wastewater quality parameters for septic tank effluent were:

- suspended solids 71 mg/l
- BOD_7 230 mg/l
- total phosphorous 16 mg/l
- total nitrogen 110 mg/l
- nitrate/nitrite-nitrogen 0.34 mg/l
- faecal coliform bacteria 4 700 000 units/100 ml.

While the effluent from, for example, ordinary sand filtration included:

- BOD_7 11 mg/l (mean value)
- total phosphorous 6.8 mg/l (mean)
- total nitrogen 64 mg/l.

(Kujala-Räty 2004 a)

These results meet the treatment requirements (BOD_7 removal of 90 per cent, P removal of 85 per cent and N removal of 40 per cent) of the decree as to BOD and nitrogen (BOD removal 95 and N removal 42 per cent). The results would have even better if the comparison could have been made in accordance with the decree: effluent should be compared with the so-called house-specific wastewater load. It can be done by multiplying the number of occupants of a house by the average wastewater load per person and day which is equivalent to 50 g of BOD_7 and 2.2 g of total phosphorous plus 14 g of total nitrogen (Paper IV). This comparison would also take into account the treatment efficiency of septic tanks. In Hajasampo Project the number of members of the households was not recorded, thus, the comparison cannot be made in accordance with the decree. Later on, total phosphorous removal methods have also been developed further as seen from the Figures 12 – 14.

The big variety of the systems and many times quite challenging conditions on the sites make it necessary to get professionals in on-site sanitation involved in all the stages of appropriate on-site sanitation. The Environmental Protection Act (86/2000) requires that the Best Available Technology (BAT) is to be used to protect our environment, and we cannot assume ordinary house owners to follow up product development continuously. This matter is discussed more thoroughly in Chapter 8.1.1 and also in Paper IV.

The costs appropriate on-site sanitation cause in the other hand to one house owner and in the other hand to Finnish national economy can be seen from several angles.

If a house is equipped with a dry toilet and the amount of grey wastewater produced is minimal, the only task required is to make sure grey wastewaters are led into the soil instead of allowing them to flow freely in surface water source (Environmental Protection Act [86/2000, 103 §]) and to take care of proper composting of faeces. There are tens of thousands of this kind of sites in Finland, where the costs of appropriate on-site sanitation are minimal.

Anyhow, most of the houses in rural areas are to invest in their on-site sanitation within the coming ten year period to meet the requirements given in the decree. The costs vary a lot from one site to another. The amount and quality of wastewater produced, the topography and soil quality, distances to the groundwater level, surface waters, neighbours and their wells as well as to the main road etc. distances important for maintenance activities are facts affecting the choice of the system. And the interests and the wills of the house owner must not be neglected as described in Paper I. Saralehto (2000) has presented the average costs of on-site sanitation

in Finland with different technologies are estimated for the time period of 15 years. These costs are also compared with a connection in a centralised sewerage system (Table 3).

Table 3. The costs of on-site sanitation in Finland with different technological alternatives compared with a connection in centralised sewerage system (Saralehto 2000, modified and translated by the author).

On-site sanitation system	***Investment costs, €***	***Operation costs, €/a***	***Total costs per system divided equally for 15 years of operation, €/a***
Connection in centralised sewerage system	1200	455	535
Soil infiltration	3 000	200	400
Soil filtration	3 700	200	450
Soil filtration with phosphorous removal unit	5 700	550	930
Double sewerage; black wastewater in a cess pool and grey wastewater in soil treatment	4 000	500	770
All wastewaters in cess pool	1 350	3 000	3 090
Biological/chemical patch treatment unit for a single house	6 000	250	650

It is interesting to notice how expensive the alternative where all wastewaters are collected into cess pools is. Still, it is one of the most popular choices especially in many areas (potential ground water resources, lake shores, river banks), where water toilets are wanted and allowed and where water deterioration is a major concern.

Peltola (2005) calculated the cost efficiencies of different on-site sanitation alternatives as to their phosphorous removal capacities and compared them with an option to join in a centralised sewerage system. The calculations were made for 20 years of operations. The results show that it takes 0.20 – 0.34 euros to remove one gram of phosphorous out from wastewaters no matter whether the centralised system or the decentralised one is chosen. Anyhow, there is one exception from this general rule: a system relying on a cess pool for all wastewaters is taking 0.84 euros per removed one gram of phosphorous. In accordance with Peltola's calculations, the most efficient system in this respect is a dry toilet and grey wastewater infiltration, which takes 0.18 euros per removed one gram of phosphorous.

What comes to the costs caused to house owners by improved sanitation, it should not be forgotten, that the aim of the new legislation is to avoid deterioration of the near by environment of the houses in rural areas, eutrophication of lakes and rivers and pollution of groundwater. Thus, finally the costs invested in improved sanitation systems might raise the value of the houses. This is the issue, which requires further studies already in near future.

The costs involved in improving on-site sanitation in Finland in the coming decade are enormous. Vehmanen (2005) has estimated that the value of the whole process will be 1 – 1.5 billion euros. Thus, the business in the sector is quite remarkable, and there are, for example, already about 40 wastewater unit manufacturers in the country. The expanding business attempts also entrepreneurs which have no previous experience on wastewater treatment. That is why it is recommended that house owners should always rely on professionals only when planning to improve their sanitation system.

6 SOCIAL DEVELOPMENT OF TECHNOLOGY AND ON-SITE SANITATION

According to the theory of Social Construction of Technology (SCOT), a solution to a basically technical question emerges through discussions and/or on the basis of public opinion rather than through selection of the best possible technical artefact. The theory is therefore highly applicable to on-site sanitation. When the matter is considered purely from the technical point of view, dry toilet technology combined with soil treatment for grey wastewaters is certainly the most reasonable solution in most cases. But due to social pressure and many other factors, the flush toilet technology has prevailed over the technical facts and has been "selected" as the best alternative by house owners (Figure 6).

A rather new study on social learning in water supply technology and understanding of the role of water resources in an individual's life was conducted The School of Water Sciences, Carnfield University, UK. The university has produced the social learning model. The developed Personal Barometer application is aimed to ease the learning process by assessing interactively personal and household water use behaviour on water resources sustainability within the user's home region. Even if this application first and foremost guides freshwater use, it nevertheless also increases the user's awareness about the vulnerability of nearby water resources and can consequently be used in promoting proper sanitation practices as well. The Personal Barometer has been the subject of a study focussing on evaluating its usefulness for participation and engagement (McIntosh and Jeffrey 2004). This type of tool could be developed further into an element guiding individuals through the jungle of selecting the appropriate on-site sanitation system.

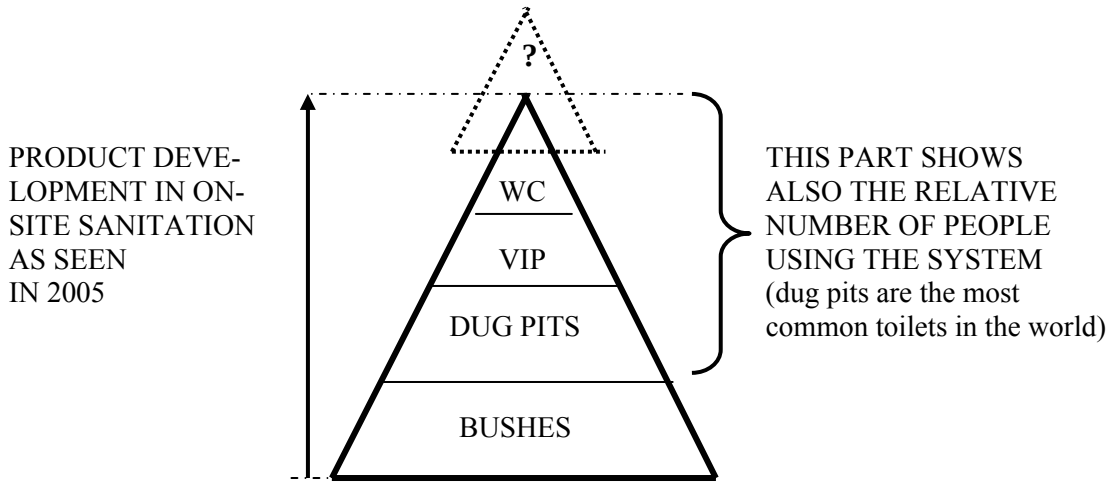
When the SCOT theory is combined with path dependence theories, one can say that in addition to the "lock-in by historical events" solutions, there are also secondary "semi-lock-in solutions", which have been introduced thanks to SCOT. The selection of the flush toilet technology in cities did not lock in the technical solution of sanitation in rural areas. But discussions about smells, flies, etc. turned the public opinion in favour of water-borne solutions, i.e. flush toilets, also in on-site sanitation. In many areas the solution was also favoured by the existing water distribution pipelines. While the flush technology has dominated, product development of the more ecological alternative has not progressed.

6.1 Public acceptance of DESAR

Vision 21, which emerged from the Second World Water Forum, held in The Hague in March 2000, gave the target of providing water and sanitation services for all by the year 2025 (Paper I). At the United Nations Millennium Summit in September 2000 the Millennium Development Target 10 (one of several Millennium Development Goals) of cutting in half the world population without proper water supply was adopted and the similar sanitation target was added at Johannesburg World Summit in 2002 (Millennium Project Task Force for Water and Sanitation 2004). These targets are naturally set mainly to improve the situation in the developing world, but the state of the water supply and sanitation sector in the industrialised countries should not be neglected, either.

Continued product development in the sector requires the rich countries to be heavily involved in the process aiming towards the Millennium Development target 10. Because there

are number of countries which will never be able to afford flush toilet and sewerage systems, a more advanced solution or solutions must be developed. Pit latrines have caused contamination of local groundwater sources, and sewerage systems are "leaking" valuable nutrients out of the loop (Figure 11). It seems that the poor sustainability of existing systems forces us to improve them and look for alternatives (Drangert 2003). And as product development continues in all other sectors and with all other equipment, why should we accept the existing WC (water closet) technology as the last step or most advanced solution for on-site sanitation? How can it be improved or what is becoming after it? (Figure 15)



WC = WATER CLOSET
VIP = VENTILATED IMPROVED LATRINE
? = What will replace the existing flush toilet + sewerage technology?

Figure 15. The product development of on-site sanitation systems as it seems to be understood by most people in 2005. The WC is seen as the pinnacle of the development, which cannot be the case, if the targets for 2015 are to be met. (Drangert 2003, modified by the author 2005)

One example of possible development after the conventional sewerage system is described by Huber (2004). Huber's office building in Berching/Erasbach in Germany is equipped with the so-called DeSaR-system (decentralised wastewater treatment and reuse with separation concept), where each wastewater fraction is treated separately. This system takes into account wastewater fraction quantity and quality and therefore provides optimal treatment processes to avoid water and nutrient wastage. This alternative still relies on the flush toilet system, but it shows that the development work is progressing.

The involvement of the industrialised countries in the development of on-site sanitation technology is necessary, not only to meet the needs of the developing world, but also for their own people. There are some 120 million European citizens without access to safe drinking water and adequate sanitation. For example, in Belgium, Ireland and Southwestern Europe only about half of the population is connected to a wastewater treatment plants. (Bärlund, 2003)

Water conservation is receiving increasing attention around the world. Water reuse is studied and already happening in many places. The development in USA, UK and Australia is shortly described by MacCann (2004 b). Decentralised sanitation and reuse of treated wastewater is researched, for example, in BedZed, a new 100 dwelling housing unit close to London. There are several sites of this type across the world (see e.g. the list of visited sites, Chapter 1, page 24), and the experiences indicate that the dominating systems with flush toilets and huge sewerage systems with expensive wastewater treatment plants are not necessarily the last step in the evolution of sanitation.

People's attitudes and values as indicated in SCOT and path dependence of water supply and sanitation are to some extent slowing down the development work in the sector. Water- and sanitation-related needs should be co-ordinated and focused in an integrated fashion (including the aspects of quality, quantity, groundwater, vs. surface water and local socio-political settings). Yet, due to other than water-related issues the agencies struggling to find solutions to water and sanitation crises are severely underfinanced. The development co-operation agencies of the industrialised countries do have the technical expertise to help, but are at the same time hindered by political and budgetary constraints (Wolf 2003). One of the recommendations by Wolf (2003) to universities and research institutes: train future water professional in an integrated fashion.

One could assume that in Finland the interest toward managing wastewaters properly would be higher among summer cottage owners than among owners of year-round houses. This is due the fact that most summer cottages are located on the shores of seas, lakes or rivers. And, naturally, the quality of the nearby water body is of interest to the cottage owners. Also, the value of a flat or even an one-family house in a city is considerably higher if a water body is part of the scene opening from the window whereas in the case of a summer house meant for leisure time the scenery as such does not matter as much. The water body near the summer house must also be suitable for various uses.

Yet, it has been interesting to notice that many summer cottage owners do not see the connection between improved wastewater treatment (or actually their own responsibility for it) and the quality of the receiving water body. This conclusion can be drawn, for example, from the studies by Salokangas (2001) and Järvinen (2003). People always tend to notice first loads caused by someone else but not themselves. This has come out clearly on many occasions when public lectures on the subject of on-site sanitation have been given: summer cottage owners tend to blame farmers for the deterioration of the lake or river in question.

Public acceptance of DESAR technology and especially the operations and maintenance activities were also surveyed in the project called Ylläpitosampo. There were two research areas in Southern Finland, the villages of Sydänmaa and Herrala in the municipalities of Säkylä and Sipoo, respectively, where the interest toward both investments and operations and maintenance activities was explored. The study clearly pointed out the need for professional organisations to manage DESAR technology. There are many house owners who are not willing and/or capable of running the sanitation equipment and whole systems by themselves. The reason may be their high age, some physical restrictions, limited time for the needed work, etc. (Heikkinen 2003).

Similar findings are presented also in Paper II. USEPA (United States Environmental Protection Authority) has recommended centralised management of the operations and maintenance of decentralised wastewater treatment (USEPA 2001). Here the stakeholder

theories clearly come into the picture: the whole management process of on-site sanitation, starting with the needs and wishes of the house owner and covering the planning and construction processes all the way to operations and maintenance activities including, for example, the duties and actions by authorities and hardware store keepers, is not a simple network. It can be compared to a football team which should work as a unit towards the same goal playing by the same rules which are also understood the same way by all the stakeholders.

Quite an interesting picture of on-site sanitation is provided by "Purity and Danger" by Douglas (1996) (the first edition came out in 1966). Accordingly, when considering the nature (and the actual chemical and physical content) of faeces, one can seriously put the question: Is it really just filth to get rid off or is it a valuable resource to be put into use to benefit food production? This question will be taken up later on when discussing dry toilet technology as an alternative in the management of on-site sanitation.

Basically, no one is against the proper management of on-site sanitation. But as the SCOT theory explains, there are so many factors affecting it, that ideas about the appropriateness of different alternatives vary widely.

6.2 Development of DESAR technology

Liebowitz and Margolis (cited by Kaivo-Oja, Katko and Seppälä 2004) recognise three degrees of path dependence. The first one involves no inefficiency, the second one leads to outcomes that are sub-optimal and rather costly to change while the third one - the strongest one - leads to inefficient outcomes. In the case of on-site sanitation one could actually add a fourth degree to the list. Social Construction of Technology (SCOT) affects development so that there are also outcomes that could be called secondary effects which are somehow off the actual path but can still be said to be locked-in by historical events. The flush toilets in towns do not necessarily lock-in the sanitation technology used in rural areas but social pressure has made the development obvious (Figure 16).

The idea may become clearer if considered the other way round. If the development of sanitation technology had been driven by events in the rural areas, it is rather impossible to see how it could have led to the present situation where flush toilet technology is used. There is no sense in mixing urine and faeces with clean water only to transport them ten or fifteen meters into a relatively expensive and inefficient wastewater treatment system, which will require as much in the way of operations and maintenance effort as the dry toilet alternative.

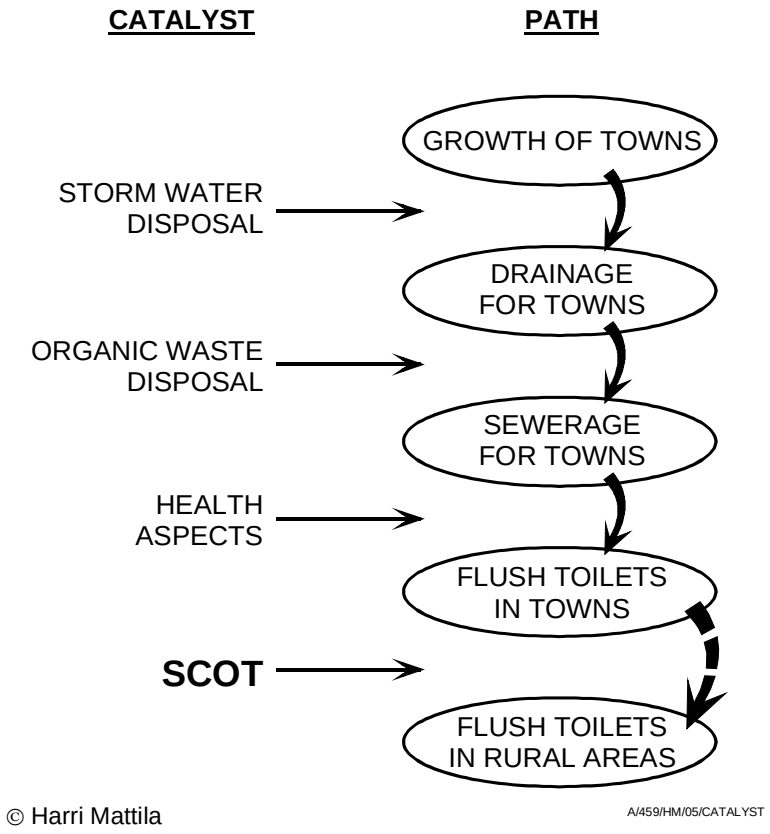


Figure 16. Path of sanitation development in towns and its side-result: flush toilets are coming to rural areas as well. SCOT is causing the fourth degree of path dependence.

It is quite possible to implement and manage an on-site sanitation system, which produces practically no environmental load at all. The technology is available, even in different cost categories: the dry solution is rather cheap while the flush solution requires more input. The question is how to "sell" an optimum solution to house owners.

