

Recovery and reuse of plant nutrients in
human excreta and domestic wastewater

Mapping the implementation in practice in Sweden

Solveig Johanneshottir and Robin Harder

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A working paper from the project:

End-of-wastewater: Co-design of a knowledge brokering toolbox to support sustainable nutrient and carbon recovery and reuse.

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END-OF-WASTEWATER

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1 Introduction

1.1 The Project 'End-of-wastewater'

'End-of-wastewater' is a collaborative research project running from 2020-2023.¹ It is carried out by Swedish researchers in close collaboration with the Swedish Nutrient Platform (SNP) – a platform that is open for engagement from all interested actors along the value chain of nutrient recovery and reuse.²

The ambition of the project is to co-design, together with committed Swedish actors, an online evidence platform to support and encourage acceptance, implementation, and upscaling of innovative and sustainable solutions to recirculate nutrients and carbon from human excreta and domestic wastewater to agriculture.

We hope that this online evidence platform will become a trusted source of knowledge that supports diverse actors who wish to contribute to increased nutrient and carbon recirculation in a way that supports healthy water, soil, food, and people.

The project gratefully acknowledges funding from the Kamprad Family Foundation.

1.2 Scope of this Working Paper

The online evidence platform will encompass two types of evidence. First, evidence from research output internationally. Second, evidence of the implementation in practice in Sweden. This working paper focuses on the second type of evidence, which henceforward is referred to as 'case examples'.

2 Finding Case Examples

Two approaches were used for mapping case examples. The first approach consisted of searching the internet for projects, reports, news, etc. that describe examples of the implementation in practice of nutrient recovery from human excreta and domestic wastewater in Sweden. The second approach consisted of contacting Swedish municipalities to ask them about any work or studies on the implementation of circular nutrient solutions other than sewage sludge land application.

2.1 Internet Searches

Several websites and online databases (see Table 1) were searched for content related to nutrient recovery and reuse from human excreta, domestic wastewater, and any organic residuals derived from these streams. Keywords used for the searches were in both Swedish and English (see Table 2) and adapted to each website, project database, or institutional repository searched.

¹ <https://www.endofwastewater.net>

² <https://www.ri.se/sv/svenskanaringsplattformen>

Table 1. List of websites, project databases, and institutional repositories that were searched.

Websites	
LRF	https://www.lrf.se
RagnSells	https://www.ragnsells.se
Project databases	
Formas	http://proj.formas.se
Havs- och vattenmyndigheten (HaV)	https://projektkatalog.havochvatten.se
Vinnova	https://www.vinnova.se/sok-finansiering/projekt/
Institutional repositories	
Chalmers Research	https://research.chalmers.se
Digitala Vetenskapliga Arkivet (DiVA)	https://www.diva-portal.org
IVL Publikationer	https://www.ivl.se/publikationer.html
Naturvårdsverket Publikationer	http://www.naturvardsverket.se/om-naturvardsverket/publikationer/
SEI Publications	https://www.sei.org/publications
SLU Epsilon Archive for Student Projects	https://stud.epsilon.slu.se
SVU Vattenbokhandeln	https://vattenbokhandeln.svensktvatten.se
SVU Filarkiv	http://vav.griffel.net/vav.htm

Table 2. List of keywords used for the searches.

	English	Swedish
Population	wastewater, sewage, sludge, excreta, blackwater, brownwater, feces, faeces, fecal, faecal, source-separation, waste	avlopp, svartvatten, klosettvatten, slam, toalettavfall, källsorterad, källsortering, urin
Intervention	recover, recycle, reuse, return, resource	återvinna, återföra, återanvända
Outcome	nutrient, phosphorus, phosphate, nitrogen, nitrate, ammonia, ammonium	näring, växtnäring, fosfor, fosfat, kväve, nitrat, ammoniak, ammonium

Search results were screened for relevance in three stages. A *first screening* was performed during searches based on project or document title, respectively. Project and document titles that suggested the described case example is obviously not about nutrient recovery from human excreta or domestic wastewater, or not connected to Sweden, were excluded. Project and document titles that seemed to describe case examples that are possibly about nutrient recovery from human excreta or domestic wastewater in Sweden were saved either to the reference management software Zotero (where citation export was possible) or to a spreadsheet in Excel (where citation export was not possible). A *second screening* was performed based on project or document abstracts, once again excluding content that was obviously irrelevant, and including content that appeared potentially relevant. A *third and last screening* looked at the full content of the project description or document, and irrelevant content was excluded. The eligibility criteria that were applied to decide whether to include a given project or document were as follows.

- The case example that is described concerns nutrient recovery and reuse from human excreta or streams containing human excreta, notably domestic wastewater. This includes systems that manage residues and products that are derived from human excreta or wastewater that contains human excreta, such as digestate, treated sludge, treated effluent, etc. Both municipal and on-site systems are relevant, as well as co-

treatment with other organic residuals. Systems that manage only greywater, stormwater, industrial wastewater, agricultural wastewater or animal manure are not considered. NOTE: Case examples of conventional nutrient recovery and reuse from sewage sludge were excluded. This applies notably to anaerobic digestion of sewage sludge and the application of sewage sludge (e.g., ReVAQ sludge) to farmland.

- The case example represents an actual implementation of a circular nutrient technology, or a feasibility study or sustainability assessments for a planned implementation of a circular nutrient technology.
- The case example is at the pilot- and full-scale. In other words, case examples at the lab- and bench-scale were not considered.
- The case example is in Sweden. No time limitations were applied.

The total number of hits per search source, including the number of projects or documents deemed relevant in terms of above eligibility criteria and after each screening level are shown in Table 3. In total, our various internet searches pointed to 65 case examples, see Figure 1.

Table 3. Search hits per source, including number of relevant projects or documents per screening level. * Indicates unknown number.

Type	Source	Hits	1 st screening	2 nd screening	3 rd screening
Website	LRF	40	1	0	0
Website	RagnSells	84	7	1	1
Project database	Formas	150	10	5	1
Project database	HaV	0	0	0	0
Project database	Vinnova	1 289	21	11	6
Institutional repository	Chalmers	427	76	4	2
Institutional repository	DiVA	6 122	*	21	9
Institutional repository	IVL	207	9	1	1
Institutional repository	Naturvårdsverket	69	16	6	5
Institutional repository	SEI	16	4	2	1
Institutional repository	SLU	531	*	14	7
Institutional repository	SVU	83	74	40	15
Projects and documents	Total	9 018	253	105	48

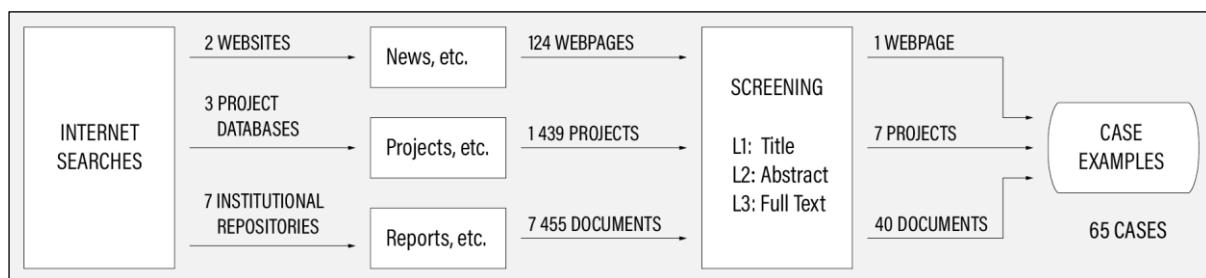


Figure 1. Procedure for identifying case examples through searching the internet.

2.2 Contacting Municipalities

Sweden has 290 municipalities, ranging from 2 425 inhabitants in Bjurholm to 968 455 in Stockholm in 2019.³ Each municipality is required to have a detailed plan for its built environment ('detaljplan' in Swedish). Municipalities can choose to elaborate a separate plan for their urban water infrastructure ('VA-plan' in Swedish). Even though these separate planning documents for the urban water infrastructure are not mandatory, many municipalities see the benefit of having a separate planning process for this critical and often expensive infrastructure. The respective planning documents are commonly in the form of a policy, strategy, or detailed plan for water and wastewater development. We assumed that municipalities that do not have a separate planning document for the urban water infrastructure are unlikely to engage in innovative ways of nutrient recovery from human excreta and domestic wastewater. The same assumption was made regarding municipalities that do have a separate planning document, but do not mention nutrient recovery or the circular economy in this document.

The municipal entities of relevance to the urban water infrastructure include the respective municipal councils ('nämnd' in Swedish) and administrations ('förvaltning' in Swedish), as well as municipal utilities ('kommunalt bolag' in Swedish). In municipalities with municipal utilities, typically, these utilities manage the sewer networks and sewage treatment plants, while the respective municipal administrations regulate and approve on-site systems. Where applicable, we decided to primarily target municipal utilities. This decision was motivated by the assumption that (1) the implementation in practice of circular nutrient solution falls under the responsibility of the respective municipal utility rather than the municipal administration, and that (2) any e-mail sent to the municipal administration would likely be forwarded to the municipal utility anyway.

The stepwise procedure of finding and screening planning documents, and of contacting municipal administrations and utility companies to obtain case examples is summarized in Figure 2 and Table 4. Details on the outcomes of each step are provided in Appendix A.

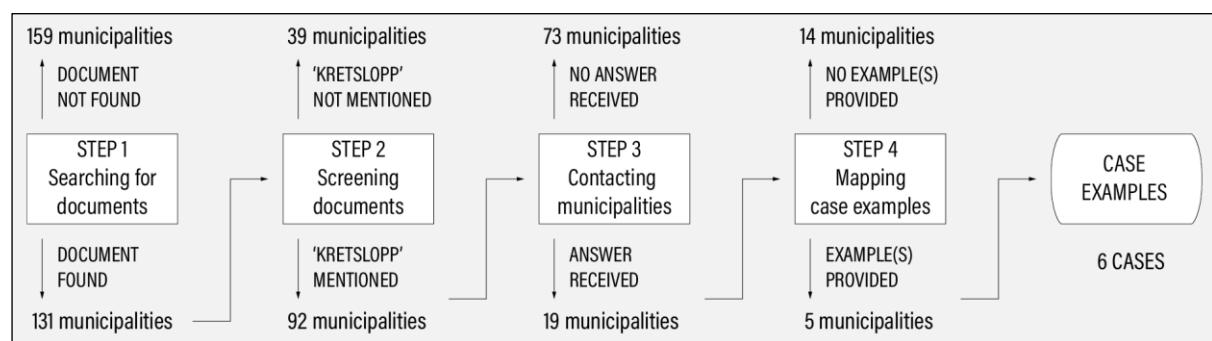


Figure 2. Procedure for identifying case examples through contacting municipalities.