Demand for the optimum solution must first be created. The selection of an on-site sanitation system is a highly personal matter, and the final decision should always be made by the persons using the system. For example, even if the optimal solution in many cases would be a dry toilet, the "reputation" of the old dry toilet alternative called *huussi* in Finnish (no more than a waste container collecting both faeces and urine and inside a small hut) with all the smells, coldness in the winter, flies in the summer, etc. may be an unsurpassed obstacle to selecting it (Kiukas 2003).

The decision being a personal matter is quite evident also from the legal point of view: in accordance with new Finnish legislation (Sec 6 of the Act on Water Services, Sec 5 of the Environmental Protection Act), the responsibility for on-site sanitation stays with the house owner no matter what kind of technical solution is selected. The need for demand-driven alternatives is obvious on different projects and studies referred to, for example, by Nadkarni (2003), Wirbelauer, Breslin, and Guzha (2003), Bergnhøj, Eilersen, and Backlund (2003) and Wegelin-Schuringa (2001). The matter is discussed also in Paper I and in the conference

paper prepared and presented by the author at the 1st International Dry Toilet Conference organised in Tampere, Finland in August 2003 (Mattila 2003 b).

From the technological point of view, one should not forget that if dry toilet technology is utilised, there will be still grey waters that need to be treated on site, which is relatively easy (Paper IV). Reuse of grey water can also be arranged in areas where it is feasible, especially if irrigation is needed. Human contact with grey water should be avoided because of health concerns, and groundwater sources should be secured, but otherwise the reuse of grey water can be practised (Uleimat 2004).

Naturally, similar types of issues need to be researched in ecological sanitation as in conventional wastewater treatment. Different kinds of harmful substances such as medicine residues and organic micropollutants in excreta are under continuous research today (Jenssen 2004).

One fact supporting the principle of ecosanitation is the constantly increasing world population and its need of food. Studies have shown that the urine and faeces from one person include enough nutrients to fertilise some 300 – 600 m^2 of crops (Jönsson, Richert-Stintzing, Vinnerås, Salomon 2004).

A successful on-site sanitation system requires that all stakeholders in the on-site sanitation management network are involved and their ability to operate is developed to the level the new laws and regulations demand. This means not only higher awareness among house owners and education of authorities, but also the creation of new enterprises to design, construct, contract, operate and maintain the on-site sanitation systems. Thus, it also requires extra efforts in product development by the system manufacturers. This is discussed in Paper II.

In accordance with the new decree (Paper IV), on-site sanitation must be quite efficient: BOD-removal >90 per cent, phosphorous removal >85 per cent and nitrogen removal >40 per cent. Because of the difficulties (Kujala-Räty 2001) in taking many reliable wastewater samples and the high costs of analysing them and due to the limited resources of municipal environmental authorities, it is absolutely impossible to control the efficiency of each installed on-site system separately. Thus, the strict requirements of the decree are a big challenge to wastewater treatment unit manufacturers and designers who must be able to introduce systems capable of treating wastewater efficiently enough.

Know-how and skills will not, however, improve if on-site sanitation is not placed on engineering curricula in Finland. So far, the only subject taught on this area has been wastewater treatment in septic tanks, which, in accordance with the new requirements is considered only pre-treatment. The designers of on-site systems are mainly trained in different projects and /or short courses. The companies manufacturing treatment units or whole systems have trained their own staff and some hardware store keepers retailing equipment as well as designers about the special features of the equipment (http://www.uponor.fi/).

Of course, Finland is not the only country lacking skilled persons in the field of on-site sanitation. The path dependence leading to centralised systems has required professionals able to design and implement that kind of technological solutions. Centralised systems have required centralised management and that combination has served well the cities and towns they were designed for. Today, the urban surroundings and dynamics in most parts of the

world look very different from the ones the centralised systems were constructed for (Lundqvist, Turton and Narain 2001).

The training aspect of system designers and treatment unit and equipment retailers cannot be underlined too much. The list of drawbacks of on-site systems shown in Chapter 4, and other similar experiences from field work show that most difficulties can be avoided by careful pre-investigations. The selection of the right system for the right yard and its correct placement are the most important duties of a designer. The rest of the work is rather easy: there are number of sources of model drawings for the design work.

The following cases are examples of sites where careful pre-investigations were not done:

The designer never visited the site:

A house was to be constructed on the side of the hill. The soil was rather coarse, between sand and gravel, thus, the soil permeability was rather high. The area was already partly constructed and there were houses also downhill from the site of this coming house. Because of the high permeability, the building designer drew soil infiltration to be constructed. Because he never visited the site to observe also the neighbourhood, the water well of the next house only some 30 meters downhill from the site of the suggested infiltration would have been in danger of getting polluted. Fortunately, the infiltration system was never constructed, thanks to the Municipal Building Inspector who was careful enough when inspecting the permit for construction.

A couple was rehabilitating the old main building of a farm. The engineer designing heating and ventilation systems for the building was asked to design the wastewater treatment system as well. The soil filtration system was designed behind a barn just on two bases: firstly, from there it cannot be seen from the main building, thus, it does not disturb the scenery and, secondly that was the lowest place of the yard, thus, wastewater can easily flow there without pumping. The problem was noticed when implementing the system: that really was the very lowest place of the yard. There was no place for outlet from the soil filter! The solution was to design an infiltration basin after the soil filter. Thus, the house has a double wastewater treatment system which, of course, resulted in double costs.

The designer visited the site, but did not make careful pre-investigations:

The site was to be equipped with soil infiltration system, but neither infiltration tests nor soil sample investigations were implemented. The final system constructed was the soil filtration but the works started with materials for infiltration. Thus, it was rather expensive and time consuming for the house owner to stop the works on the site, to send the excavator contractor away and book another day for the works, to order more materials, sand and pipes, etc.

Yet, proper design does not necessarily mean a proper on-site sanitation system. Even the most advanced design can easily be spoiled by unskilled construction. In many cases the actual construction or installation is done slightly differently than originally designed. This is

most often due the fact that there is no sense (financially) in breaking a huge rock or the surface of the bedrock met when digging trenches for on-site systems. But there are also other reasons: changes in soil quality or different ground water table level than assumed. Thus, the more carefully the preliminary investigation is done, the more viable the design of the system. Of course, the differences between designs and actual implementation are not always the result of circumstances on the site. House owners' changing opinions and requirements, the contractor's wish to make the work easier, poorly selected materials, etc. might also ruin the system.

The following are giving examples of such sites:

Implementation of on-site systems was not done according to the designs:

A farmer had an enterprise that processed meat (smoke-cured products). Thus, the wastewaters from the farm were quite problematic as they contained much grease. The designer did not rely on the efficiency of a single wastewater treatment unit but proposed two parallel units. Wastewater was to be divided into the two units in a fabricated well designed for the purpose. On the construction site, the contractor and the farmer decided to save some money and constructed the water dividing well using old concrete rings found in the backyard of the farm. The result was that no wastewater entered the treatment units due to the leaking dividing well. Again, this all meant extra costs to the farmer who had to dig open the site and reconstruct it.

A house owner decided to change the location of the soil filtration system designed, in his opinion, for a too visible spot in the yard. The result was that the excavator reached the ground water level while constructing the filter. Thus, the implementation became more expensive than expected due to the required durable isolation material between the bottom of the filter and the surface of the ground water.

Maybe the most common way house owners are trying to save money is the use of ordinary sub-surface drainage pipes for infiltration in soil treatment instead of infiltration pipes especially designed for the purpose. This causes, firstly inefficient treatment results due to uneven distribution of wastewater in the filter and, secondly, shorten the lifespan of the system due to clogging phenomena. Once again, the "savings" in the implementation phase lead to extra costs later on.

In Finland, construction of on-site sanitation systems is controlled by municipal authorities. A building inspector from the municipal engineer's office is supposed to control that everything is done in accordance with the approved designs. Still, in the beginning of 2005, legislation (Land Use and Building Decree [895/1999]) requires this kind of control of wastewater treatment systems only for new buildings. The decree is now being amended, and it seems likely that the control will be extended to cover existing houses as well, that is, when the wastewater treatment system is rehabilitated to include more than just a septic tank, or some other major modification is done. This, for sure, would be desirable to reduce the number of failures to a minimum.

Actual control is exercised in connection with approving the designs, and the works at the construction site are controlled by Engineer in Charge, officially nominated for each construction site. The control of the works is discussed further in Chapter 8, but one matter will be taken up already at this stage, since it has a remarkable effect on the development of on-site sanitation. Unfortunately some municipalities are competing for inhabitants by interpreting the legislation too freely. Sometimes it is the "official policy" of the municipality and sometimes due to the attitudes of certain persons in charge, such as the inspector supervising construction sites (Paper I, Anon 2002).

All the mentioned issues show how sensible the management of on-site sanitation is as a process where many stakeholders are involved and where the strengths and operations of a stakeholder make a big difference to the operational skill of the entity. This is discussed more thoroughly in Chapters 5.2 and 9.

In accordance with the Finnish legislation, sludge from septic tanks and wastewater containers is considered household waste. That is why municipalities are supposed to organise its collection and treatment also in rural areas. This matter will be discussed in Chapters 7 and 8 in more detail. Let us start here by asking, what is it that makes septic tank sludge waste? Obviously, it is the faeces. Thus, the faeces of dry toilets and collected urine in its container should be considered wastes and their collection organised by municipalities as well. And as previously (Chapter 6.1) asked, are they really wastes or valuable resources for food production? The validity of the above questions should determine the future of the product development of dry toilet technology. For example, Stockholm Water Company is carrying out research on the use of separating toilets and utilisation of urine in agriculture (Johansson 2000).

The sites visited (listed in Chapter 1) showed that if dry toilet technology is to become a serious option for on-site sanitation in countries like Finland, where the lack of water for flushing is not a problem, a lot of work still needs to be done. Development is needed not only in the toilet itself but also in buildings and the whole society and infrastructure servicing it. People can afford service similar to that they have when connected to a sewerage system with a dry toilet, but some one must "sell" the idea of the dry alternative to them. It is obvious that the industry is not interested in manufacturing houses with more ecological sanitation alternatives unless there is demand for them in the markets.

Urban areas have also other alternatives than dry technology. Separating flush toilets could also be ecological. In that alternative urine with a minimum amount of water (so-called yellow wastewater) is collected separate from faeces and a minimum of flush water (so-called brown wastewater) already in the toilet bowl. Both fractions, yellow and brown, are then treated separately to improve the intake of nutrients for reuse. When grey waters are then collected and reused separately, ecological sanitation occurs. This technology is in use in the HUBER office building of 200 employees in Berching, Germany. The specific treatment and reuse of the produced material flows has been found to be cost-effective and sustainable. (Huber and Christ 2004)

The principle of not mixing different waste fractions on a wider scale, in three different cities, is described by Drangert (2004). He concludes that conventional sewerage systems are not affordable by all or they are managed poorly, and alternative technological and management options are needed.

There have been studies on the use of urine-separating toilets also in Finland. The municipality of Västanfjärd has been promoting new toilet technology, which allows urine to be collected and utilised in agriculture and horticulture. For example, Heinonen-Tanski, Sjöblom, Fabritius and Holopainen (2005) have noticed that urine can be used as fertilizer for cucumbers.

7 MANAGEMENT OPTIONS FOR ON-SITE SANITATION

It can be said that in the last century no management of on-site sanitation existed. The Water Act of 1962 stated that in rural areas wastewater must be treated in septic tanks or otherwise properly, but no one actually controlled what was going on. Finns are quite law-abiding people, and almost all house owners constructed septic tanks in their yards. Yet, no one controlled the operation of wastewater systems.

After the changes in the legislation, this issue has been studied, and it has been noted that only 10 - 15 per cent of septic tank sludge is collected and treated properly (collection is done by a registered collector, and treatment is recorded and controlled). In several projects examining the state of on-site sanitation it has been noted that people have not been sufficiently interested in taking care of their sanitation systems. And no one has controlled the condition of the septic tanks, not to speak about entire systems (Paper I, Viitala 2001, Aho 2002).

Now we have the new laws and regulations and the whole management system for on-site sanitation has to be set up almost from the scratch. Thus, practically all the options are still open. Here the weak path dependence between sanitation management in urban and rural areas presented in Figure 16 gives flexibility. Solutions for single houses are different than those for centres of towns, and new paths can open. The SCOT and the stakeholder theories are more applicable to this work. There are a great number of opinions, attitudes, knowledge, beliefs, policies, etc. affecting the development, and quite a number of stakeholders also have a role to play. The futures research must also be used since there are both technical and management alternatives which have not been tested in practice before.

7.1 Centralised wastewater treatment undertakings providing on-site sanitation

As soon as improved on-site sanitation systems (incorporating more than just septic tanks) were taken into use, management problems became obvious (Paper II). The first attempts to involve centralised wastewater treatment utilities in operation activities were made already in the first phase of the Lake Pyhäjärvi Restoration Project (1995 – 2000). Since the interest to get involved shown by the utilities (or by the owners of them, i.e. municipalities) was not enough, the project proposed to establish a company owned by municipalities capable of assuming these duties. The proposal was made in 1997 while the legislation was not yet as far developed as it is today. It proved that the time was not yet ripe, because there was not enough business on the horizon. (Mattila 2001)

It would be beneficial to get the wastewater undertakings involved in the management of on-site sanitation (Paper II). The professional skills of the staffs of undertakings could guarantee the good quality of the work done. Besides, this could even ensure the survival of small water supply and wastewater undertakings. There is a rather intensive migration process from rural areas into towns going on in Finland. It means that small wastewater undertakings are losing their customers and revenues. Thus, on-site sanitation could bring new business and new income to these undertakings.

Kujala-Räty (1984) proposed already 20 years ago that a solution to improve the operations of on-site sanitation systems could be to connect them to a centralised wastewater undertaking

based on a contract. The undertaking could take care of maintenance duties on-site and collect revenues just as it does from customers of the centralised system.

The new decree on on-site sanitation concerns all units treating wastewater similar to domestic ones designed for less than 100 population equivalent. According to Viitala (2001), many of the bigger units (bigger than a few households and less than the mentioned 100 population equivalent) are not functioning properly because of non-existent or inefficient management of the systems. These bigger systems mostly consist of chemical or biological/chemical treatment units. Thus, such systems should be quite familiar to staff of centralised wastewater treatment plants and they are capable to manage small systems properly at least after a rather short introduction to the operations. The wastewater utility of Ulvila municipality has taken the first steps in this direction.

> *The Technical Board of Ulvila municipality has decided (at its meeting on 19.2.2004, item 21§) that the municipal wastewater utility will take care of the operations and maintenance of the small wastewater treatment system for 5 to 7 houses to be implemented in a housing area situated too far from the sewerage network of the centralised system (Kaunisto 2004).*

Other water undertakings should also see households in rural areas as new paying customers rather than extra burdens. After all, big wastewater plants employ skilful professionals that can take care of decentralised wastewater treatment units and secure their better performance.

Naturally, Social Construction of Technology (SCOT) plays an important role in implementing on-site sanitation through big wastewater treatment utilities. Decisions made by municipal boards are highly political not to speak about the other matters referred to in Figure 6. But after the first decision is made, the second one is most probably much easier: on the one hand, the inhabitants of the municipality should be treated equally and, on the other hand, decision making is much easier when results of the first decision are known. Thus, path dependence also has a role to play in this type of decisions.

The policy in Finland today is to construct long sewer lines and convey wastewaters from rural areas into centralised wastewater treatment plants also from as many rural areas as feasible. However, this development can be called into question. The legislation highlights the individual's responsibility in protecting the environment. When wastewaters are treated sometimes tens of kilometres away from the place of origin, responsibility for disposed wastes may not be felt.

> *Let us take an example: no one would throw paper towels, diapers or the like into a sewer leading into the infiltration field of their own yard, because the field would be clogged pretty soon. Yet, the same person does not have any problem in disposing similar items into a large sewer network that carries the wastes far downstream for treatment (Rantanen 2004).*

Security also needs to be considered when comparing small systems with large ones. The possible harms, health hazards, etc. are distributed very efficiently by large schemes compared to smaller ones. This is the subject of discussions rather often today due to the increased danger of terrorism (Reina 2004).

7.2 Co-operatives operating on-site sanitation

There is a long tradition of co-operatives particularly in rural water supply in Finland (Katko 1997). That is why this type of the management of on-site sanitation is discussed separately in this research. A co-operative is worth considering as one alternative on the basis of a few factors, the most important one being the participatory decision making process - including decisions about the prices of the services - which helps people understand the facts behind the calculations. When prices are transparent they are also easier to accept (Paper III).

It is beneficial for a co-operative to have a professional sanitary engineer or someone else with wide experience from the field of sanitation technology to help in decision making, but as soon as different reasonable alternatives are known, the SCOT process produces results which can be accepted by all, even if they may be only "second best" alternatives.

There were a couple of relatively dry years (2002 and 2003) in Finland in the beginning of the 21st century (Kaatra 2003). This, and the new legislation concerning wastewater treatment in rural areas, made water co-operatives even more popular in Finland. And because the need for improved water services is also recognised by the authorities, they are supporting people in forming water co-operatives (Heinänen 2003).

The support for co-operatives can also be other than financial support. Uusimaa Regional Environment Centre (2004) is preparing a guide book called Vesiosuuskunnan ABC (ABC for Water Co-operatives) where all the stages of the lifespan of a water co-operative are explained and clarified. This kind of activity is one of the best ways of securing the good quality of water services in rural areas. Further more, it will certainly benefit house owners also financially when the systems selected conform to the principle of best available technology, BAT (Figure 17 in Chapter 8.1), as the construction phase is subject to better supervision and control and as the operation and maintenance tasks are often bought from professionals.

The use of community-managed systems to solve the problems of small scale water and sanitation services had been found effective also in the developing world, where the practical problems are often more serious than in the industrialised world (Lane 2004). So, if we have found a way to solve the management of on-site sanitation in various circumstances, why not encourage different stakeholders to apply this method also in the future.

> *Schiller and Schienle (2004) presents an example from North-eastern Brasil, where rural communities in the states of Bahia, Ceará and Piauí experimented with self-sustainable and self-administrated water supply projects under a special Health and Basic Sanitation Program. The program covered 48 rural communities and approximately 10 500 households with 52 000 inhabitants. They noticed that end users can regulate and monitor their own water supply and sewerage systems. But, all stakeholders must be involved: 48 user groups working in close cooperation with local and state public administration ensured that all the relevant parties in the area were participating.*

7.3 Small scale enterprises producing services for on-site systems

The Environment Protection Act has been in force in Finland since March 2001, and the decree based on the law giving the detailed requirements concerning on-site sanitation since 1.1.2004. Already in 2003 new enterprises offering their services in designing, contracting and running operations and maintenance of on-site systems were established. (Jokinen 2003, Kujala-Räty 2004 b) This is an important phenomenon considering the need to keep rural areas alive: new jobs are needed to help areas suffering from out-migration. Thus, improvements in on-site sanitation can also be reviewed from the angle, that they are not just an extra burden on house owners.

The critical factor is the training of these new professionals, and the control of the quality of their work. In the beginning the training was mainly provided by different water protection and/or restoration projects. But after the legislation was amended, for example, Häme Polytechnics and Finnish Environment Institute have been running courses on the subject (Anon 2003, http://www2.hamk.fi/ymparistoteknologia/). In future, on-site sanitation will occupy a more visible role in the curricula of all polytechnics which will help establishing new enterprises in the sector.

One factor which is considered to favour small scale enterprises over big consulting firms is the small scale of the design input needed per site which keeps the cost rather low. The professionals in the field of on-site sanitation also proposed setting up new special enterprises when they compared various future scenarios about possible stakeholders in the sector. This matter will be discussed more in Chapter 9.

One path that society in general has followed is having everyone specialised on a certain field of activity that he/she knows best. Big companies are nowadays outsourcing quite a few services which were originally performed by their own staff but are no longer seen as core business. The same has happened also with smaller companies and during the last couple of years also with households. The more people get used to buying cleaning, repair and maintenance for their houses the more likely it is that the small scale enterprises running on-site sanitation systems will survive.

The current taxation policy in Finland which favours households buying services from private companies or entrepreneurs supports the described development. This is the case when a person pays an enterprise for cleaning his/her house, for a small scale renovation, for maintenance, etc. (Tuloverolaki [1535/1992 127 a – c § and changes 995/2000, 1162/2002 and 1273/2004]) This type of indirect incentive is very beneficial for both the house owner and the entrepreneur. And it could be the best way to support the development of high quality on-site sanitation as well. Small enterprises would get more work, and the house owners would get professional quality at a subsidised prize.

Actually, the financial incentive by the government should in one way or another be addressed to support quality development in the sector instead of purely subsidising the investments of house owners. If the limited amount of euros is distributed equally between all households making the necessary investment, there will be only some ten euros available per household. But by ensuring the good quality of works, we could extend the lifetime of on-site systems by years, which would bring savings of hundreds of euros to a house owner. The financial matters are naturally subject to wide public discussion (for example Kinnari-Kuparinen 2004), and it has been noted that the government should support households only

on the basis of social reasons. The decision is up to municipal authorities. They know the local conditions and applicants best.

The creation of small scale enterprises for on-site sanitation in Finland is supported by different parties. Fise Oy Ltd (a company owned by 14 different organisations for professionals (Table 4) in Finland) is creating an optional test for those interested in working in the field of the on-site sanitation by which they could prove their professional qualification. The system is under development and is expected to be operative within 2005 (www.fise.fi).

Table 4. Owners of Fise Oy Ltd (www.fise.fi). The organisations owning Fise Oy Ltd are all associations, or similar, for different professionals in construction or related business. Fise Oy Ltd grants certificates of proficiency for different duties within construction business.

Official name of organisation	**English translations**
Rakennusinsinöörit ja –arkkitehdit RIA ry	The Association of Finnish Construction Engineers and Architects RIA
Rakennusmestarit ja –insinöörit AMK RKL ry	The Association of Finnish Construction Technicians and Engineers AMK RKL
Rakennustarkastusyhdistys RTY ry	The Association of Construction Control RTY
Rakennusteollisuuden koulutuskeskus RATEKO	Specialised Vocational Institute of Confederation of Finnish Construction Industries
Suomen Betoniyhdistys r.y.	Concrete Association of Finland
Suomen geoteknillinen yhdistys ry	Finnish Geotechnical Society
Suomen LVI-liitto, SuLVI ry	The Finnish Association of HVAC Societies
Suomen Rakennusinsinöörien Liitto RIL ry	RIL – Finnish Association of Civil Engineers
Teräsrakenneyhdistys ry	Finnish Constructual Steelwork Association
Wood Focus Oy	Wood Focus Ltd
Insinööriliitto IL ry	Union of Professional Engineers in Finland
Julkisivuyhdistys ry	Finnish Facade Association
Suomen Konsulttiyhdistys SNIL ry	The Finnish Association of Consultants SNIL
Maanalaisten tilojen rakentamisyhdistys r.y.	Finnish Tunnelling Association

The role small scale enterprises could have in operating on-site sanitation systems is discussed in Paper IV. There is no possibility of municipal authorities visiting regularly all sites to control whether on-site sanitation systems are operating properly or not. Yet, it has been known already for a long time that on-site systems require regular control and operation and maintenance almost daily (Kujala-Räty 1984).

Therefore, management should rely on professionals monitoring and maintaining on-site sanitation systems. The authorities could then control the work of these professional operators. In the case of a non-operative system, the operators should be allowed to report not only to the house owner but also to the municipal authority to allow them to make a control visit to the site. To make this possible, the municipalities should have this policy in their Municipal Environment Protection Orders. Otherwise, in accordance with Finnish legislation, it is prohibited to give information about the business relationship between two stakeholders to a third one, which means that a major failure of on-site sanitation system might only be known of by the operator and house owner (Paper IV).

7.4 Big water technology and consultant companies

The new decree on on-site sanitation includes rather ambitious wastewater treatment requirements (Paper IV) and is actually primarily concerned with the industry manufacturing on-site sanitation systems. This is due the following facts. Firstly, the huge variations in the quality and quantity of wastewater produced in a household make it economically impossible to control the treatment results of the treatment units and the whole system. Secondly, municipalities do not have enough manpower to control individual systems regularly and it is not economically feasible to hire enough staff for that in the municipal environmental offices.

Thus, system manufacturers must meet the challenge of producing systems that fulfil the given requirements. When the right system is then chosen for each site, constructed carefully according to the instructions and operated as recommended, both the authorities and the house owners should be able to assume that treatment results will be satisfactory. For that, that all the stakeholders must do their share with care and reliably.

The budget for constructing an on-site sanitation system is usually rather limited. The preliminary investigations and design, the contracting and construction and the purchase price of the unit should total approximately 3 000 to 8 000 euros depending on the site and its requirements (Halla 2005 b). In any case, the cost of a single system is not high enough to attract big companies into the field. Yet, for manufacturers there is a clear market available.

There have been cases in Finland where a manufacturer has assumed a bigger role in managing on-site sanitation systems. Such were reported by Saralehto (2000) and Mattila (2001). Unfortunately, the limited number of on-site wastewater treatment systems implemented so far also limits the manufacturer's ability to offer full service packages.

7.5 Role of house owners in on-site sanitation

Even if the role of house owners in the actual running of on-site sanitation systems would appear to be declining in future, the final responsibility for the environmental effects of sanitation always remains with them. This is a very important fact, which was clarified by the new legislation and which moved decentralised wastewater treatment from the category of diffuse pollution to point source pollution. The matter is discussed in more detail in Chapter 8.

One quite important fact to be considered is the value of the house. As the legislation states that wastewater must not cause a danger of negative impacts on nature, and the statute gives more detailed requirements concerning on-site sanitation, it is more than obvious that the actual level of on-site sanitation implemented has direct effect on the value of the house. If on-site sanitation is properly managed the value is certainly higher, and if on-site sanitation is in bad shape, the value is lower.

Property value can motivate house owners to improve on-site sanitation systems. It is important when marketing a certain housing area to new potential inhabitants. And it should be taken into account when the costs of the new legislation to society are calculated. Improved on-site sanitation is not just an extra cost to someone, but it really increases the monetary value of our infrastructure.

The value of a house or a summer cottage next to a lake or a river as well as the value of a clean and safe environment are believed to motivate people to implement the new legislation. This was the case in Anttola municipality where a positive attitude towards the development of on-site sanitation was detected especially among the summer cottage owners (Mononen 2002). Social Construction of Technology (SCOT) has a remarkable role in this respect. Certainly, the selections made by neighbours also affect a house owner when he/she considers sanitation alternatives.

Thus, it can be asked: does the path selected by a neighbour affect your decisions? This introduces a one new angle to path dependence. Once again, path dependence and SCOT are working together?

A private house owner has to rely on several professional stakeholders in the field of on-site sanitation. And still the responsibility lies with the house owner. Thus, co-operation with the stakeholders is a must to meet the targets set by the legislation.

7.6 Partnerships in on-site sanitation

There are several successful versions of joint efforts to solve the management of on-site sanitation. Some big water companies like Hämeenlinnan Seudun Vesi Oy (Hämeenlinna Region Water Ltd), which serves the region around the town of Hämeenlinna, Finland are supporting new water co-operatives at least with guidance and instructions (Heinänen 2003). The same is happening in several Finnish municipalities according to the Municipal Water Supply Development plans prepared for the municipalities during the last years as required by the new Water Services Act.

Another successful example of a partnership is from the city of Espoo on the southern coast of Finland. Suvisaaristo is a housing area of about 400 households situated on islands outside the Espoo city centre. The inhabitants of Suvisaaristo have built a pressure sewerage network including a wastewater pump in every house. Wastewater is collected into a pumping station and pumped into the sewerage system of Espoo Water Services Company which treats it in a centralised treatment plant. The house owners of Suvisaaristo formed a co-operative for the purpose, and Espoo Water Services Company did not charge any connection fee from the co-operative. Thus, the inhabitants of Suvisaaristo avoided constructing expensive on-site systems in their very challenging circumstances of rocky sites surrounded by the sea, and the city of Espoo avoided a major environmental problem. (Donner 2002)

Sometimes legislation prevents otherwise beneficial partnerships. This was the case, for example, in the Volvo leisure time and conference village at Bokenäs, Sweden, where originally sludge from an anaerobic reactor treating both wastewater and kitchen wastes was used for agriculture by farmers, but where the activity is forbidden today because of new European Union directives (Jenssen 2003).

If we consider all the processes related to on-site sanitation, the need for co-operation of different stakeholders is obvious. For example, operations and maintenance activities implemented as presented in Figure 3 in Paper IV require quite smooth information flow between different organisations and individuals. That is possible by using modern information technology. The DLW computer program originally designed by DL-Systems Oy Ltd for controlling construction activities, has already been tested and modified in Southeast Pirkanmaa, Finland. The program was found useful and was taken into use as part of the KuntaNet map application software in four municipalities (Kiukas 2004).

Involvement of all stakeholders and more transparent management systems are assumed to become reality also within the urban context in future (Lundqvist et. al. 2001). Thus, successful management of decentralised systems certainly requires participation of all stakeholders, including house owners, wastewater engineers, environment specialists, bankers, etc as well as politicians, who are creating the common “rules of the game”.

Maybe in the context of partnership, we should revisit the international sanitation crisis. Certainly, this problem is so huge that much more active involvement of all stakeholders is needed. Even if money as such cannot solve the crisis, we should remember that the current financial resources used for solving the world’s sanitation problem should be multiplied by at least a factor of 100 to meet the MDG target (Heierli, Hartmann, Münger, and Walther 2004). Would that be the rule number one?

8 LAWS AND REGULATIONS CONCERNING ON-SITE SANITATION

The legislation concerning on-site sanitation has undergone total reformulation in the beginning of this century (see the operational framework of the research on the page 16). Some of the changes have been excessive. For example, the laws protecting nature from activities that cause the danger of pollution certainly needed rewriting. Originally the protective stipulations were incorporated in several separate laws and were difficult to interpret. The birth of the Environmental Protection Act clarified the situation a lot, and the experiences of implementing the law have been quite positive so far.

But some of the changes deserve to be criticised. One could ask, for example, whether the decree on on-site sanitation is necessary. The Environmental Protection Act prohibits causing even the danger of polluting the nature, and it also gives the municipal environmental authority the right to inspect sites and to give orders to improve, for example, on-site sanitation systems if necessary. These sections of the act would in principle have been enough for proper management of on-site sanitation. Local circumstances could have been given more weight to avoid unnecessary investments. Of course, the decree reinforces the management of on-site sanitation. And now, as the decree is in force, the management must be adjusted accordingly.

The existing legislation concerning on-site sanitation in Finland is described in Paper IV. Thus, the text below is just to clarify some important details and especially to compare how the experiences from the field correspond to the spirit of the legislation.

8.1 Existing legislation and its interpretation and effects

The basis of the new legislation lies in the Constitution of Finland, which obliges all citizens to take care of the environment to all citizens. This fact and the general principles of the Environmental Protection Act (Paper IV) underline citizens' own responsibility also concerning on-site sanitation. The word *responsibility* has quite an interesting and important role when considering the effects of the new legislation as discussed in Chapter 9.

The Government Decree on Treating Domestic Wastewater in Areas Outside Sewer Networks (542/2003) (came into force on the 1st of January 2004) sets detailed requirements on the efficiency of on-site sanitation. These requirements concern biological oxygen demand and phosphorous and nitrogen loads while the efficiency of the system is determined on the basis of the loads determined by multiplying the number of occupants of a house by the average wastewater load per person and day (Paper IV). The way of evaluation gives the house owner freedom to choose the technology utilised. This fact gives a lot of opportunities to different stakeholders as described in Chapter 9. The average wastewater load per person in Finland is considered to be quite high in nitrogen but average in phosphorous and BOD compared to some other investigations. Henze et al. (referred by Henze and Ledin 2001) have presented the figures 15 - 80 g/(person x d) of BOD, 2 -15 g/(person x d) of total nitrogen and 1 -3 g/(person x d) of total phosphorous, the corresponding figures are 50 g, 14g and 2.2 g, respectively, in Finland.

Quite notable feature of the decree is the way it requires septic tank and wastewater container sludge to be collected and transported. Actually, the Waste Act already defined sludge as any solid waste born in a household which need to be collected by an authorised waste collector who is to report also the method of waste treatment and final disposal. But because municipalities (which are to organise waste management in their areas) have not met this obligation it is stressed in the decree on on-site sanitation. The way the sludge issue is treated shows that the role of all stakeholders is important.

There are several issues related to on-site sanitation to which the legislation cannot directly answer and which still require some years of experience to be solved. The following list presents the most common unclear points observed so far.

i) The Environmental Protection Act states that minimal amounts of grey wastewater (no flush toilet in the house) can be discharged into the ground if there is no danger of deteriorating the environment. What is a minimal amount?

During the first years with the new act, in the first years of 2000's, the "minimal amount" has been defined by the way that water is taken into a building. When water consumed is carried in buckets water consumption is remaining minimal. When there is piped water coming into a building, the amount of wastewater produced cannot be minimal anymore. This is quite logical way of thinking. But what about the case where water is pumped in pipes next to the outdoor of the building and thus, carrying water is not anymore such a burden? And what about the case where water is pumped into the building by manpower?

It would be wise to be quite strict with this interpretation to avoid too lax requirements leading to lax practices. The position of the end of the pipe - no matter what the energy used for pumping – would be the most appropriate solution. Whether it is chosen, it should be taken into use all over the country to avoid confusion and to treat citizens equally.

ii) While the new decree supports the choice of a dry toilet system, it is not clear on what to do with urine. Faeces are to be composted properly, but in many cases urine is infiltrated with grey wastewater.

Naturally, it would be wise to collect urine for half year storage to make it safe to be utilised as fertiliser. Otherwise, the idea of more ecological sanitation is lost and valuable nutrients are wasted. Thus, infiltrating urine together with grey waters should be forbidden. This is necessary also to avoid drugs and other chemicals from entering groundwater. Urine-separating toilets and utilisation of urine as an agricultural fertiliser have been studied a lot in Sweden (Johansson 2000).

iii) People find it difficult to determine whether a person calling him/herself a designer of on-site systems really is qualified. The quality requirements given in the legislation seem to be of a too general level for this type of special work.

This problem will be solved in the long run. At the moment there is a limited number of engineers or others with the other appropriate background to plan and design on-site systems. This is because previous education concerning on-site systems was limited to the use of septic tanks only. In fact, training and certification of professional designers

and controllers for on-site sanitation systems will start in 2005 (www.sulvi.fi). In any case, certification is optional; there is no law or decree requiring certification. The professional capability of designers as well as site engineers is determined as for any other construction task and according to the Land Use and Building Decree (895/1999)

There is a great need for certified on-site sanitation designers. It will take a few years before the certification process produces enough capable persons to meet the demand. The costs of design work have already settled on a certain level, and the certification process will not raise the costs even if there are only some tens or hundreds of persons trained especially for the purpose.

Since there are ready-made model designs with all necessary details available for infiltration and soil filtration systems, and there is nothing a designer can change in the manufactured wastewater treatment units, the most important part of the whole process is the selection of the correct system for a particular site and determining the actual place for the installation or construction of the selected system. The quality of the preliminary investigations on site and the interpretations of their results is the most appropriate way to judge the professional qualification of the person in question, not the formal qualifications of certification bodies. This is something the authorities in charge of controlling the construction activities should keep in mind.

iv) At which degree of preparedness should the designs of on-site sanitation system be when a person applies for a permit to build a new house? The decree states what a proper design must include, but it does not specify a schedule.

The answer can be found above. Preliminary investigations and the system selected based on them should be submitted with the application for a construction permit. Whether the proposed on-site sanitation system is appropriate or not should be decided in close co-operation between the municipal authorities in charge of controlling construction activities and environmental protection. The detailed drawings can then be submitted as soon as they are finalised, the most appropriate time being the opening meeting of the construction site. The meeting will have to be held in any case on the basis of the new Land Use and Building Act (132/1999). Other detailed drawings will also be presented in the meeting.

v) One extremely important matter is the operations and maintenance of an on-site sanitation system. How should it be organised to make the system work properly and to keep both the costs reasonable and make the life of the system long enough?