³ <https://www.scb.se/hitta-statistik/statistik-efter-amne/befolkning/befolknings-sammansattning/befolkningsstatistik/pong/tabell-och-diagram/kvartals--och-halvarsstatistik--kommun-lan-och-riket/forsta-halvaret-2019/>

Table 4. Description of the four individual steps.

Step	Description
1	Google was searched for 'VA-plan', 'VA-strategi' and 'VA-policy'. For some municipalities, only a 'VA-strategi' or 'VA-policy' document was found, for others only a 'VA-plan' document, and for some both (see Appendix A).
2	Each planning document was searched for the Swedish term 'kretslöpp', which conveys the idea of resource recovery and reuse in general. The term 'kretslöpp' furthermore needed to be used in a context relevant for this mapping, that is, wastewater and resource management. Hereby, it did not matter how detailed or ambitious the plan for managing resources in wastewater were.
3	Relevant e-mail addresses were searched for each municipal administration or utility on the respective websites. The following order of preference was applied for contacting municipalities through e-mail. <ol style="list-style-type: none"> 1. Relevant municipal utility (e.g., wastewater utility). 2. Relevant municipal administration (e.g., wastewater or environmental department). 3. General contact address of the municipality (e.g., 'contact@municipalityname.se'). The complete e-mail can be found in Appendix A. In summary, we asked two questions. First, about any work or studies on nutrient recovery from wastewater (other than spreading sewage sludge on farmland). Second, about the usefulness and interest of a list of case examples for Sweden. We also attached a spreadsheet with a list of 17 case examples from Sweden. The idea was to exemplify the kind of case examples and information we are looking for. This, we hoped, would increase the likelihood of getting a response.
4	Case examples were mapped based on the responses we obtained. We also noted whether the municipal administrations or utilities that responded stated that such a map of case examples could be of interest to them.

Of the 92 municipalities that we contacted, only 19 responded, which is a response rate of just over 20 percent. Only 5 of the 19 municipalities that responded reported on work regarding nutrient recovery from wastewater (other than land application of sewage sludge on farmland). Yet 11 out of the 19 municipalities that responded, which is just under 60 percent of the respondents, stated that they would be interested in a map of case examples in Sweden. In addition to this attempt, the research team as well as municipalities participating in the SNP were asked to contribute with relevant knowledge.

2.3 Coding Case Examples

From each case example, we aimed to compile the following information:

- Short description in Swedish and English
- Size of the operation (e.g., m³, p.e.)
- Type of operation (e.g., full scale, pilot scale, theoretical study)
- In operation (yes, no)
- Year of construction/commissioning or year of study
- Operated by (municipality, research, company)
- Source stream (e.g., urine, blackwater, conventional wastewater)
- Access stream (e.g., raw wastewater, reject water, sewage sludge ash)
- Technology or process (e.g., storage, liquid composting, ammonia stripping)
- Nutrient product (e.g., struvite, ammonium sulfate)
- Location (i.e., place and municipality)

3 Preliminary List of Case Examples

We would like to emphasise that the following preliminary list of case examples in Sweden is not complete. There is a lot of knowledge to be found within municipal administrations and utilities, as well as consultancy companies, that is not necessarily accessible through any website or report. Likewise, technology providers may have ongoing pilot studies that are up and running, but not necessarily reported on yet.

Above said, the list of case examples that we have compiled first and foremost represents examples that are described in the literature, with a few more examples added through the contact with municipal administrations and utilities. We hope that the compilation of this dataset can motivate various actors to contribute more case examples in the future.

3.1 Source-Separating Sanitation Systems

With source-separating sanitation systems we here refer to systems where urine and/or faeces are collected and treated separately from other domestic wastewater fractions, notably greywater. Broadly, one can distinguish three system configurations. First, systems where urine is diverted for separate treatment while the faecal fraction is sent to the municipal sewer system together with other domestic wastewater fractions. Second, urine diversion systems where the faecal fraction is treated separately from other domestic wastewater fractions. Third, systems where urine is collected and treated together with faeces, and possibly flush water.

3.1.1 Urine Diversion without Separate Treatment of Faecal Fraction

In most of the systems where urine is diverted and the faecal fraction sent to the municipal sewer system, urine is treated by means of storage, see Table 5. The notable exception is a urine drying toilet that was recently installed at the headquarters of VA SYD. There are also a few examples of municipalities operating central infrastructure for the treatment of urine, see Table 6, and of pilot experiments for centralised urine treatment, see Table 7.

Table 5: Case examples of urine diversion without separate treatment of the faecal fraction.

Location	Scale	Municipality	Year	Treatment	Product
Svedden	Semi-detached house	Östhammar	1993	Storage	Treated urine
Björbyn Ekoby	Residential area	Luleå	1993	Storage	Treated urine
Mjölnartorpet Ekoby	Residential area	Karlstad	1995	Storage	Treated urine
Understenshöjden	Residential area	Stockholm	1995	Storage	Treated urine
Nytorgsgatan 4	Apartment building	Hallsberg	1995	Storage	Treated urine
Palsternackan	Residential area	Stockholm	1996	Storage	Treated urine
Hushagen	Apartment building	Borlänge	1996	Storage	Treated urine
Liljan 2	Apartment building	Linköping	1996	Storage	Treated urine
Stiernhööksgymnasiet	School	Rättvik	1996	Storage	Treated urine
Vallens School	School	Sundsvall	1996	Storage	Treated urine
Håga Ekoby	Residential area	Uppsala	2000	Storage	Treated urine
Tanum kommun	Onsite sewerage	Tanum	2002	Storage	Treated urine
Ekerödsrasten	Rastplatz	Hörby	2003	Storage	Treated urine
Kullön	Residential area	Vaxholm	2004	Storage	Treated urine
Nyckelviken	School	Nacka	2004	Storage	Treated urine
VA SYD Huvudkontor	Single toilet	Malmö	2021	Dehydration	Dried urine

Table 6: Examples of decentralised municipal infrastructure. Year in parenthesis indicates when operation of facilities stopped (where known).