The question is discussed in Paper IV, Figure 3. (NB There is a mistake in the figure: Finnish Environmental Authority should be Finnish Environmental Institute.) Appropriate operations and maintenance of on-site sanitation systems requires the involvement of several stakeholders. A professional maintenance crew or person is needed to ensure that the performed activities are the correct ones. This is not said in the legislation, but it can be argued for based on the author's experiences and examples from literature.

To make the maintenance of the systems successful, it is necessary to issue Municipal Environment Protection Orders which require sending maintenance reports in case of major repairs, etc. to the controlling authority, i.e. the Municipal Environmental

Authority. Otherwise maintenance activities can be left to be dealt with by the maintenance provider and the customer. Because the legislation makes the Municipal Environmental Protection Orders optional, the reporting responsibility should have been written into the decree. The principal mistake of the decree is that it leaves the maintenance activities to the discretion of house owners even though it is known that the systems do not operate properly then (Paper I, Wilderer 2001 and Viitala 2001).

A very important stipulation of the new legislation is that from 1.1.2004 onwards on-site sanitation can be considered a source of point-source instead of non-point source pollution. This gives authorities more possibilities to control the systems, and what is even more important: it leaves clearly the responsibility of the effects of wastewater to the producer. Until the end of 2003, wastewater from one-family houses was more or less equated with agricultural or forestry runoff, even though in most cases there is a clear point (outlet), where the load can be measured if necessary.

With this type of legislation now in force through, with the word *responsibility* included in the new Constitution, and considering the general principles of the Environmental Protection Act (Paper IV), one can seriously ask whether the present attitude toward on-site sanitation will eliminate the concept of diffuse pollution totally? Actually, all water pollution except natural leaching is caused by someone. When talking about diffuse pollution, we actually forget that someone is responsible for it allowing the responsible stakeholder to “hide” him/herself behind the phrase. The photographs in Chapter 9 show both point-source pollution and diffuse pollution sources and clarify the matter further.

One of the effects the new legislation will have is an increase in new small scale enterprises in the sector. This is discussed to some extent in Paper IV. The new legislation incorporates the principle of BAT (Best Available Technology) to be followed to protect the environment as efficiently as possible. As explained in Paper IV, the principle cannot be followed if the management of on-site sanitation is left to just house owners. This is clarified as by Figure 17. It is unrealistic to assume that ordinary house owners would continuously follow up the product development of on-site sanitation systems.

The existing legislation sets requirements for the level of on-site sanitation. The circumstances on the site are such that some of the systems the legislation allows are not feasible; for example, infiltration might not be utilised because of the danger of polluting ground water. On the other hand, there are a number of technological alternatives to deal with sanitation. But some of the alternatives might not be usable on the site because of topography, soil quality, etc. And the final selection of BAT is determined by SCOT. The house owner is capable/willing to invest a certain amount of money and manpower to implement on-site sanitation, and makes his/her decisions based on SCOT (Figure 6). The BAT for the site is depicted by the dark grey area in Figure 17. There are many technological alternatives for proper on-site sanitation of a certain site, some of which are better than the others due to costs, durability, etc. The best one in all respects is selected rarely for reasons other than purely technological or economical ones, but the “second best” alternative is selected for other reasons related either to available manpower or available financing.

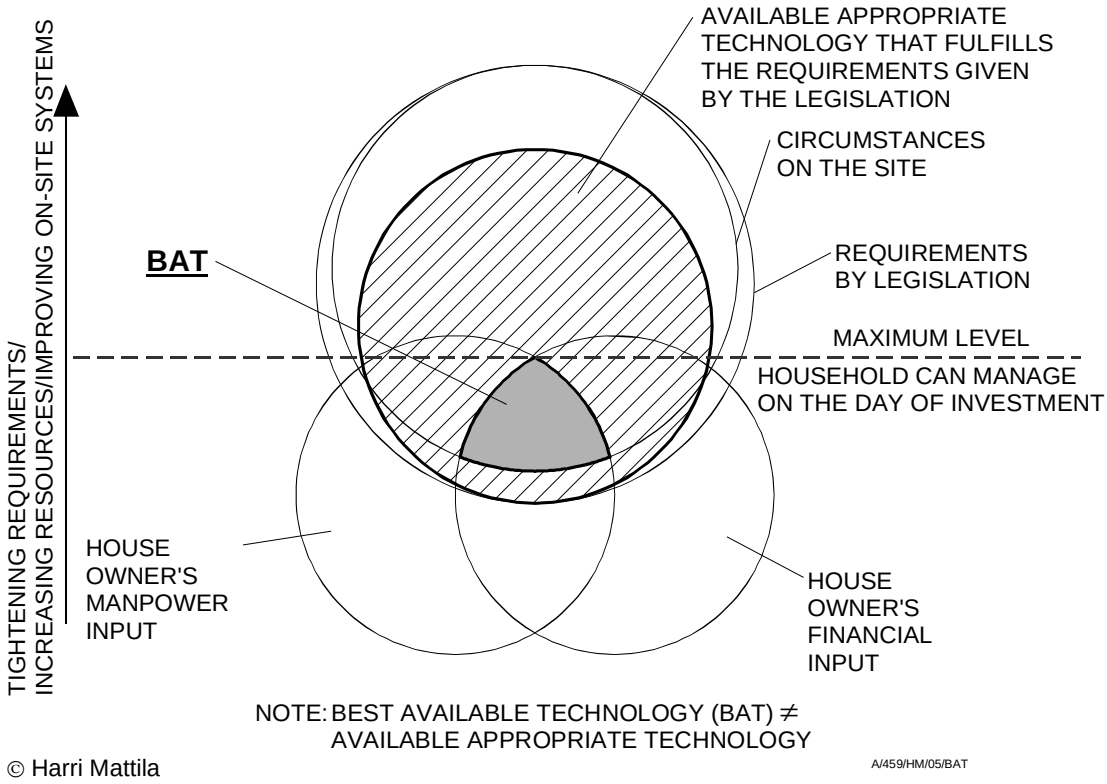


Figure 17. The principle of BAT in the management of on-site sanitation. BAT can be found through the SCOT process. Only those on-site systems which satisfy both the legislation, the site itself and the house owner can be considered BAT. A professional organisation is needed in the process to determine when the selected system no longer meet the requirements, when the system needs to be replaced or modified due to product development, or if there are, for example, more efficient or cheaper systems available.

When the requirements of legislation increase slightly and the appropriate technology available for on-site sanitation systems has to be modified, or if product development is producing more efficient modifications of available technology, there is no need to promptly modify the on-site sanitation system. But when the changes are more radical, only a professional monitor the development and apply the new systems accordingly.

The selection of on-site sanitation system is discussed also in Paper III, Figure 1. When making the selection, one criterion normally becomes more important than another. In Figure 1 of Paper III the house owner's own interests are supposed to be most important in the final selection. If for example, the welfare of the environment would be the leading criterion, technological alternatives based on ecological engineering would most probably be favoured and conventional end-of-pipe technology would no longer be the first alternative to be selected. All depends on SCOT and the stakeholders' impact on the decision.

The regional environmental offices in Finland are nowadays strongly supporting centralised sanitation by extending sewerage networks or granting incentives to new water service co-

operatives. It has been estimated that in southern Finland even half of the population now out of sewerage networks will be served by the year 2015 (Halla 2005 a).

The next impact of the new legislation, and especially the decree, which can be predicted, is that dry toilet technology will take huge steps forward in the near future. This is possible thanks to the new way calculating the efficiency of on-site sanitation, which favours dry toilets. The development of the dry toilet technology will lead to totally new thinking in house design as concerns sanitation. So far in Finland, toilets have mainly been located in the middle of houses, which is not very practical due to the maintenance measures required by dry toilets. (Actually, this applies also to flush toilets as well - not due to maintenance but smell.)

Accordingly, land use planning should also be changed to favour dry toilet technology. Housing areas should be designed to allow professional maintenance crews to work on sanitation facilities. The interest of house owners' toward proper disposal of their faeces to avoid health hazards cannot be relied on, and more common utilisation of dry toilet technology will lead to the need of centralised operation and maintenance activities at least in densely populated areas. Actually, when considering the Waste Act, which considers septic tank sludge as solid waste to be collected as any other solid household waste by a professional collection contractor or equivalent, we should ask: what makes sludge solid waste? The answer is: faeces. Thus, why not collect dry toilet wastes in a centralised fashion as well? Yet, it is not more than approximately 50 kg/person annually (Heinonen-Tanski, Sjöblom, Fabritius and Holopainen 2005).

The need to reuse the nutrients in faeces and urine discussed in Chapter 5.1.2 supports the mentioned effect of the legislation. The international interest in ecological sanitation will certainly speed up the product development of dry toilet technology also in Finland. Or at least it should. There is much demand for proper dry toilet solutions in the world.

Proper sanitation is no doubt one of the key issues of sustainable development, and there are more than 2 billion people in need of proper sanitation in the world (almost 2 million people, mostly children, also die from diarrhoeal diseases annually) (Ocampo 2004). Dry toilet technology could be a partial solution to sustainable development as it allows taking the nutrients from faeces and urine for food production, which could better the lives of the poor. Calculations have shown that the nutrients in the faeces and urine produced by a single person in a year can be used by him/her to grow some 250 kg of grains (Werner et.al. 2003). Actually, there are already a few signs of increasing interest for the dry toilet business also in Finland. Biolan Ltd, Lassila & Tikanoja Ltd, Raita Environment Ltd and PikkuVihreä Ltd intend to get their share of the huge dry toilet markets in China (Haapio 2004). The International Dry Toilet Conference arranged in Tampere in August 2003 also showed that some private people and companies are actively developing alternative sanitation technology.

There are many examples of more competitive alternatives for the conventional sewerage from different parts of the world. Some of them were observed by the author during this research (Chapter 1), and many trials are also described in literature (Huber 2004, Rosemarin 2004 b). In Västanfjärd, Finland ecological sanitation has been implemented since 1999 (Sjöblom 2002).

One of the problems related to this competition between conventional and ecological systems is that the conventional systems were developed and constructed during the 20th century

without considering other alternatives. The existing sewerage networks and wastewater treatment plants are huge capital investments and assets and, therefore not easy to replace the. The path was selected a long time ago.

To operate a sanitation system different from a centralised one requires in most cases a certain number of customers to make it feasible, or a totally separate area with a quite stable population as in the case of the Volvo leisure time and conference village at Bokenäs, Sweden which the author visited in the spring of 2003. In that village wastewater is collected together with kitchen wastes through the same sewer lines into a biogas reactor. (Jenssen 2003)

Another example is a housing area in Lűbeck which the author visited during the 2nd International Symposium on ecological sanitation, April 7-11, 2003. The area has a vacuum sewer system with an anaerobic digester for toilet and kitchen wastes and a soil filtration system (vertical constructed wetland) for grey waters (Otterpohl, Braun and Oldenburg 2004). Yet, there was not enough organic waste for biogas production because of the slow construction of the housing. Thus, there were not enough waste producers for proper operation.

Decentralised and on-site systems are nevertheless very popular across the world and they are seen as important sanitation alternatives everywhere. Many international events indicate this – one of which is described by Santala (2004). Santala attended the First International Conference on Onsite Wastewater Treatment & Recycling which was organised at the same event of IWA (International Water Association) supported Fifth Specialised Conference on Small Water and Wastewater Treatment Systems in Australia 11-14.2.2004. The event had participants from 30 different countries, which shows that the policy of decentralisation interests professionals all over the world. Some matters highlighted in the conference were:

1. In many cases, the developing world cannot rely on similar types of technological solutions in sanitation as the Western countries have during the last 150 years. The technologies are far too expensive.

2. It is essential that we find, create and implement systems to fit local conditions and the needs of users. Again, we see the importance of understanding the principle of SCOT in providing sanitation.

There are some quite ambitious projects adhering to the principle of ecological sanitation going on in the world. One of them is being carried out in the City of Dong Sheng in Erdos Municipal District of Mongolia. A town with different types of buildings, including also multi-storey buildings, is currently being built. This first ecosanitation town in China will have some 7 000 inhabitants. The town is supposed to be completed by 2007. (Rosemarin 2004 b)

The concept of ecological sanitation can be compared with the concept of modern waste policy. Items, which are no longer used in a household for their intended purpose, should preferably be given (or sold) for the same purpose elsewhere. The second alternative is to utilise parts of the items for another purpose. The third step is to check whether the material of the item could be reused in the production of new items. The fourth option is the possibility to use the material for energy production and the last one is disposing the material into a land fill (www.europa.eu.int/comm/environment/waste/index.htm). It is quite possible that the development of sanitation will follow the same route in future. Wastewaters and toilet wastes

could be divided into different categories on-site and utilised according to the concept of ecological sanitation, mainly in food production in the form of nutrients, humus and water for irrigation.

There are today problems with the disposal of wastewater sludge all over the world. Agricultural use is decreasing due to concerns about the possible pathogen content, disposal to landfills is an outlet which will be closed in the near future and incineration is also problematic (Stedman 2003). The problems related to wastewater treatment plants also receiving septic tank sludge are described for example by Nygren and Joensuu (2004). According to them, all sludge treatment is not up to requirements in Finland. Their solution to the problem is to implement bigger treatment systems where the operations could be controlled easier. That is a possible solution, but not the only one. What about diminishing the amount of sludge? That would lessen the load on existing treatment units. This would also favour dry toilet systems in on-site sanitation. Wastewater treatment plant operators are not happy about septic tank and wastewater container sludge which they are supposed to treat together with sewage brought in by the sewerage network.

One important effect of the new legislation on on-site sanitation is that there will be more enterprises in the markets selling wastewater treatment instead of just related equipment. The need of professional entrepreneurs in the sector is commonly recognised also outside Finland (Santala 2004 and Vehmanen 2005).

More intensive involvement of professionals will really be a positive phenomenon: it will improve the quality of the work remarkably. Actually, many wastewater treatment unit manufacturers are already selling also operations and maintenance services. And some of them are even offering a guarantee for the treatment results if also given the responsibility for running the system (Saralehto 2000).

9 DISCUSSION AND REVIEW OF THE RESEARCH

From the beginning of 2004 there have been adequate legislation, rules and regulations concerning on-site sanitation in Finland. These new tools should now be utilised carefully: if even the weakest tool is now ignored or its role is undervalued, the strongest ones could also be inefficient.

Appropriate management of on-site sanitation is analysed in Figure 18 by analogy with a football team and its operation. The defensive line tends to be penetrated at the weakest link. In comparison, the legislation on the right might be strong and appropriate enough, but municipal regulations on the left are not carefully written or do not exist at all. Similarly, authorities might not be powerful enough to operate on their position, or they are not following the regulations accurately for one reason or another. All this means difficulties for the midfield players and the defenders who cannot play a controlled game, and too much depends on the goal keeper who has the final responsibility for protecting the goal.

The referee in this match is the local (also national to some extent) political atmosphere: the players perform properly only if they are allowed, and required, to do so. The media also plays an important role in implementing appropriate management of on-site sanitation: they can either motivate the players to do their job with enthusiasm and care or highlight the weakest links to ruin the tactics of the team.

If the referee (political atmosphere of society) allows and encourages the players to be active, they may also start attacking instead of just defending. Active attacking in solving on-site sanitation problems means unconventional innovations and application of the futures research to guiding development into a favourable direction. This is not possible if the players are not co-operating. Successful tactics allow one or two weak players on the field at a time, but the work becomes too difficult if anyone in the team does not follow the tactics.

The operation of a football team is a good analogy of the management of on-site sanitation considering the effects of SCOT. We could also represent the idea of the weakest link using the traditional chain of stakeholders, but there the co-operation between different stakeholders is not highlighted, while everyone knows that a sports team will get the best results through active and smooth co-operation within. If the midfielder of a football team is not filling his place, the efficient co-operation of other players can make up for this midfielder. But friction in the team as a result paralyse the whole team. In on-site sanitation this “midfielder” might be a store selling house owners wastewater treatment units without consulting other involved stakeholders. This results in wasted money and deterioration of the environment due to non-operating systems and slowly worsening management of on-site sanitation due to the fact that no one believes in the “tactics” any longer.

The weakest link in the “team” might be anyone of the stakeholders. If the laws and regulations are do not work properly, the defence is "porous" at the “weakest links”. If the designer is not a professional, he might introduce a system that does not work properly. Or if the authorities do not take the matter seriously, people tend to select the path of least resistance (Axelsson 2005).