Location	Scale	Municipality	Year	Treatment	Product
Municipal facility	Onsite sewerage	Tanum	2002	Storage	Treated urine
Bornsjö	Onsite sewerage	Stockholm	2000 (2008)	Storage	Treated urine
Municipal facility	Onsite sewerage	Södertälje	2009	Storage	Treated urine

Table 7: Examples of centralised municipal infrastructure.

Location	Scale	Municipality	Year	Treatment	Product
Hammarby Sjöstadsvärk	Pilot tests	Stockholm	2002	Reverse osmosis	Nutrient concentrate

3.1.2 Urine Diversion with Separate Treatment of Faecal Fraction

All examples of urine diversion with separate treatment of the faecal fraction represent systems where the urine is treated by means of storage and the faecal fraction by means of composting, see Table 8. Typically, the treated urine is used in agriculture, while the faecal-derived compost is typically used on non-productive land such as flower beds or lawns. Most examples we found are from the 1990s.

Table 8: Case examples of urine diversion with separate treatment of the faecal fraction. Year in parenthesis indicates when operation of facilities stopped (where known).

Location	Scale	Municipality	Year	Treatment	Product
Bålarna Ekoby	Residential area	Nordanstig	1991	U: Storage F: Composting	U: Treated urine F: Compost
RuSchool Ekoby	Residential area	Övertorneå	1991	U: Storage F: Composting	U: Treated urine F: Compost
Åkesta Ekoby	Residential area	Västerås	1993	U: Storage F: Composting	U: Treated urine F: Compost
Ekopiloterna	School and hostel	Söderköping	1995 (1999)	U: Storage F: Composting	U: Treated urine F: Compost
Ekoporten	Residential area	Norrköping	1995	U: Storage F: Composting	U: Treated urine F: Compost
Elias Fries School	School	Hylte	1995	U: Storage F: Composting	U: Treated urine F: Compost
Laggarbergs School	School	Timrå	1995	U: Storage F: Composting	U: Treated urine F: Compost
Grafikens hus	Exhibition hall	Strängnäs	1996 (2003)	U: Storage F: Composting	U: Treated urine F: Compost
Smedens Ecovillage	Residential area	Jönköping	1996	U: Storage F: Composting	U: Treated urine F: Compost
Private facility	Household	Knivsta	1996	U: Storage F: Composting	U: Treated urine F: Compost
Teknikhuset	School (College)	Kalmar	1997 (2001)	U: Storage F: Composting	U: Treated urine F: Compost
Östra Torn School	School	Lund	1997	U: Storage F: Composting	U: Treated urine F: Compost
Gebers	Apartment building	Stockholm	1998	U: Storage F: Composting	U: Treated urine F: Compost
Frösaskulls School	School	Halmstad	1998	U: Storage F: Composting	U: Treated urine F: Compost
Hulta By	Onsite sewerage	Linköping	1999	U: Storage F: Composting	U: Treated urine F: Compost
Eklanda School	School	Mölnadal	1999	U: Storage F: Composting	U: Treated urine F: Compost
Brandstationen	Firestation	Mölnadal	1999	U: Storage F: Composting	U: Treated urine F: Compost
Private facility	Farm	Solna	1999	U: Storage F: Composting	U: Treated urine F: Compost
Frillesås School	School	Kungsbacka	2000	U: Storage F: Composting	U: Treated urine F: Compost
Glasberg School	School	Mölnadal	2000	U: Storage F: Composting	U: Treated urine F: Compost

3.1.3 Treatment of Excreta or Blackwater

Regarding examples of the joint collection of urine and feces, there are a few examples of dry composting toilets, see Table 9, and of flush toilets where the liquid and/or solid fraction are treated in various ways, see Table 10. Two recent case examples of separate blackwater treatment in an entire residential area are Munga in Västerås and Oceanhamnen/RecoLab in Helsingborg. We also found quite a few case examples where municipalities offer treatment of blackwater that is collected from on-site sanitation facilities, see Table 11. Here, typical treatments are liquid composting and various forms of hygienisation. Lastly, we found a pilot test where blackwater was anaerobically treated in a membrane bioreactor (AnMBR) and the nutrients in the effluent concentrated through reverse osmosis (RO), see Table 12.

Table 9: Case examples with dry composting toilets.

Location	Scale	Municipality	Year	Treatment	Product
Tuggelite Ecovillage	Residential area	Karlstad	1984	Composting	Compost
Kloster Ecovillage	Residential area	Hedemora	1991	Composting	Compost
Dalby Ecovillage	Residential area	Lund	1993	Composting	Compost
Myrstacken Ecovillage	Residential area	Malmö	1993	Composting	Compost

Table 10: Case examples with separate collection and treatment of blackwater. Year in parenthesis indicates when operation of facilities stopped (where known).

Location	Scale	Municipality	Year	Treatment	Product
Vibyåsen	Residential area	Sollentuna	1996 (2002)	L: Storage S: Composting	L: Effluent S: Compost
Tegelvikens School	School	Eskilstuna	1998	Liquid composting	Treated blackwater
Skogaberg	Residential area	Göteborg	2005	S: Composting	S: Compost
Munga	Residential area	Västerås	2019	S: Hygienization	S: Treated sludge
Oceanhamnen (RecoLab)	City district	Helsingborg	2021	Precipitation Stripping	Struvite $(\text{NH}_4)_2\text{SO}_4$

Table 11: Examples of municipal infrastructure for the treatment of blackwater from on-site sanitation systems.

Location	Scale	Municipality	Year	Treatment	Product
Municipal facility	Onsite sewerage	Enköping	2000	Storage	Treated blackwater
Municipal facility	Onsite sewerage	Katrineholm	?	Storage	Treated blackwater
Municipal facility	Onsite sewerage	Lund	?	Storage	Treated blackwater
Karby	Onsite sewerage	Norrälje	1999	Liquid composting	Treated blackwater
Municipal facility	Onsite sewerage	Norrälje	2004	Liquid composting	Treated blackwater
Municipal facility	Onsite sewerage	Örebro	?	Liquid composting	Treated blackwater
Municipal facility	Onsite sewerage	Strängnäs	?	Liquid composting	Treated blackwater
Municipal facility	Onsite sewerage	Södertälje	2012	Liquid composting + Urea hygienization	Treated blackwater
Municipal facility	Onsite sewerage	Uddevalla	2013	Urea hygienization	Treated blackwater
Municipal facility	Onsite sewerage	Haninge	?	Urea hygienization	Treated blackwater
Municipal facility	Onsite sewerage	Aneby	?	Urea hygienization	Treated blackwater

Table 12: Pilot experiments with the separate treatment of blackwater.

Location	Scale	Municipality	Year	Treatment	Product
Hammarby Sjöstadsvrk	Pilot tests	Stockholm	2005 (2006)	Reverse osmosis on AnMBR effluent	Nutrient concentrate

3.2 Nutrient Recovery from Wastewater and Sludge

Finally, there are the case examples of nutrient recovery and reuse from wastewater and sludge (other than land application of sewage sludge). Pilot experiments range from nutrient extraction from raw wastewater and reject water to thermal treatment and nutrient recovery from sludge, see Table 13. We also found a few case examples of full-scale infrastructure, see Table 14.

Table 13: Pilot experiments for nutrient recovery and reuse from wastewater and sludge. Year in parenthesis indicates when operation of facilities stopped (where known).

Location	Technology	Municipality	Year	Treatment	Product
Knivsta ARV	AquaCare BioPhree®	Knivsta	2019	Sorption from raw wastewater	P solution
Hammarby Sjöstadsv verk	EkoBalans eco:N	Stockholm	2020	Stripping from reject water	$(\text{NH}_4)_2\text{SO}_4$
Hammarby Sjöstadsv verk	-	Stockholm	2005 (2005)	Precipitation in reject water	Struvite
Öresundsverket	-	Helsingborg	2013 (2013)	Precipitation in reject water	Struvite
Hammarby Sjöstadsv verk	-	Stockholm	2002 (2002)	Reverse osmosis on MBR effluent	Nutrient concentrate
Hammarby Sjöstadsv verk	-	Stockholm	2005 (2005)	Reverse osmosis on AnMBR effluent	Nutrient concentrate
Hammarby Sjöstadsv verk	-	Stockholm	2005 (2005)	Reverse osmosis on UASB effluent	Nutrient concentrate
Himmerfjärdsverket	-	Botkyrka	2011	Sludge granulation + fish industry waste	Granular fertilizer
Ellinge ARV	-	Eslöv	Planned	Pyrolysis	Biochar
C-Green Pilotanläggning	C-Green OxyPower HTC	Örnsköldsvik	201?	Hydrothermal carbonisation	Biochar
Margretelund ARV	C-Green OxyPower HTC	Österåker	2021	Hydrothermal carbonisation	Biochar
Norr sundet Slamförädling AB	TerraNova® Ultra	Gävle	2019	Hydrothermal carbonisation + P Extraction	Biochar + Granular fertilizer

Table 14: Full-scale infrastructure for the nutrient recovery and reuse from wastewater and sludge. Year in parenthesis indicates when operation of facilities stopped (where known).

Location	Technology	Municipality	Year	Treatment	Product
Ellinge ARV	-	Eslöv	1992 (2006)	Stripping from reject water	$(\text{NH}_4)_2\text{SO}_4$
Umeå kommun	EkoBalans eco:S	Umeå	Planned	Pyrolysis	Biochar

APPENDIX A:

Internet Search

The following documents that emerged from the internet search were screened for case examples. We separately list reports, journal articles, student theses, fact sheets, and municipal planning documents.