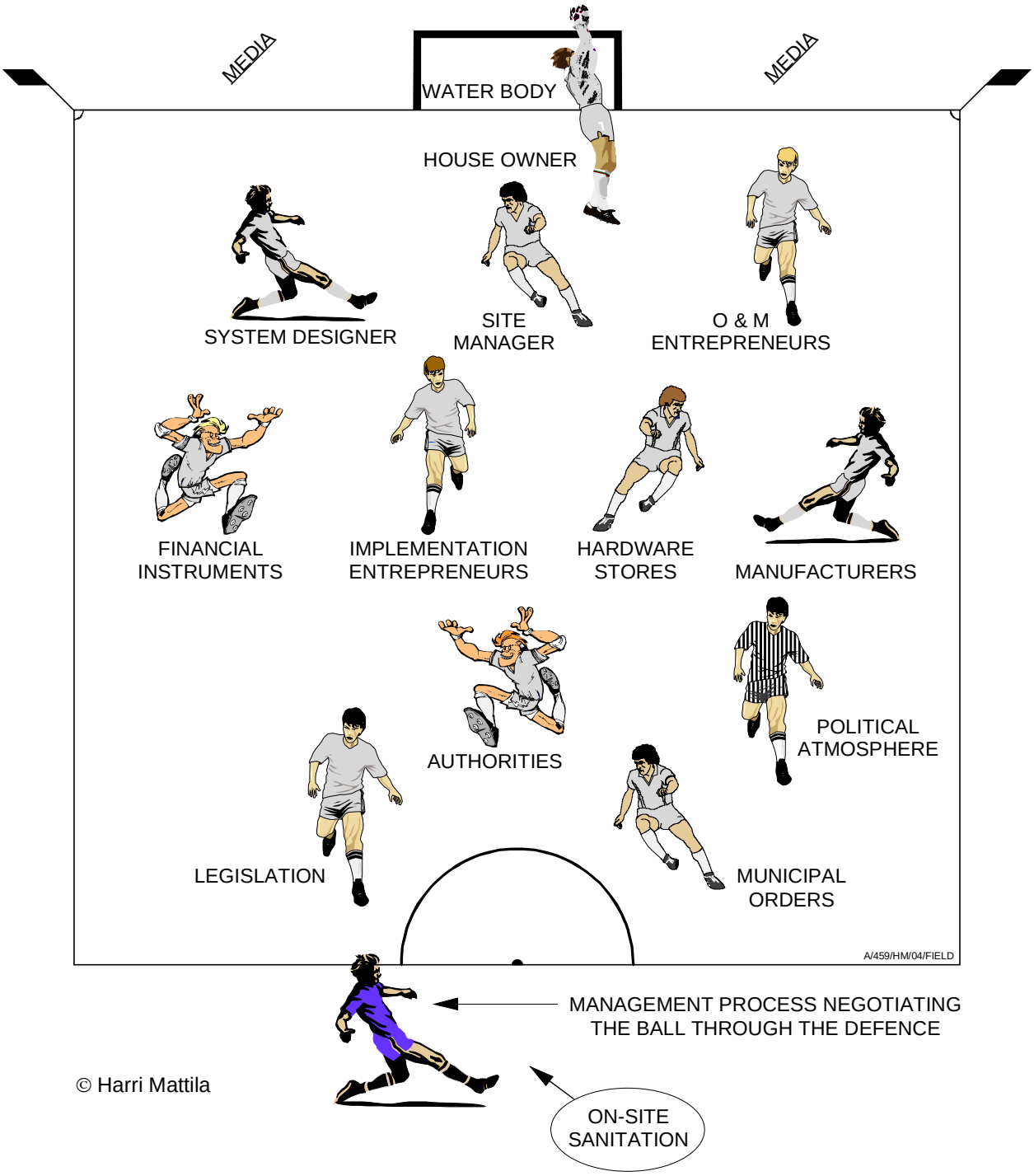


Figure 18. A football defensive line tends to be penetrated at the weakest link. On-site sanitation involves so many players (stakeholders) that the opposing team can be stopped by co-operation between the other players. Yet, in the absence of several players or proper team work the game will be paralysed. The role of the referee (local and national political atmosphere) is also vital. If there is no political will to take the play seriously one cannot expect good results at the end. All the players should do their share; otherwise the goal keeper has too much to do.

There are a couple of examples of what might happen if the new tools are not put properly into use. The first one is the implementation of the Waste Act as concerns septic tank sludge. In accordance with the law, the sludge must be collected from houses just like any other waste, that is, municipalities should control that all houses are either a customer of a waste collection company selected by the municipality through a tendering process or have a contract with one of the official waste collection enterprises. This has not been done by municipalities, and according to the studies only about 10 - 15 per cent of all sludge is collected and treated properly (Ekola 2003, Anon 2004 a).

Another example from Finnish municipalities is the construction activities. It has been found out that there are some 25 600 buildings built without official permit in Finland. Either no permit has been granted for the building, or it has been built in a location found more preferable by the house owner than the one indicated in the official permit documents (Kortelainen 2004). This is in line with the analogy of Figure 18. The political atmosphere or culture of the municipality guides also the control of construction. In some municipalities construction control has not been able to compete with "more important" activities. It is regarded only as one service among others offered by the municipality and, for some reasons, sometimes does not get enough resources (Axelsson 2005).

The similar question of resources concerns municipal environmental authorities as well. They are supposed to control the operations of on-site sanitation, but especially in small municipalities – which rather often are also having lot of summer cottages to be controlled: the population of these municipalities might double in summer time – the resources have been diminishing in the beginning of the century. Valpasvuo (2002) proposes not only enough resources but also active co-operation between municipalities to secure high quality environmental services to citizens.

Municipalities are easily tempted to please house owners by not taking the legislation seriously as also described in Paper I. According to the Aamulehti -newspaper (5.4.2004), Finns spend annually about 2.9 billion euros to improve and live in their summer cottages (Anon 2004 b). This means extra income for municipalities with many summer cottages. Further more, many municipalities are also trying to entice people to build year-round homes by allowing construction on the shores of lakes (Tuusa 2005). One such case was reported by the Iltasanomat tabloid (24.11.2004): a municipality granted a permit to convert a summer cottage into a year-round the house in spite of the fact that the building is only 30 meters from the lake shore instead of the 150 meters required in the approved land use plan (Anon 2004 c). Even if the distance to a water course cannot be the only criterion in considering the construction permit, decisions like this tend to weaken respect for the municipal regulations.

Similar thing occur also in other contexts. Especially the experiences from international development co-operation indicate that project failures are more often caused by poor management or badly operating institutions than technology (Katko and Nygård 2000). It is worth noticing that there is no player on the football field (Figure 18) named "technology", only several stakeholders working with the technology, developing it, selling it, etc.

If the co-operation between stakeholders in on-site sanitation does not work, new laws and regulations will be just "empty" words in ten or twenty years. Danger of too lax interpretation of the legislation concerns especially municipalities suffering from net out-migration and those located in the Finnish archipelago. The competition for new inhabitants can make the

environment suffer. Especially, considering that the previous violations of, for example, the Waste Act (uncontrolled collection and treatment of sludges) the and Land Use and Building Act (buildings without permits) have not resulted in sanctions. On the other hand, properly managed environmental protection might be good advertisement for a municipality as well (Valpasvuo 2002). Hopefully this fact will be realised in many municipalities.

In any case, we should remember that the responsibility for on-site sanitation lies with the house owner. There is an interesting relationship between sanitation responsibilities and the value of a house. With legislation as strict as it is today, the condition of the sanitation system and its maintenance records have a direct effect on the value of a house on the market. Thus, proper on-site sanitation is as important as any other maintenance activity like painting the house or repairing a roof. This is a fact to be remembered when discussing the costs of on-site sanitation. Actually, attempts have been made to create so-called environmental classification of properties (Hakaste 2003). It could be a big help in determining the value of a piece of real estate, but is obviously rather complicated. The existing classification system involves some 36 different indicators, and only a couple of them are related to sanitation as such. Thus, it will take some time before the system could be ready and in use.

Incentives to households to improve on-site sanitation systems

There have been many requests for money to support the investments in on-site sanitation from the government budget. One should keep in mind that there are about 250 000 year-round houses and 460 000 summer cottages outside sewer networks, most of them in need of improved on-site sanitation. That means the government cannot support each and every house with a direct monetary subsidy.

It has been estimated that the needed investment is on average at least 2 000 euros per site, this estimation includes also those sites where no investment is needed; naturally, costs vary a lot: generally speaking they could be in the range of 0 to 7 000 euros per site (Kujala-Räty and Santala 2001). (Or even up to 8 000 euros as estimated by Halla 2005 b) All in all, this means total costs of at least 1.4 billion euros within the next ten years. If the government was to finance just 20 per cent of the investment costs, that would bring the total to 300 million euros (30 million euros annually). Thus, it is clear that it is not possible to give incentives to all for that purpose. In 2004 the government budget included 5.4 million euros for the purpose which was mainly directed to bigger systems including several houses treating their wastewaters together. Single houses got only 150 000 euros from the total sum of 5.4 million. (Loiskekoski 2005).

A much better way is to help new enterprises to survive and improve their skills. In the long run this will be beneficial also for house owners: their investigations will be valid for longer periods than if they were done according to designs made by unprofessional designers or constructed by unskilled craftsmen. Using the previously described football team analogy for better results, it is better to train the weak player(s) than buy new gloves for the goalkeeper. A quite interesting form of supporting both house owners and small scale enterprises is to allow the house owner to deduct paid salaries and fees from taxable income in the case of investments in on-site sanitation. That is the mode to be developed further.

The individual's responsibility for the environment

In Finland, every sixth summer cottage has a shower in the bathroom and every ninth has a washing machine. About 30 percent of the cottages are equipped for year-round living. Thus, on-site sanitation is an interesting issue also from the viewpoint of energy consumption. In the cold Finnish climate, the technology used for summer cottages matters a lot. The calculations by Reijonen (2002) in Chapter 5.1.2 should be taken seriously.

One interesting aspect of the new legislation is its impact on definition of non-point (diffuse) versus point-source pollution. Also non-point pollution often occurs in highly visible places, sometimes even through a pipe. One can seriously ask whether a certain pollution source is really belonging into the category of non-point pollution. The photographs of Figures 19 – 24 show some examples related to this.

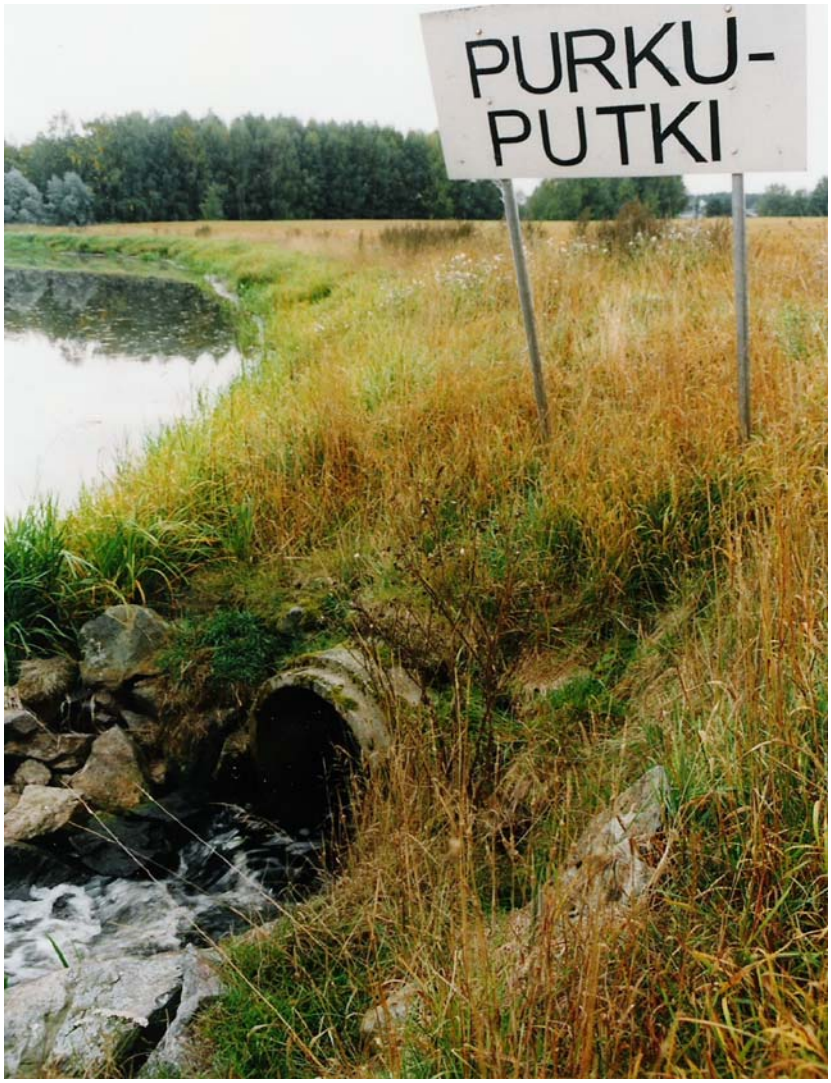


Figure 19. Point source pollution. The outlet of the wastewater treatment plant of the municipality of Toijala. The sign "WASTEWATER OUTLET" shows the point source of pollution.

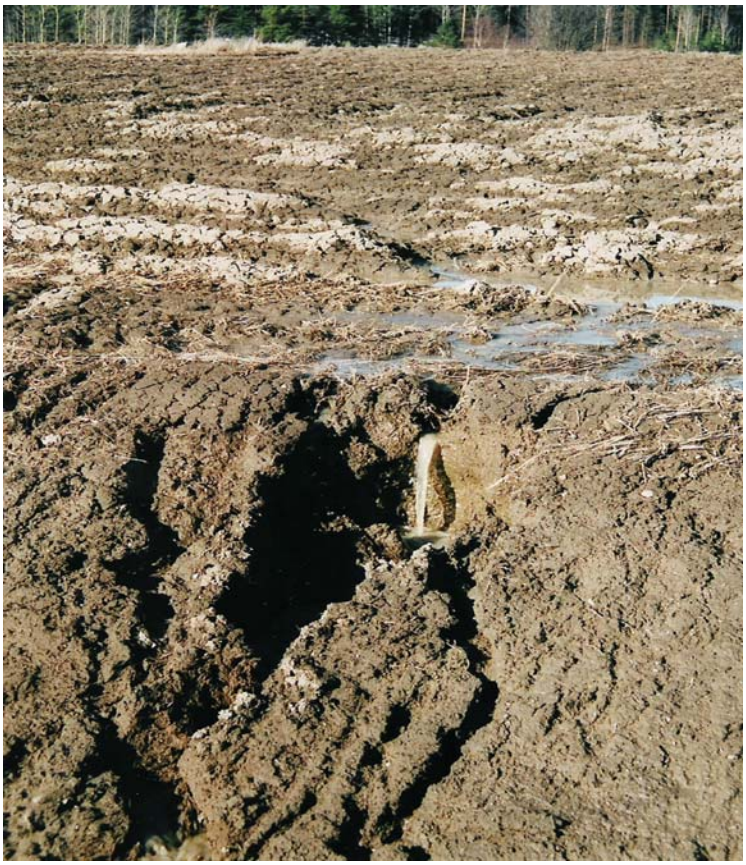


Figure 20. Non-point source pollution, in spite of very easily defined spot where runoff water dilutes soil and fertilisers from a cultivated field

Figure 21. Non-point source pollution, newly excavated ditches cause erosion.

…….

Figures 22, 23 and 24. Non-point source pollution, Even if it is known, that runoff water from densely populated areas carries a lot of solids and harmful material into water courses

The recent trend in the legislation has been to equate on-site sanitation more with point-source pollution than non-point one (Figure 25). This is the result of improved water pollution control and water analyses technology: even very small amounts of a certain impurity can be traced in the nature. The development of water protection measures is simplified in Figure 9, where the changes from bigger loads to smaller ones can be seen. The latest changes are written into the Government Decree on the restriction of discharge of nitrates from agriculture into waters (931/2000) and in the Government Decree on on-site sanitation described in Chapter 8.1. The former sets technical requirements aimed at diminishing the amount of nitrate leaching into water courses (Kaloinen 2004). Research also affirms trend. MTT Agrifood Research Finland has researched the environmental effects of cattle yards and recommends treatment of run-off water from at least bigger yards (Uusi-Kämppä and Rissanen 2004).

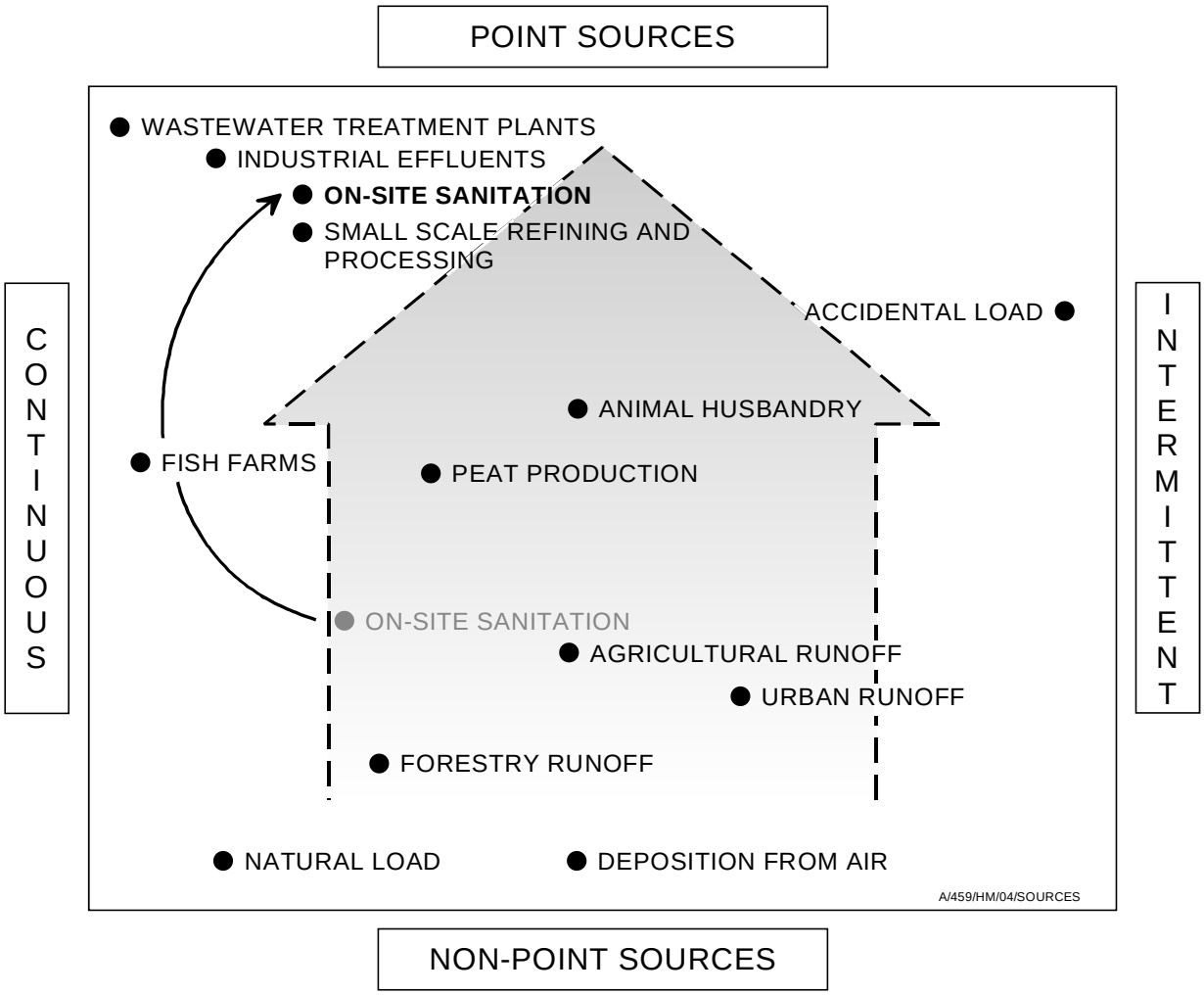


Figure 25. New Finnish legislation of the early 2000's moved on-site sanitation from the non-point sources' section of the chart different kinds of water polluters closer to the point sources' section. The change followed to the trend indicated by the big arrow. Certainly the sources resulting human activities in the lower section of the chart can be expected to be subject to stricter regulations before they move towards the point source status according to the trend. (Butler and Maksimović 2001, modified by the author)

Relation between non-point source pollution and environmental legislation is under careful examination in several parts of the world. Ongley (2004) writes that in the United States, there is an extensive legislative and administrative framework for non-point pollution management and control and the same is evaluated in China as well.