Reports

Organisation	Number	Title	Year
Chalmers VA-Teknik	1995:1	Utvärdering av olika avloppssystem, metod- och fallstudier	1995
Chalmers VA-Teknik	1996:1	Miljökonsekvensbeskrivning tillämpad på alternativa avloppssystem i Bergsjön och Hamburgsund	1996
JTI	18	Hantering av svartvatten och köksavfall i Västerås stad	1999
SLU JB	19	Näring, kadmium och bakterier i huvhållsavlopp - en fältstudie av ett urinsorterande avloppssystem med lecabädd i Östhammar	1995
SLU LT	228	Mätning på två urinsorterande avloppssystem - urinlösning toalettanvärdning och hemvaro i en ekoby och i ett hyreshusområde	1998
SLU BT	2005:04	Hygienisering av klosettvattnen för säker växtnäringsåterförsel till livsmedelsproduktion	2005
SLU BT	2005:05	Wastewater management integrated with farming - An environmental systems analysis of the model city Surahammar	2005
SLU ET	038	Avloppsfraktioner från enskilda kretslopp - Kunskaps sammanställning om klosettvattnen samt exempel på kretslopparbetet i Stockholmsregionen	2010
SLU ET	061	System för återföring av fosfor i källsorterade fraktioner av urin, fekalier, matavfall och i liknande rötat samhälls- och lantbruksavfall	2013
VA-Forsk	1993-1	Alternativ VA-teknik – Exempelsamling	1993
VA-Forsk	1997-1	Utvärdering av VA-lösningar i ekobyar	1997
VA-Forsk	1997-8	Alternativa avloppssystem i Bergsjön och Hamburgsund. Sammanfattande slutrappport från ECO-GUIDE-projektet	1997
VA-Forsk	1999-10	Kompletterande avloppslösningar i flerfamiljshus och offentliga lokaler	1999
VA-Forsk	2000-1	Källsorterad humanurin i kretslopp	2000
VA-Forsk	2000-3	Hantering av svartvatten från Tegelvikens skola - kretsloppssystem med vätkompostering	2000
SVU	2007-05	Sammansättning och flöden på BDT-vatten, urin, fekalier och fast organiskt avfall i Gebers	2007
SVU	2008-08	Anaerob behandling av hushållsspillvatten och kloettavlopp blandat med organiskt hushållsavfall – resultat från Sjöstadsvetket, Stockholm	2008
SVU	2008-10	Återvinning av näringssämnen ur svartvatten – utvärdering projekt Skogaberg	2008
SVU	2011-09	Kväveberikning och skogsgödsling med torkat granulerat avloppsslamm	2011
SVU	2017-04	Källsorterande system för spillvatten och matavfall – erfarenheter, implementering, ekonomi och samhällsnytta	2017
SVU	2017-11	Rejektvattenbehandling – en kunskaps sammanställning	2017
SVU	2019-21	Återvunnet avloppsvatten för industriell användning och bevattning	2019
NV	5406	Avlopp i kretslopp – en utvärdering av LIP-finansierade enskilda avlopp, vassbäddar och bevattningssystem med avloppsvatten	2005
WRS	-	Helsingborg Interreg – Handbok om urinsortering	2005
TemaNord	2006:503	Kloettvattensystem – Nordisk inventering och förslag till FoU	2006
WEFCF	-	Urine diverting toilets in climates with cold winters – technical considerations and the reuse of nutrients with a focus on legal and hygienic aspects	2007

Organisation	Number	Title	Year
SVOA	6	Utvärdering av anaerob membranbioreaktor och omvänd osmos för utvinning av biogas och näringssämnen ur avloppsvatten från hushåll	2007
SGC	2021:271	Hållbara system för biogas från avlopp och matavfall	2012
Various	-	Den varma och rena staden 2	2016
EkoBalans	P44317-1	Kväveåtervinning - nyckel till cirkulär ekonomi	2021
IVL	B2421	Kväveåtervinning genom stripping och kristallisation	2021

Student Theses

University	Number	Title	Year
CTH	MSc 2014:26	Socio-technical evaluation of urine diversion in Linköping and Norrköping	2014
KTH	TRITA-KET-IM 2005:19	Återvinning av fosfor från avloppsvatten som behandlas med biologisk fosforrenings: En studie i att fälla ut struvit ur rejektvatten från rörat Bio-P-slamp	2005
LIU	LIU-ITUF/MV-D--02/06	Källsorterande avloppssystem – ett rimligt alternativ till konventionellt reningsverk? Exemplet Ekoporten	2002
LIU	LIU-ITUF/MV-C--02/15	Environmental systems analysis of sewerage alternatives in an urban district – "Blackwater System – Skogaberg" – A pilot project in Göteborg	2002
SLU	-	Urinsorterande toaletter – Rensning av stopp samt uppsamling och attityder	1999
SLU	244	Faecal separation and urine diversion for nutrient management of household biodegradable waste and wastewater	2001
SLU	UPTEC W11 007	Val av komplementmaterial för våtkompostering av klosettvattnen	2011
SLU	PhD 2020:33	Safe nutrient recovery from human urine – System and hygiene evaluation of alkaline urine dehydration	2020
UU	-	Återvinning av näringssämnen från hushållspillvattnen med omvänd osmos	2005
UU	UPTEC W05 034	Avloppsvattenbehandling med membranbioreaktor – En jämförande systemanalys avseende energi, miljöpåverkan samt återföring av närsalter	2005
UU	UPTEC W06 012	Analys av system för rening av avloppsvatten i en anaerob membranbioreaktor	2006
UU	UPTEC W10 016	Jämförelse mellan våtkompostering och andra VA-system i omvandlingsområden - en fallstudie i Norrtälje kommun	2010

Fact Sheets

Organisation	Number	Title	Year
NV	-	Näring i kretslopp i Hulta by	2008
NV	-	Avlopp i kretslopp på Kosteröarna	2008
NV	-	Bostadsområde i Malmö blev Ekostad	2008
NV	-	Kretsloppsanpassade VA-lösningar i Norrtälje	2008
NV	-	Spillvatten blir träd i Tönnersjö	2011
NV	-	Gödsel och avloppsvatten driver Katrineholms biogasbilar	2012
SLU LTV	2017:25	Näringsberikad zeolit som gödselmedel	2017

Municipal Planning Documents

Organisation	Number	Title	Year
-	1997:158 RII	Miljökonsekvensbeskrivning för ombyggnaden av Gebers konvalescenthem till kollektivhus med ekologisk inriktning	1997
Castor & Pollux	-	Lokala kretslopp, Gotland – En utredning av förutsättningar och möjligheter för lokala kretsloppsanpassningar med fokus på små avloppsreningsanläggningar	2011
-	-	Kosteröarnas vatten- och avloppssystem – Strategi för utbyggnad av vatten- och avloppssystem, tillägg till MasterPlan 2013-06-19. Utredning kompletterad med alternativ 3.	2017
Mälarenergi	-	Miljörapport Kvicksund och Munga 2020	2020
Ecoloop	-	Förstudie avseende avloppslösningar för nya stadsdelar i Knivsta och Uppsala	2020

Journal Articles

Journal	Issue: Pages	Title	Year
Nutrient Cycling in Agroecosystems	68: 191-198	Ammonia emissions after application of human urine to a clay soil for barley growth	2004
Biomass and Bioenergy	30: 428-438	The prospects for willow plantations for wastewater treatment in Sweden	2006
Ecological Engineering	47: 174-181	Willow bed fertigated with domestic wastewater to recover nutrients in subarctic climates	2012

APPENDIX B:

Contacting Municipalities

Box 1: E-mail sent to municipal administrations and utilities to enquire about work or studies on implementing nutrient recovery from human excreta and domestic wastewater (other than sewage sludge land application).

Ämne: Sammanställning av svenska fallstudier inom näringåtervinning från avlopp

Datum: November 2020

Bilaga: 'Exempel på svenska fallstudier inom näringåterföring från avlopp.xlsx'

Hej,

Mitt namn är Solveig Johannesdottir och jag jobbar inom projektet End-of-Wastewater: Co-creation of a knowledge brokering and public engagement toolbox to support sustainable nutrient and carbon recovery and reuse finansierat av familjen Kamprads stiftelse. Mer information om projektet finns [här](#).

En del av projektet är att kartlägga testbäddar, pilotstudier eller fullskaliga system i Sverige som utvecklar, testar eller tillämpar återvinning av näringssämnen från avloppsfraktioner. Notera att slamanvändning inom exempelvis Revaq inte ingår, vi är intresserade av näringåtervinning *utöver* konventionellt slam. Anledningen till att jag kontaktar just er är att er kommun i VA-plan, policy eller strategi lyft fram resursåterföring eller kretslopp från avlopp. Vi har kommit en bit med kartläggningen och bifogat finner ni en Excelfil med exempel på fallstudier vi har identifierat. Dessa inkluderar bland annat: struvitutfällning och omvänt osmos vid Hammarby Sjöstadsvärk, våtkompostering av klosettvattnen och pyrolysis.

Mina frågor till er är:

1. Har ni gjort något arbete kopplat till näringåterföring från avlopp i er kommun? Exempelvis pilotstudie eller förundersökning, utöver återföring av slam till jordbruk inom exempelvis Revaq. Om ni vill får ni gärna fylla på det bifogade Excelarket och skicka tillbaka!
2. Är denna information om svenska fallstudier intressant för er och ert arbete med resursåterföring från avlopp? Eller skulle annan typ av information vara mer attraktiv för er?

Har ni frågor, eller föredrar kommunikation via telefon är ni varmt välkomna att kontakta mig. Om ni önskar kan vi även boka in ett telefonmöte.

Tusen tack på förhand!

Solveig Johannesdottir

Description of the steps referred to in the following tables can be found in Table 4.

Municipality	Municipal utility	Step 1	Step 2	Step 3	Step 4	Cases
Ale	-	◦	Y	N		
Alingsås	-	N				
Alvesta	-	ooo	Y	N		
Aneby	Aneby Miljö & Vatten AB	◦	Y	Y	Y	1
Arboga	Arboga Vatten och Avlopp AB	oo	N			
Arjeplog	-	N				
Arvidsjaur	-	N				
Arvika	Arvika Teknik AB	N				
Askersund	-	N				
Avesta	Avesta Vatten AB	oo	Y	Y	N	
Bengtsfors	-	oo	Y	N		
Berg	Vatten och miljöresurs i Berg Härjedalen AB	N				
Bjurholm	-	N				
Bjuv	Nordvästra Skånes Vatten och Avlopp AB	N				
Boden	-	N				
Bollebygd	-	N				
Bollnäs	Helsinge Vatten	oo	Y	N		
Borgholm	Borgholm Energi AB	oo	Y	N		
Borlänge	Borlänge Energi AB	ooo	Y	N		
Borås	Borås Energi och Miljö AB	oo	Y	N		
Botkyrka	SYVAB	N				
Boxholm	Boxholmsteknik AB	N				
Bromölla	Bromölla Energi & Vatten AB	ooo	Y	N		
Bräcke	-	N				
Burlöv	VA SYD	oo	N			
Båstad	Nordvästra Skånes Vatten och Avlopp AB	oo	N			
Dals-Ed	-	N				
Danderyd	Veolia AB	N				
Degerfors	-	oo	Y	N		
Dorotea	-	N				
Eda	-	N				
Ekerö	Roslagsvatten AB	oo	Y	N		
Eksjö	Eksjö Energi	oo	N			
Emmaboda	Emmaboda Energi	◦	Y	N		
Enköping	-	oo	Y	N		
Eskilstuna	Eskilstuna Energi & Miljö	ooo	Y	N		
Eslöv	VA SYD	oo	N			
Essunga	-	N				
Fagersta	Norra Västmanlands Kommunalteknikförbund	N				
Falkenberg	Vatten och Miljö i Väst AB	N				
Falköping	-	N				
Falun	Falu Energi och Vatten AB	ooo	Y	N		
Filipstad	-	N				
Finspång	Finspångs tekniska	oo	Y	N		
Flen	Sörmland Vatten	oo	Y	N		
Forshaga	-	N				
Färgelanda	Färgelanda Vatten AB Västvatten AB	◦	Y	N		
Gagnef	Dala Vatten och Avfall AB	N				
Gislaved	-	oo	N			