Evaluation of possible scenarios by professionals

Because the legislation concerning on-site sanitation is rather new in Finland, only a few scientific studies have been published on the subject. There are a number of problems to be solved, several difficult questions to be answered and a lot of experimental work to be done.

Due to the lack of analysed facts on the management of on-site sanitation, five scenarios about future development were presented to 25 Finnish professionals working on the issue. Nineteen of them evaluated the paths into the future and the results are as follows:

Table 5. Evaluation of the future scenarios concerning the control of on-site sanitation systems. Ranking: 1 = most probable, 5 = least probable

The decree sets strict and measurable wastewater treatment requirements for on-site systems. How will control function in future?	**Ranking**	**Notes**
No changes foreseen. On-site sanitation is recorded as non-point pollution and there is practically no control at all.	3	
On-site sanitation is recorded as non-point pollution. There is random control of the systems.	1	Clear number 1: thirteen persons graded this scenario as the most likely.
On-site sanitation is recorded as point source pollution. There is no control of the systems but statistics are processed by calculations.	4	
On-site sanitation is recorded as point source pollution. There is random control of the systems.	2	
On-site sanitation is recorded as point source pollution. The control is done by controlling professional enterprises working with on-site sanitation.	5	

All scenarios except the second one got almost equal support. In the comments concerning this evaluation, several experts informed that they would personally prefer the two last ones, but being realistic (and “pessimistic” like two people said) they had to select the second one. According to the experts, the last two options could become realistic with the development of GPS-technology.

Table 6. Evaluation of the future scenarios concerning centralised versus decentralised sanitation and reuse of nutrients. Ranking: 1 = most probable, 4 = least probable

Experiments on separating toilets and urine reuse as fertiliser are going on in several places. How do you see the future of DESAR technology?	**Ranking**	**Notes**
No changes foreseen. Centralised sewerage systems will expand further and sewage sludge utilisation will be developed.	2	
Centralised sewerage systems will serve densely populated areas only. Decentralised systems are non-separating ones. Septic tank sludge will be transported to centralised wastewater treatment plants.	1	"There is even the danger of cesspools and wastewater transportation becoming more prevalent not only transportation of sludge!"
Centralised sewerage systems will serve densely populated areas only. Decentralised systems are separating ones. Wastewater fractions are treated separately and sludges are utilised locally.	3	
Wastewater fractions are treated separately also in densely populated areas. Wastewater is seen as a resource instead of waste and reuse will become more common.	4	

When commenting these alternatives several experts indicated their belief in the third and even the fourth scenario, but the second one was nevertheless considered most probable. The fourth scenario could come true after a couple of decades or a century at the earliest.

Table 7. Evaluation of the future scenarios concerning the technological alternatives applied and the targets of the decree. Ranking: 1 = most probable, 3 = least probable

The legislation leaves the choice of technology for on-site sanitation open. How are the selections made and the targets of the legislation fulfilled?	**Ranking**	**Notes**
No changes foreseen. House owners are implementing improved systems at a slow speed, O&M is not regular and the targets of the legislation are not met.	2	
Flush toilet will remain the most popular toilet alternative. More efficient wastewater treatment units will be developed. About half of households have improved their sanitation system within the given ten year period for the duty.	1	"MOAF and MOE do not favour the policy of denying flush toilets, as they should especially in summer cottages."
Houses will be better equipped, but water consumption will not increase because of the development of dry toilet technology. Most households will have improved their sanitation by 2013.	3	"I believe in development. Ten years should be a long enough period for reaching the targets. Finns (especially housewives!) are law-abiding people."

Again, while the second alternative was ranked as the most probable one the third one would please the experts most.

Table 8. Evaluation of the future scenarios concerning the question of non-point and point source pollution. Ranking: 1 = most probable, 2 = least probable

Water protection measures have sifted from big point source polluters to ever smaller non-point polluters during the last decades. Will this continue?	**Ranking**	**Notes**
No changes foreseen. Even the smallest pollution sources are under careful examination but they are still recorded as non-point sources.	1	
Even the smallest pollution sources are under careful examination. The consept of non-point source pollution will be abandoned: only point source pollution, natural leaching and deposition from air will remain.	2	

The experts commented that the second scenario is the most desirable, but it will take so long (a couple of guesses were around 20 years) that they decided to select the first one. Only three out of eighteen experts selected the second scenario.

Table 9. Evaluation of the future scenarios concerning operation and maintenance of on-site sanitation. Ranking: 1 = most probable, 4 = least probable

Water protection targets will not be reached if the implemented improved on-site sanitation systems do not operate properly. How will O&M be organised?	**Ranking**	**Notes**
No changes foreseen. House owners are operating and maintaining on-site systems as they have done with existing septic tanks.	2	
House owners will operate and maintain on-site systems as they have done with existing septic tanks, but they will record the work performance in the maintenance record books required by the new legislation and controlled by municipal authorities.	3	
A professional organisation specialised in O&M of on-site sanitation systems will be hired by house owners. Control of on-site sanitation will be assigned to these organisations.	1	Almost all evaluators (14) thought a private enterprise would be the most probable organisation for O&M. Only two saw a centralised waste-water utility performing this duty.
On-site sanitation system manufacturers will sign leasing-contracts with house owners. Manufacturers will own the systems and operate them. Thus, house owner will buy wastewater treatment instead of a system.	4	No one ranked this alternative as first.

The third scenario was the most probable one to the experts. According to them, on-site systems are going to be too complicated to be just the house owners' responsibility. It is worth noticing that even if the third option was ranked most likely, the first one was ranked second and the second one was ranked first in as many answers as the third one. One expert expressed it thus: "All the scenarios are probable. The organisation of O&M activities will vary from one area to another."

The evaluation process brought up a few interesting points:

- In the case of all scenarios, several experts ranked "the second best" scenario as the most probable one. The best one was considered "too optimistic". Thus, it seems that the futures research methods should be taken into use among water professionals to guide the future in the preferred direction.

- In many of the comments by experts quality of actions at all stages of managing on-site sanitation was suspected. This reflects the previous point, but it also shows the importance of involving all stakeholders in the process to avoid poor practices and actions due to ignorance.

- The importance of Social Construction of Technology is reflected in the comments by the experts: "People act differently in their summer places than in towns. Thus, dry toilet technology could develop in summer cottages." "Things develop at their own speed. After mistakes are noticed, corrections are made." "The financial support to households will determine the development." "I believe in future. It is lucky Finns, and especially housewives, are quite law-abiding people". "The actions taken vary from one area to another depending on the attitudes and awareness of municipal authorities."

- The comments given at least partly support the further development of dry toilet technology for summer cottages. This could hopefully lead to some solutions applicable to the global sanitation crisis as well. From this point of view, it is a pity that the experts see no hope for ecological sanitation in urban areas in the foreseeable future. Anyhow, there were no scenarios concerning possible solutions for future sanitation solutions in cities in developing countries included.

Validity of the research

This research has made some findings and proposals related to the questions raised during the first years of the new legislation (the early 2000's) concerning on-site sanitation in Finland. The answers are based on experiences from field work, comparisons of national information and limited research results and international studies, and on the basis of established theories. Some of the answers might work for years to come, but some may prove to be more short-lived.

The most common questions raised have been discussed in this research. Yet, there are more questions appearing when the time goes on and more experience about the implementation of the new legislation is gained. The analogy between on-site sanitation and a football team can help in finding solutions to problems arising. The challenge to motivate 11 individuals to play together as a team, in accordance with the agreed tactics, in the guidance of one referee and under the pressure by media is teaching us the complexity of managing on-site sanitation as

well. Maybe one of the world's top football coaches should be invited to give some neighbourly help.

The questions concerning the selection of centralised versus decentralised sanitation technology and the possible abandonment of the concept of non-point source pollution are certainly valid. These issues should be discussed thoroughly in the near future. The both are important matters in stopping eutrophication of waters in Finland, but they have wider and far-reaching effects as well. People's attitudes towards the environment, economical aspects, technological constraints, etc. have to be taken into account in the considerations.

Knowledge about the management of on-site sanitation will increase at an accelerating rate as the new legislation begins affecting practices. The conclusions and recommendations of this research should be carefully considered by all involved stakeholders. Development will not move in the desired direction unless the stakeholders adopt a critical attitude and the recommended further researches are implemented.

This research has not discussed the global sanitation crisis in detail. Yet, possibilities of Finnish development co-operation to be involved in easing the crisis are evident. That is the issue taken up, for example, by professionals in water and sanitation sector at the international seminar organised in Helsinki in February 2005 (Tompuri 2005).

There is plenty of experimental and empirical data supporting this action research. Taking into account the fact of cyclic nature (planning – action – monitoring – reflection) of action research this research can be taken as a pioneering work of the new period of the development of on-site sanitation under the new legislation in Finland. The conclusions and recommendations in Chapter 10 can be taken as reflections from where the next actions can be planned.

Time was the limiting factor in this research. The results would be more trustworthy if several other on-site sanitation management options than only a co-operative could have been followed carefully. The development of on-site sanitation in the form the new legislation requires is far too young in Finland for several management options to be tested. Especially centralised operations and maintenance activities require certain density of on-site systems. Otherwise they would not be reasonably arranged. It just takes for some years to come until there are enough rehabilitated and/or new on-site systems implemented.

The results gained from the futures research part of this thesis appeared to be interesting. It might have been valuable if this part had been extended and thus, more information on possible paths for future development would have been gathered. So far, there are quite a limited number of experts of on-site sanitation existing in Finland. Thus, the extension of the research of management of on-site sanitation by utilising the futures research methods would be quite easily arranged in the next cycle of action research on the sector.

The theoretical framework (Figure 5 on the page 29) proved to be suitable to be used in research on the management issues of on-site sanitation. The principles of SCOT are involved in all stages of the management of on-site sanitation. They are present also when applying the path dependence theory, stakeholder theories and futures research in considering the possible ways of managing on-site sanitation. Yet, the selected theories could have been discussed more deeply to give readers more tools for considering the correctness of the conclusions and also for creating basis and ideas for next actions to be taken.

10 CONCLUSIONS AND RECOMMENDATIONS

Appropriate management of on-site sanitation in Finland requires on the other hand up-to-date legislation and on the other hand appropriate technology by which the requirements given can be reached. But these two elements are not enough. Even the most advanced rules and regulations and the most developed technology are worthless if not properly used. Commonly agreed details in interpreting the legislation and site-specific selections of sanitation systems are required for successful on-site sanitation. The key conclusions of the study concerning the management of on-site sanitation in Finland are the followings:

1. The new legislation has created enough efficient tools to manage on-site sanitation properly. The question now is whether the new tools are applied thoughtfully or whether an attempt is made to solve management problems by addressing the weakest points of the chain with the lowest possible cost. The latter would lead to a situation where people's confidence in the beneficiality of on-site sanitation might weaken and the environmental protection gains might be minimal.

2. In the beginning the new legislation should be interpreted very strictly to create efficient management of on-site sanitation. It will be difficult to make practices stricter in future if management is not taken seriously enough in the first years of implementation.

   - The Environmental Protection Act (86/2000) states that minimal amounts of grey wastewater (no flush toilet in the house) can be discharged without special treatment into the ground if there is no danger of deteriorating the environment. The "minimal amount" should be defined: When water consumed is carried in buckets water consumption is remaining minimal.
   - The quality of the preliminary investigations done on site and the interpretations of their results is the most appropriate way to judge the professional qualification of the person who designed the system, not the formal qualifications of certification bodies.
   - Preliminary investigations on site and the system selected based on them should be submitted with the application for a construction permit. No construction permit for a residential building should be granted without these documents.
   - Wastewater infiltration should be denied in case of even the slightest possibility of negative effects on the ground water.

3. The quality of activities at all stages, - design, contracting, construction, control, operation, maintenance and repair of on-site sanitation systems - is very critical to the success of the process in the long run. That is why the state should now support all efforts that improve the quality of on-site sanitation. The speed at which new wastewater treatment units are built is not that important. Thus, resources should now be addressed to education and training of all stakeholders, product development and support of new enterprises specialised in on-site sanitation.

4. The management of on-site sanitation needs the next improvements in the quality of systems and product development especially in dry toilet technology but also house design and other infrastructure planning. This would not only facilitate the management of on-site sanitation in Finland, but also solving global sanitation problems. In Finland, dry toilet technology will be

primarily a solution for recreational housing, summer cottages, camping areas and the like. Dry toilets may later be found more often also in year-round houses.

5. There is a great need for immediate study and development activities to find out the best possible ways to support on-site sanitation investments financially. What kinds of incentives should be given to house owners, what kind of support to new enterprises and to secure the quality of different simultaneous activities? Taking into a consideration the government's goals of creating new job opportunities and hindering migration into cities, the tax deductions for house owners could be one interesting alternative worth further development.

   It should be noted that supporting all efforts aiming at improving the quality of the management of on-site sanitation would be most beneficial to house owners as well. Properly selected, designed, constructed, operated and maintained system will have much longer life span than the one which lacks any of these. In this respect, the Government Decree on Treating Domestic Wastewater in Areas Outside Sewer Networks (542/2003) would need one change: it should clearly order professionals to be hired to take care of maintenance of the on-site systems.

6. We should carefully consider to what direction we want sanitation solutions to develop. The futures research methods should be applied in all decision making concerning sanitation solutions, no matter centralised or decentralised. It looks that professionals in the field would prefer different scenarios they feel would be plausible. In accordance with the futures research, we can reach the preferred future by making the needed choices today. Thus, we can make our future to become more preferred one by acting proactively.

7. Finding solutions to the sanitation crises facing 2.6 billion people around the world should interest more of us in Finland as well. We should keep the Millennium Development Goal of cutting this number in half before 2015 in our minds. This means that some 350 000 persons should get proper sanitation every day within the coming ten years. All efforts – also those of the Finns – are needed.

8. The process of improving the management of on-site sanitation in Finland can have huge effects in the whole society if properly managed. About 1.4 billion euros invested in on-site sanitation within the coming ten to fifteen years could make quite a difference in our environment and by that way also in raising up the value of housing and recreational areas. But it could also improve employment situation and, thus, living conditions in rural areas. It could also bring extra income to farmers trained to maintain on-site systems.

Recommendations for future studies

There is a clear need for a research concerning the effects that properly managed on-site sanitation make on the value of a house. The environmental rating of houses should be further developed to motivate house owners to take care of their sanitation systems and their close by environment as well.

One important process that should be under continuous research also in future is the utilisation of wastewater sludge whether from conventional wastewater treatment plants or on-site systems. When operating in accordance with the existing legislation, practically all septic tank or wastewater container sludge will end up at the centralised wastewater treatment plants. The challenge in sludge utilisation is to take advantage of the nutrient content instead

of discharging it in water courses. An interesting issue to study in this context is biogas production by processing wastewater sludge, animal manure, kitchen wastes and other organic wastes in anaerobic reactors. Farmers having big cattle or number of other animals and thus, plenty of organic waste, could start producing biogas and at the same time help in solving the sludge problem.

Different chemical substances and pharmaceuticals captured by wastewater filter media of on-site systems are not screened properly to allow giving final recommendations about the utilisation of the media. As long as the question is unclear, the media has to be transported into landfills. This applies also to soil infiltration systems. As long as it is not known what happens with drugs and other pharmaceuticals in infiltration systems, the implementation of these systems must be done with extreme care to avoid polluting ground water. Extreme care means here that infiltration should be denied in case of even the slightest possible of negative effects on the environment.

Decentralisation versus centralisation is a subject which requires further research in near future also in Finland. The correctness of the government policy, promoted by regional environmental centres, favouring ever larger wastewater treatment plants and, thus, longer sewer lines followed in Finland today can also be questioned. Decentralised systems may offer benefits not realised presently.

The development in water protection has moved towards controlling smaller and smaller sources of pollution. One could ask, whether the concept of non-point source pollution is relevant anymore? All comes back to the same responsibility. While some sources of pollution are classified under non-point sources, these are the responsibility of no one. Whether the point source pollution, natural leaching and deposition classes are enough should be made the subject of careful research and consideration in the near future. This is a very up-to-date subject in Finland because of the foreseen climatic changes which might cause increasing precipitation in Finland.

Finally, there is very prominent research topic concerning environmental legislation: What are sanctions a municipality or a municipal authority can face in case of neglecting its responsibilities concerning the control of on-site sanitation? So far, municipalities or authorities have not got any sanctions even if septic tank sludge has not been managed in accordance with the Waste Act and even if there are thousands of buildings constructed without any permit required by the Land Use and Building Act in the country. In the both cases the primary responsibility of controlling the activities is in municipalities. And further, for example in accordance with the Waste Act the secondary responsibility of controlling septic tank sludge lies with regional environment authorities. It seems that these authorities have neglected their duties to some extent. How are these responsibilities divided between the municipal and regional authorities in practise?

11 REFERENCES

Andersson, S. 1982. Positivism kontra hermeneutik (Positivism versus Hermeneutics). Bokförlaget Korpen. Gotherburg, Sweden. Original in Swedish.

Anon 1991. Introduction course to psychology. University of Tampere. Tampere, Finland.

Anon 2002. Kunnissa totuttu kähmimään. Rakennuslehti 21.2.2002. Original in Finnish.

Anon 2003. Jätevesien käsittelijät koulun penkille. Aamulehti newspaper 13.10.2003. Original in Finnish.

Anon 2004 a. Riihimäellä tutkitaan 40 000 jätelietekuution kohtaloa. Aamulehti newspaper 6.10.2004. Original in Finnish.

Anon 2004 b. Mökkiläisistä kunnan kultakaivos. Aamulehti newspaper 5.4.2004. Original in Finnish.

Anon 2004 c. Häkkinen muuttaa huvilansa vakituiseksi asunnoksi. Iltasanomat tabloid 24.11.2004. Original in Finnish.

Anon 2005. Tutkijat epäilevät Itämeren olevan luultua huonommassa kunnossa – Nykyiset päästövähennystavoitteet riittämättömiä tilan parantamiseksi. Helsingin Sanomat newspaper 23.2.2005. Original in Finnish.

Aho, J. 2002. Responsibilities and management of on-site wastewater treatment in sparsely populated areas. The publication serie of West Finland Regional Environment Centre and Finnish Environment Institute: Regional Environment Publications no 261. Multiprint Oy. Vaasa, Finland. Original in Finnish, Abstract in English.

Ahola, M. 2003. Länsimaisen käymäläkulttuurin kehitys vesivessoista kadunkulmiin ja takaisin (The development of western toilet culture from WCs to street corners and back). Ympäristö ja Terveys-lehti. Vol. 34, No. 10/2003. pp. 12 - 15. Original in Finnish.

Axelsson, M. 2005. Rakennuskuri pohdintaan, palvelujulistus rakennusvalvontaan. Kuntalehti. Vol. 13, No. 2/2005, pp. 32 – 34. Original in Finnish.

Barty-King, H. 1992. Water the book, An illustrated history of water supply and wastewater in the United Kingdom. Quiller Press Ltd. London, UK.

Bergnhøj, H., Eilersen, A.M. and Backlund, A. 2003. Experiences with Ecosan in Danish Allotment Gardens and in Development Projects. Conference proceedings of the 2nd International Symposium on ecological sanitation. 7 – 11.4.2003. Lübeck, Germany.

Bijker, W.E., Hughes, T.P. and Pinch, T.J. 1987. The Social construction of technological systems: new directions in the sociology and history of technology. MIT Press. Cambridge, Massachusetts, USA.

Butler, D. and Maksimović, Č. 2001. Interactions with the environment. Chapter 3 in the book Maksimović , Č. and Tejada-Guibert, J.A. Frontiers in Urban Water management, Deadlock or Hope. IWA Publishing. London, UK.

Bärlund, K. 2003. Water supply and sanitation - a challenge for Europe. The opening speech in the 1st International Dry Toilet Conference. 20 – 23.8.2003. Tampere, Finland.

Cooper, P.F. 2001. Historical aspects of wastewater treatment. In Lens, P., Zeeman, G. and Lettinga, G. (eds.) 2001. Decentralised Sanitation and Reuse, Concepts, systems and implementation. IWA Publishing, London, UK.

David, P.A. 2000. Path dependence, its critics and the quest for 'historical economics'. evolved from David's 'Keynote Address' to the European Association for Evolutionary Political Economy. Athens, November 7 – 9, 1997. Oxford, UK.

Donner, R. 2002. Matalaan perustetut vesi- ja paineviemärijohdot (Water and pressure drainage pipes in shallow soil). Vesitalous, Journal for professionals in the water sector, Vol. 43, No. 4/2002. pp. 15 – 16. Original in Finnish, Abstract in English.

Douglas, M., 1996. Puhtaus ja vaara, Rituaalisen rajanvedon analyysi. Gummerus Kirjapaino Oy. Jyväskylä, Finland. In Finnish. The original in English: Purity and Danger. An analysis of the concepts of pollution and taboo. Routledge, London & New York.

Drangert, J-O. 2003. Requirements on sanitation systems- The flush toilet sets the standard for ecosan options. Oral presentation in the 2nd International Symposium on ecological sanitation. 7 – 11.4.2003. Lübeck, Germany.

Drangert, J-O. 2004. Managing resource flows in a sustainable city. The 14th Stockholm Water Symposium.16 – 20.8. 2004. Abstract Volume, Drainage Basin Management – Regional Approaches for Food and Urban Security. pp. 372 – 373. Stockholm International Water Institute. Stockholm, Sweden.

Edwards, M. 2005. Civil Society – theory and practice. Available at http://www.infed.org/association/civil_society.htm (24.2.2005).

Ekola, E. 2003. Situation of On-Site Wastewater Treatment and Amount of Sludge form Septic Tanks and Cesspools in Kaakkois-Pirkanmaa. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Elomaa, H., Mattila, H. and Reko, J. 2001. Haja-asutuksen jätevedet in Sarvala, M. and Sarvala, J. (eds.), Pyhäjärvi, Yhteistyöllä vauhtia vesiensuojeluun Lounais-Suomessa. the final report of the first operation period (1995 to 1999) of Lake Pyhäjärvi Protection Fund. Newprint, Uusikaupunki, Finland. Original in Finnish, Summary in English.

Esrey, S.A., Gough, J., Rapaport, D., Sawyer, R., Simpson-Hérbert, M., Vargas, J. and Winblad, U. (eds.) 1998. Ecological sanitation. Swedish International Development Cooperation Agency. Stocholm, Sweden.

Esrey, S.A., Andersson, I., Hillers, A. and Sawyer, R. (eds.) 2001. Closing the loop, Ecological sanitation for food security. UNDP, Publications on Water Resources No. 18. Mexico.

Falkenmark, M. 2004. Overarching conclusions and comments from 2004 Stockholm water symposium. available at http://www.siwi.org/press/presrel_04_SWS%20Conclusions.htm (1.11.2004).

Gomez, J.D. and Graham, J.P. 2004. Community participation in dry sanitation projects. Water Policy Vol. 6, No. 3/2004, pp. 249 - 262. IWA Publishing. London, UK.

Haapio, M. 2004. Seuraava vientihitti: HUUSSI. Iltalehti tabloid 23.11.2004. Original in Finnish

Hakaste, H. 2003. Rakennuksille ympäristöarvosana, Luokitus testaa kiinteistön ekologisen kestävyyden. Asu ja Rakenna. Vol. 10, No. 5/2003, pp. 18 – 19. Original in Finnish.

Halla, T. 2005 a. Viemäriverkko laajenee, Kuntien suunnitelmat vuoteen 2015 kunnianhimoisia. Maaseudun Tulevaisuus newspaper 16.2.2005, Jätevesiliite, p. 3. Original in Finnish.

Halla, T. 2005 b. Asetuksesta tuli tiukka. Maaseudun Tulevaisuus newspaper 16.2.2005, Jätevesiliite, p. 5. Original in Finnish.

Heierli, U., Hartmann, A., Münger, F. and Walther, P. 2004. Sanitation is a business, Approaches for deman-driven policies. Swiss Agency for Development and Cooperation (SDC). Bern, Switzerland.

Heikkinen, T. 2003. Kiinteistökohtaisen jätevedenkäsittelyn sosiaaliset vaikutukset (Social Impacts of Decentralised Wastewater Treatment). Unpublished; in the draft of the final report of Ylläpitosampo-project. Finnish Environmental Institute. Helsinki, Finland. Original in Finnish.

Heikkilä, E. 2004. The Present Situation of Wastewater Treatment and its Development in Villages of Pahkala and Pernu. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Heinonen-Tanski, H., Sjöblom, A., Fabritius, H. and Holopainen, P. 2005. Erottelevien käymälöiden virtsa sopii avomaakurkun lannoitteeksi (Urine from urine-separating toilets can be used as fertilizer for cucumbers). Vesitalous, Finnish journal for professionals in the water sector. Vol. 46, No. 2/2005, pp. 34-37. Original in Finnish.

Heinänen, T. 2003. Vesiosuuskunta vireillä monessa Kanta-Hämeen kylässä. Hämeen Sanomat newspaper 4.9.2003. Original in Finnish.

Henze, M. and Ledin A. 2001. Types, characteristics and quantities of classic, combined domestic wastewaters. In Lens, P., Zeeman, G. and Lettinga, G. (eds.). Decentralised Sanitation and Reuse, Concepts, systems and implementation. IWA Publishing. London, UK.

Holm, R. 1999. Ikityhjentämätön sakokaivo vai piikattu umpikaivo? Vesiensuojeluyhdistysten tiedotuslehti Aquarius 1/99. pp. 8 - 9. Suomen Vesiensuojeluyhdistysten Liitto ry. Original in Finnish.

Huber, H. 2004. Commitment on decentralised treatment. Water 21, August 2004, p. 31. IWA Publishing.

Huber, H. and Christ O. 2004. Full Scale Implementation of a Water and Nutrient Recycling. The 14th Stockholm Water Symposium.16 – 20.8.2004. Abstract Volume, Drainage Basin Management – Regional Approaches for Food and Urban Security. pp. 150 -151. Stockholm International Water Institute. Stockholm, Sweden.

Jenssen, P.D. 2003. Information given by Prof. Peter D. Jenssen. Agricultural University of Norway, during the visit in Volvo Fritids- och Konferenceby on 15.4.2003.

Jenssen, P.D. 2004. Ecological Sanitation – A Technology Assessment. The 14th Stockholm Water Symposium, 16 – 20.8.2004. Abstract Volume, Drainage Basin Management – Regional Approaches for Food and Urban Security. pp. 140 – 142. Stockholm International Water Institute. Stockholm, Sweden.

Johansson, M. 2000 (ed.). Urine separation - closing the nutrient cycle, Final reoprt on the R&D project Source-Separated Human Urine - a future source of fertilizer for agriculture in the Stockholm region? S-M Ewert AB. Stockholm, Sweden.

Jokinen, K. 2003. A Co-operative as an Organisation to Take Care of On-Site Wastewater Treatment – Varsinais-Suomen Vesihuolto-osuuskunta as an example. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Juuti, P. and Katko, T. 1998. Ernomane vesitehras, Tampereen kaupungin vesilaitos 1835 – 1998 (Municipal Water Supply And Sewerage For Nearly Two Centuries, the history of water supply and sewerage services in Tampere 1835 – 1998). Tammer-Paino Oy. Tampere, Finland. Original in Finnish. Abstract in English.

Juuti, P., Rajala, R. and Katko, T. 2001. Terveyden ja ympäristön tähden - Hämeenlinnan kaupungin vesilaitos 1910 -2000 (For health and the environment - Hämeenlinna water works 1910 – 2000). Karisto Oy. Hämeenlinna, Finland. Original in Finnish, Summary in English.

Juuti, P.S. and Wallenius, K.J. 2005. Brief history of wells and toilets – the case of Finland. KehräMedia Inc. Pieksämäki, Finland.

Järvinen, A. 2003. Study on wastewater and runoff water load on the shores of Lake Kotkajärvi. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Järvinen, P. 2004. Supplementing Ron Weber's view on a theory building. Department of Computer Sciences, Series of publications D - Net publications D-2004-8. University of Tampere. Tampere, Finland. Available at www.cs.uta.fi/reports/dsarja/D-2004-8.pdf (30.3.2005)

Jönsson, H., Richert-Stintzing, A., Vinnerås, B. and Salomon, E. 2004. Guidelines on Use of Human Urine and Faeces in Crop Cultivation. The 14th Stockholm Water Symposium. 16 – 20.8., 2004. Abstract Volume, Drainage Basin Management – Regional Approaches for Food and Urban Security. pp. 143 – 144. Stockholm International Water Institute. Stockholm, Sweden.

Kaatra, K. 2003. Vesihuolto ja kuivuus. Ympäristö ja terveys –lehti. Vol. 34, No. 5/2003. pp. 24 – 27. Original in Finnish.

Kaivo-Oja, J.Y., Katko, T.S. and Seppälä, O.T. 2004. Seeking convergence between history and futures research. Futures. Vol. 36, pp. 527-547.

Kaloinen, J. 2004. Typpi vesiensuojelun säännöksissä ja tavoiteohjelmissa (Nitrogen in legal provisions and target programmes for water protection). Vesitalous, Finnish journal for professionals in the water sector. Vol. 45, No. 6/2004. Original in Finnish. Abstract in English.

Kamppinen, M., Kuusi, O. and Söderlund, S. (eds.) 2002. Tulevaisuudentutkimus, perusteet ja sovelluksia (Futures research, basics and applications). Suomalaisen Kirjallisuuden Seuran Toimituksia 896. Helsinki, Finland. Original in Finnish.

Kankaansydän-Lahtinen, A. 2003. Johtovesi Lopella kiven takana. Hämeen Sanomat newspaper 30.1.2003. Original in Finnish.

Katko, T. 1997. Water: Evolution of Water Supply and Sanitation in Finland from the mid-1800s to 2000. Finnish Water and Waste Water Works Association. Helsinki, Finland.

Katko, T. and Nygård, H. 2000. Views on the history of water, wastewater and solid waste services. Journal Tekniikan Waiheita, Vol. 18, No. 4/2000. Finland.

Kaunisto, A. 2004. Manager of the water services utility in Ulvila, Finland, Personal communication 14.11.2004.

Kero, E. and Seppovaara, J. 1994. Huussi. Gummerus Kirjapaino Oy. Jyväskylä, Finland. Original in Finnish.

Kinnari-Kuparinen, S. 2004. Hallitus esittää maaseudulle harkinnanvaraisia avustuksia, Rahan meno yllätti maalle muuttaneet and Harvalta ympäristökeskukselta heruu rahaa yksittäisille kiinteistöille, three articles in Hämeen Sanomat newspaper, 6.9.2004. p. 3. Original in Finnish.

Kiukas, R. 2003. Kuivakäymälä – vieläpä sisälle. Ympäristö ja Terveys-lehti. Vol. 34, No. 10/2003. pp. 17 - 20. Original in Finnish.

Kiukas, R. and Repka, T. 2003. Ensimmäinen kansainvälinen kuivakäymäläkonferenssi. Ympäristö ja Terveys-lehti. Vol. 34, No. 10/2003. pp. 4 - 11. Original in Finnish.

Kiukas, R. 2004. Kaakkois-Pirkanmaan hajalietteet, Selvitys seutukunnan haja-alueen kiinteistökohtaisesta jätevesienkäsittelystä ja hajalietteiden käsittelyn nykytilasta ja käsittelyn vaihtoehdoista. Kaakkois-Pirkanmaan seututoimikunta. Tehokopio Oy. Original in Finnish.

Korkka-Niemi, K., Sipilä, A., Hatva, T., Hiisvirta, L., Lahti, K. and Alfthan, G. 1993. Nationwide rural well water survey. The quality of household water and factors influencing it. National Board of Waters and the Environment. Publication serie A No. 146. Helsinki, Finland. Original in Finnish, Abstract in English.

Kortelainen, M. 2004. Luvattomia rakennuksia yli 25 000. Rakennuslehti 1.4.2004. Original in Finnish.

Koskiaho, B. 1990. Ohi, läpi ja reunojen yli, Tutkimuksen peruskysymyksiä (Past, through and over edges, The basics of research). Oy Gaudeamus Ab Ltd. Helsinki, Finland. Original in Finnish.

Kujala-Räty, K. 1984. Käymälän ja jäteveden puhdistustavan valinta kunnallisen viemärilaitoksen ulkopuolella. Journal Kunnallistekniikka – Kommunalteknik, No. 4/1984. pp. 12 - 15. Original in Finnish.

Kujala-Räty, K. 2001. Wastewater treatment plants' functionality study. Chapter 6 in Kujala-Räty, K. and Santala, E. (eds.). Improvement of Wastewater Treatment in Rural Areas - Final Report of the Hajasampo Project. The publication serie of Finnish Environment Institute: The Finnish Environment no 491. Edita Oy. Helsinki, Finland. Original in Finnish, Summary in English.

Kujala-Räty, K. 2004 a. On-site Wastewater Treatment Plants' Functionality Study. Hajasampo Project. The publication serie of Finnish Environment Institute: The Finnish Environment no 654. Edita Oy. Helsinki, Finland. Original in Finnish, Summary in English.

Kujala-Räty, K. 2004 b. Haja-asutuksen jätevesipulmat (Wastewater problems in sparsely populated areas). Vesitalous, Finnish journal for professionals in the water sector, Vol. 45, 3/2004. pp. 11 – 15. Original in Finnish, Abstract in English.

Kujala-Räty, K. and Santala, E. (eds.) 2001. Improvement of Wastewater Treatment in Rural Areas - Final Report of the Hajasampo Project. The publication serie of Finnish Environment Institute: The Finnish Environment No 491. Edita Oy. Helsinki, Finland. Original in Finnish, Summary in English.

Lane, J. 2004. Positive experiences from Africa in water, sanitation and hygiene. Water policy, Vol. 6, 2/2004. pp. 153 – 158. IWA Publishing.

Ledin, A., Eriksson, E. and Henze, M. 2001. Aspects of groundwater recharge using grey wastewater. Chapter 18 in Lens, P. Zeeman, G. And Lettinga, G (eds.) Decentralised Sanitation and Reuse – concepts, systems and implementation. IWA Publishing. London, UK.

Lehtovuori, P. 2002. Development of Purification Standards of On-Site Wastewater Treatment in Hämeenkyrö. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Lens, P., Zeeman, G. and Lettinga, G. (eds.) 2001. Decentralised Sanitation and Reuse, Concepts, systems and implementation. IWA Publishing. London, UK.

Loiskekoski, P. 2005. Jätevesihuollon avustukset ohjautuvat lähinnä yhteishankkeisiin. Maaseudun Tulevaisuus newspaper 16.2.2005. Jätevesiliite, p. 16. Original in Finnish.

Lundqvist, J., Turton, A. and Narain, S. 2001. Social, institutional and regulatory issues. Chapter 8 in Maksimović, Č. and Tejada-Guibert, J.A. Frontiers in Urban Water management, Deadlock or Hope. IWA Publishing. London, UK.

MacCann, B. 2004 a. Hopes for a household solution. Water 21, February 2004. p. 29. IWA Publishing.

MacCann, B. 2004 b. Necessity drives a thirst for conservation. Water 21, June 2004. pp. 16 – 18. IWA Publishing.

MacCann, B. 2004 c. Soil issues shape sludge thinking. Water 21, December 2004. pp. 27-29. IWA Publishing.

Mattila, H. 2001. Hajasampo. In Sarvala, M. and Sarvala, J. (eds.). Pyhäjärvi, Yhteistyöllä vauhtia vesiensuojeluun Lounais-Suomessa. The final report of the first operation period (1995 to 1999) of Lake Pyhäjärvi Protection Fund. pp. 67 – 70. Newprint. Uusikaupunki, Finland. Original in Finnish, Summary in English.

Mattila, H. 2003 a. Haja-asutuksen jätevesihuolto ja kunnat (On-site sanitation and municipalities). Suomen kuntaliitto (The Association of Finnish Local and Regional Authorities). Original in Finnish. Available in www.kunnat.net (23.11.2004).

Mattila, H. 2003 b. Dry Toilet - a Solution to Meet New Requirements for On-site Sanitation in Finland. Conference proceedings of the 1st International Dry Toilet Conference. 20 – 23.8.2003. Tampere, Finland.

Mattila, H. 2004. Haja-asutuksen jätevesien käsittelyn perusteet (The Basics in On-site Sanitation). Haja-asutuksen jätevesihuollon suunnittelijakoulu, kurssimateriaali. Hämeen ammattikorkeakoulu. Hämeenlinna, Finland. Original in Finnish.

Matsui, S., Henze, H., Ho, G. and Otterpoohl, R. 2001. Emerging paradigms in water supply and sanitation. Chapter 5 in Maksimović , Č. and Tejada-Guibert, J.A. Frontiers in Urban Water management, Deadlock or Hope. IWA Publishing. London, UK.

McIntosh, B. and Jeffrey, P. 2004. Social learning: a contribution to sustainability. Water 21, October 2004. p. 51. IWA Publishing.

Millennium Project Task Force for Water and Sanitation 2004. Interim Report. Coordinators Lenton, R. And Wright, A., UNDP, 1.2.2004. Available at www.unmillenniumproject.org (13.1.2005).

Miller, C., Wert, J. and Beaudoin, B. 2004. Composting upgrade combined with water reuse. Water 21, December 2004. p. 30. IWA Publishing.

Ministry of the Environment 1999. Water Protection Targets for the Year 2005. The publication serie of Ministry of the Environment: The Finnish Environment no 340. Edita Ltd. Helsinki, Finland.

Ministry of Agriculture and Forestry 2005. Environmental Programme Changes Farming Practices. Available at http://www.mmm.fi/english/agriculture/environment/ (24.2.2005).

Mononen, K. 2002. Loma-asutus – uhka vesistöille?, Asiantuntijoiden ja kesämökkiläisten näkemyksiä vapaa-ajan asuntojen jätevesihuollosta Anttolassa. M.Sc. thesis. University of Joensuu. Department of Geography. Joensuu, Finland. Original in Finnish.

Mäkelä, M. 2004. Elintarvikeketjun vedet –hanke kumppanina maatilan ja elintarvikeyrityksen vesiasioissa (The Waters in Food Chain Project helps farms and enterprises refining food in water related problems). Information booklet Tuutti of Pyhäjärvi-Institute No. 1/2004. Original in Finnish.

Nadkarni, M. 2003. Faecal Sludge Use in High Density Urban Environments. Conference proceedings of the 1st International Dry Toilet Conference. 20 – 23.8.2003 Tampere, Finland.

Nikkari, I. 2001. Wastewater Treatment Plan Based on Zone Division in Sparsely Populated Areas and Farms in Loimaa Region. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

North, D.C. 1990. Institutions, Institutional Change and Economic Performance. Cambridge University Press. Melbourne, Australia.

North, D.C. 2005. Understanding the Process of Economic Change. In Mokyr, J. (ed.) The Princeton Economic History of the Western World. Princeton University Press. Oxford, USA.

Nygren, A. and Joensuu, K. 2004. Pirkanmaan vesihuollossa monia kehittämistarpeita – kriisivalmiuksia parannettava. Tekniikka ja Kunta. Vol. 28, No. 4/2004. pp. 17 – 18. Original in Finnish.

Näsi, J. and Näsi, S. 2002. Management tensions and configurations. Papers on strategic management issues in the stakeholder society. Reports from the School of Business and Economics, No. 30/2002. University of Jyväskylä, Jyväskylä, Finland.

Ocampo, J.A., 2004. Water, sanitation and shelter: Key issues for sustainable development. The conference programme of Stockholm Water Week 2004. pp. 49 – 51. Stockholm, Sweden.

Ojanperä, P. 2003. Kiinteistönomistajan pakko investoida ilman tietoa laitteiden toimivuudesta. Turun Sanomat newspaper, 16.11.2003. Original in Finnish.

Ongley, E.D. 2004. Non-Point Source Water Pollution in China: Current Status and Future Prospects. Water International. Vol. 29, No. 3/2004. pp. 299 - 306. International Water Resources Association, IWRA.

Otterpohl, R., Braun, U. and Oldenburg, M. 2004. Innovative Technologies for Decentralised Water-, Wastewater and Biowaste Management in Urban and Peri-Urban Areas. Water Science & Technology. Vol.48, No.11/2004. pp. 23 – 32. IWA Publishing.

Pacey A, 1977. Technology is not enough: the provision and maintenance of appropriate water supplies. *Aqua*. Vol. 1, No. 1/1977. pp. 1-58.

Peltola, T. 2005. Haja-asutuksen jätevesihuollon kehittämisvaihtoehdot, tapaus Maliskylä. M.Sc. thesis. University of Oulu, Department of Process and Environmental Engineering. Oulu, Finland. Original in Finnish.

Price, W.T. 2001. A Pracademic Research Agenda for Public Infrastructure. Public Works Management & Policy, Vol. 5, No. 4/2001. pp. 287 – 296.

Radnor, H. 2002. Researching Your Professional Practice – Doing interpretive research. Open University Press. Philadelphia, USA.

Rannisto, J. 2003. Comparison of the Sanitation Service Costs and Environmental Effects within a Mobile Sewer System Test in Terälahti Village in Tampere. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Rantanen, R. 2004. IT vesihuollossa ja ympäristönhoidossa. Kunnossapito, Vol 18, No 4/2004. pp. 44 – 46. Original in Finnish.

Reijonen, H. 2002. Mökeille oma vesihuoltomalli. Helsingin Sanomat newpaper 4.5.2002. Original in Finnish.

Reina, P. 2004. Wastewater's wait for terrorism legislation. Water 21, December 2004. p. 38 39. IWA Publishing.

Rosemarin, A. 2004 a. Sustainable Sanitation and Water in Small Urban Centres. The 14th Stockholm Water Symposium. August 16 – 20, 2004. Abstract Volume. Drainage Basin Management – Regional Approaches for Food and Urban Security. pp. 147 – 149. Stockholm International Water Institute. Stockholm, Sweden.

Rosemarin, A. 2004 b. The Building of China's First Ecosan Town in Inner Mongolia – Aspects Relating to Sustainable Urban Water and Sanitation. The 14th Stockholm Water Symposium.16 – 20.8.2004. Abstract Volume, Drainage Basin Management – Regional Approaches for Food and Urban Security. pp. 63 – 65. Stockholm International Water Institute. Stockholm. Stockholm, Sweden.

Rouse, M. 2004. Sweden, sanitation, and signing off. Water 21, October 2004, p. 65, IWA Publishing.

Ruuska, M. 2001. Questionnaire study about experiences of using composting toilets. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Salokangas, S. 2001. Study on wastewater load of housing on the shores of Lake Isojärvi. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Santala, E. 2004. Hajautettu ja kiinteistökohtainen jätevesien käsittely kiinnostavat maailmalla. Tekniikka ja Kunta. Vol. 28, No. 4/2004. pp. 12 – 14. Original in Finnish.

Saralehto, K. 2001. The Full Service Package for WasteWater Treatment of Rural Areas – Business Strategy. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Sarvala, M. and Sarvala, J. (eds.) 2001. Pyhäjärvi, Yhteistyöllä vauhtia vesiensuojeluun Lounais-Suomessa, the final report of the first operation period 1995 - 1999 of Lake Pyhäjärvi Protection Fund. The Publication Serie of Pyhäjärvi-institute, no 26. Newprint. Uusikaupunki, Finland. Original in Finnish, Summary in English.

Schiller, T. and Schienle, S. 2004. Self-Administration by Users in the Delivery of Water and Wastewater Services – the Sistema Integrado de Saneamento Rural do Piauí. The 14th Stockholm Water Symposium. 16 – 20.8.2004. Abstract Volume, Drainage Basin Management – Regional Approaches for Food and Urban Security. pp. 83 – 84. Stockholm International Water Institute. Stockholm, Sweden.

Scott, C.A. 2003. Recycling and reuse of 'derivative water' under conditions of scarity and competition. Chapter 6 in Figuěres, C.M., Tortajada, C. and Rockström, J. Rethinking Water Management. Earthscan Publications Ltd. London, UK.

Seppälä, O.T. 2004. Visionary Management in Water Services: Reform and Development of Institutional Framework. Doctoral dissertation. Tampere University of Technology, Publications No. 457. Tampere, Finland.

Sjöblom, A. 2002. Västanfjärd – päästötön kunta. Tekniikka ja Kunta. Vol.26, No. 5/2002. pp. 18 - 19. Original in Finnish.

Soininen, A. 2002. The Tracking and Maintenance of Real Estate Wastewater System. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Suojanen, U. 2005. Toimintatutkimus (Action research). Available at www.metodix.com. In Finnish.

Stark, K., Levlin, E. and Hultman, B. 2004. Phosphorous Recovery from Sludge – National Policies and Assessments in Sweden, the Netherlands and Germany. The 14th Stockholm Water Symposium.16 – 20.8.2004. Abstract Volume, Drainage Basin Management – Regional Approaches for Food and Urban Security. pp. 169 – 171. Stockholm International Water Institute. Stockholm, Sweden.

Stedman, L. 2003. Sludge solution seekers. Water 21, December 2003. pp. 25 – 26. IWA Publishing.

Stedman, L. 2004. Global goals 2004. Water 21, October 2004. p.12. IWA Publishing.

Tammi, S. 2003. Sewage to the Sewer System or to the Sewage Treatment Plant of Real estate? – cost comparison. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Tampereen vesipiirin vesitoimisto, Tampereen seutukaavaliitto and Satakunnan seutukaavaliitto 1986. Pirkanmaan ja Pohjois-Satakunnan haja-asutusalueiden vedenhankinnan yleissuunnitelma. Painokehä. Tampere, Finland. Original in Finnish.

Tapaninen, A. 1997. Hausjärven kaivovesitutkimus kesällä 1996. Ympäristö ja Terveys-lehti. Vol. 28, No. 1/1997. pp. 20 - 22. Original in Finnish.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., Schindler, D., Schleisinger, W.H., Simberloff, D. and Swackhamer, D. 2001. Forecasting Agricultural Driven Global Environmental Change. Science, Vol 292. April 2001.

Tompuri, V. 2005. Vesiala jäänyt Suomen kehitysyhteistyössä paitsioon. Rakennuslehti. Vol. 39, No. 8. p. 20. Original in Finnish.

Tuusa, P. 2005. Rantatonteilla kalastellaan kuntiin uusia asukkaita. Kuntalehti. Vol. 13, No. 2/2005. pp. 32 – 34. Original in Finnish.

Uleimat, A.A. 2004. Quality Aspects of Gray water in Jordan. The 14th Stockholm Water Symposium.16 – 20.8.2004. Abstract Volume, Drainage Basin Management – Regional Approaches for Food and Urban Security. pp. 133 – 135. Stockholm International Water Institute. Stockholm, Sweden.

USEPA 2001. Onsite Wastewater Treatment System Manual. United States Environmental Protection Agency. February 2002. EPA/625/R-00/008. Cincinnati, USA.

Uusi-Kämppä, J. 2004. Kotieläintalouden vesiensuojelu ja ympäristönhoito (Water protection and environmental management in animal husbandry). Vesitalous, Finnish journal for professionals in the water sector. Vol. 45, 3/2004. pp. 7 – 9. Original in Finnish, Abstract in English.

Uusi-Kämppä, J. and Rissanen, P. (eds.) 2004. Suuret pihatot – eläinten hyvinvointi, lypsyn työmenekki ja ympäristönhoito. The publication No. 47 of MTT Agrifood Research Finland. Dark Ltd. Finland. Original in Finnish.

Uusimaa Regional Environment Centre 2004. Vesiosuuskunnan ABC. A guide for water co-operatives. Draft 2004. Helsinki, Finland. Original in Finnish.

Valpasvuo, V. 2002. Kuntien ympäristönsuojeluvoimavarojen muutoksesta. Ympäristö ja Terveys-lehti. Vol. 33, No. 1/2002. pp. 32 - 33. Original in Finnish.

Vehmanen, J. 2005. Takamaiden jätevesissä muhii miljardibisnes. Turun Sanomat newspaper. 16.04.2005, p.23. Original in Finnish.

Vienonen, H. 2003. Utilization of Excess Liquid of Composting Toilet and Urine from Separating Composting Toilet. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Viitala, P. 2001. Performance of Small Sewage Treatment Plants in Pirkanmaa. B.Sc. thesis. Häme Polytechnic, Environmental Engineering. Hämeenlinna, Finland. Original in Finnish, Abstract in English.

Vilpas, R., Kujala-Räty, K., Laaksonen, T. and Santala, E. 2005. Enhancing nutrient removal efficiency of on-site wastewater treatment systems, Part 1: Treatment of domestic wastewater. The publication serie of Finnish Environment Institute: The Finnish Environment 762. Edita Oy. Helsinki, Finland. Original in Finnish. Abstract in English.

Wegelin-Schuringa, M. 2001. Public awareness and mobilization for sanitation. Chapter 28 in Lens, P. Zeeman, G. And Lettinga, G (eds.). Decentralised Sanitation and Reuse – concepts, systems and implementation. IWA Publishing. London, UK.

Werner, C., Fall, P.A., Schlick, J. and Mang H.-P. 2003. Reasons for and Principles of Ecological Sanitation. Conference proceedings of the 2nd International Symposium on ecological sanitation. 7 – 11.4.2003. Lübeck, Germany

Wilderer, P.A. 2001. Decentralized versus centralized wastewater management. In Lens, P., Zeeman, G. and Lettinga, G. (eds.) Decentralised Sanitation and Reuse, Concepts, systems and implementation. IWA Publishing. London, UK.

Wirbelauer, C., Breslin, E.D. and Guzha, E. 2003. Lessons Learnt on Eco-San in Southern Africa - Towards Closed-loop Sanitation? Conference proceedings of the 2nd International Symposium on ecological sanitation. 7 – 11.4.2003. Lübeck, Germany.

Wolf, A.T. 2003. The present and future of transboundary water management. Chapter 9 in Figuěres, C.M., Tortajada, C. and Rockström, J. Rethinking Water Management. Earthscan Publications Ltd. London, UK.

Wynn, J. 2002. Innovative and alternative on-site treatment of residential wastewater. United States housing and urban development program. January 2002.

Yli-Tolppa, H. and Vaitomaa, K. 2002. Vesihuolto. Chapter 7.5 in Enckell, E., Airola, H., Tornivaara-Ruikka, R., Villa, L. and Salasto R. (eds.). Changes seen in the environment. Report from Uusimaa Regional Environmental Centre. Regional Environmental Publications 269. Edita Publishing Ltd and Uusimaa Regional Environmental Centre. Helsinki, Finland. Original in Finnish, Abstract in English.

Yläjärvi, S. 2004. Nyt Eeli Salmelalla riittää vettä. Aamulehti newspaper 15.5.2004. Original in Finnish.

www-pages

www2.gtz.de/ecosan/english/symposium2.htm#7 (16.12.2004)

www2.hamk.fi/ymparistoteknologia/ (13.10.2004)

www.ciesin.columbia.edu/indicators/ESI (5.9.2004)

www.ecosanres.org (2.2.2005)

www.europa.eu.int/comm./environment/nsf/index.htm (12.1.2005)

www.europa.eu.int/comm/environment/waste/index.htm (12.1.2005)

www.euro.who.int (12.1.2005)

www.euro.who.int/eprise/main/who/progs/wsn/home?language=English (12.1.2005)

www.fise.fi (13.3.2005)

www.gwdg.de/~uwvw/icr.htm (3.12.2004)

www.iwahq.org (1.1.2005)

www.johannesburgsummit.org/ (1.1.2005)

www.nwl.ac.uk/research/WPI (13.2.2005)

www.siwi.org (10.10.2004)

www.sulvi.fi (6.3.2005)

www.unesco.org/water/wwap (12.1.2005)

www.uponor.fi/ (12.12.2004)

www.uponor.fi/ifs/files/Uponor/fin/Presentation/Website/News/UponorjaRautakeskokoulutta vatjxtevesiosaajia.jsp (6.3.2005)

www.visitfinland.com (25.2.2005)

www.who.int (2.2.2005)

www.who.int/water_sanitation_health/diseases/burden/en/ (2.2.2005)

www.wsscc.org (2.2.2005)
www.ymparisto.fi/default.asp?contentid=117364&lan=fi (1.3.2005)

Legislation (available at www.finlex.fi)

Act on Water Services (119/2001)

The Constitution of Finland (731/1999)

Environmental Protection Act (86/2000)

Government Decree on the restriction of discharge of nitrates from agriculture into waters (931/2000)

Government Decree on Treating Domestic Wastewater in Areas Outside Sewer Networks (542/2003)

Health Protection Act (763/1994)

Land Use and Building Act (132/1999)

Land Use and Building Decree (895/1999)

Tuloverolaki (1535/1992 127 a – c § and changes 995/2000, 1162/2002 and 1273/2004). Original in Finnish.

Waste Act (1072/1993)

Water Act (264/1961)

Directives

European Union Water Framework Directive (2000/60/EC)

I

Paper I

Mattila, H. The role of public acceptance in the application of DESAR technology. Chapter 27 in Lens, P. Zeeman, G. And Lettinga, G. (eds.) 2001 Decentralised Sanitation and Reuse – concepts, systems and implementation. IWA Publishing. London, UK. ISBN: 1900222477

II

Paper II

Mattila, H. Management of Wastewater Treatment in Rural Areas. Conference proceedings. An oral presentation in the 9th International Conference on the Conservation and Management of Lakes. November 11-16, 2001. Shiga, Japan.

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III

Paper III

Mattila, **H**., Santala, E. and Aho, J. Consumer Managed Co-operative – A Solution for Progressing Wastewater Management in Rural Areas. Journal Water Science & Technology. Vol. 48, No. 11. pp 385–391. IWA Publishing 2004. London, UK.

IV

Paper IV

Mattila, H. New legislation for on-site sanitation in Finland. Conference proceedings. An oral presentation in 2nd International Symposium on ecological sanitation. April 7-11, 2003. Lübeck, Germany.

Tampereen teknillinen yliopisto
PL 527
33101 Tampere

Tampere University of Technology
P.O. Box 527
FIN-33101 Tampere, Finland