Y = Yes, N = No. Contacted: ◦ only municipal administration, oo only municipal utility, ooo both.

Municipality	Municipal utility	Step 1	Step 2	Step 3	Step 4	Cases
Gnesta	-	N				
Gotland	-	ooo	Y	N		
Grums	-	N				
Grästorp	-	o	N			
Gullspång	-	oo	Y	N		
Gällivare	-	N				
Gävle	Gästrike Vatten AB	ooo	Y	Y	N	
Göteborg	Gryaab AB	N				
Götene	Götene Vatten AB	oo	Y	N		
Habo	-	N				
Hagfors	-	N				
Hallsberg	-	N				
Hallstahammar	-	N				
Halmstad	Laholmbuktens VA	N				
Hammarö	-	N				
Haninge	-	ooo	Y	Y	Y	1
Haparanda	-	N				
Heby	-	N				
Hedemora	Hedemora Energi AB	N				
Helsingborg	Nordvästra Skånes Vatten och Avlopp AB	N				
Herrljunga	Herrljunga Vatten AB	N				
Hjo	-	oo	N			
Hofors	Gästrike Vatten AB	N				
Huddinge	Stockholm Vatten och Avfall AB	oo	Y	N		
Hudiksvall	-	N				
Hultsfred	Östra Smålands Kommunal Teknikförbund	oo	Y	N		
Hylte	-	oo	Y	N		
Håbo	-	o	Y	Y	N	
Hällefors	Samhällsbyggnad Bergslagen	N				
Härjedalen	Vatten och miljöresurs i Berg Härjedalen AB	ooo	Y	Y	N	
Härnösand	Härnösand Energi & Miljö	o	Y	N		
Härryda	-	oo	Y	N		
Hässleholm	Hässleholms Vatten AB	ooo	Y	Y	Y	1
Höganäs	-	N				
Högsby	Östra Smålands Kommunal Teknikförbund	ooo	Y	N		
Hörby	Mittskånevatten	ooo	Y	N		
Höör	Mittskånevatten	ooo	N			
Jokkmokk	-	N				
Järfälla	-	N				
Jönköping	-	oo	N			
Kalix	-	N				
Kalmar	Kalmar Vatten AB	oo	Y	Y	N	
Karlsborg	-	N				
Karlshamn	Karlshamn Energi Vatten AB	oo	N			
Karlskoga	VA-Bolaget i Karlskoga AB	N				
Karlskrona	-	oo	Y	Y	N	
Karlstad	-	ooo	Y	N		
Katrineholm	Sörmland Vatten	oo	Y	N		
Kil	-	N				
Kinda	-	N				
Kiruna	Tekniska Verken i Kiruna	N				

Y = Yes, N = No. Contacted: ° only municipal administration, °° only municipal utility, °°° both.

Municipality	Municipal utility	Step 1	Step 2	Step 3	Step 4	Cases
Klippan	-	N				
Knivsta	Roslagsvatten AB	ooo	Y	N		
Kramfors	-	N				
Kristianstad	-	oo	N			
Kristinehamn	-	N				
Krokom	-	N				
Kumla	-	N				
Kungsbacka	-	o	Y	N		
Kungsör	Kungsörs Vatten AB	N				
Kungälv	-	ooo	Y	N		
Kävlinge	-	N				
Köping	Västra Mälardalens Energi och Miljö AB	oo	N			
Laholm	Laholmbuktens VA	N				
Landskrona	Nordvästra Skånes Vatten och Avlopp AB	N				
Laxå	Laxå Vatten AB	N				
Lekeberg	-	N				
Leksand	Dala Vatten och Avfall AB	oo	Y	N		
Lerum	-	oo	Y	N		
Lessebo	-	N				
Lidingö	Käppalaförbundet	N				
Lidköping	-	N				
Lilla Edet	-	N				
Lindesberg	Samhällsbyggnad Bergslagen	N				
Linköping	Tekniska Verken i Linköping	ooo	Y	Y	N	
Ljungby	Ljungby Kommun	N				
Ljusdal	Ljusdal Energi AB	oo	N			
Ljusnarsberg	Samhällsbyggnad Bergslagen	N				
Lomma	VA SYD	N				
Ludvika	Wessman Barken AB	N				
Luleå	-	oo	N			
Lund	VA SYD	oo	N			
Lycksele	Lycksele Vatten & Avfall AB	N				
Lysekil	LEVA i Lysekil AB	oo	Y	Y	N	
Malmö	VA SYD	N				
Malung-Sälen	Vatten och Avlopp i Malung-Sälen AB	oo	Y	N		
Malå	-	N				
Mariestad	-	oo	N			
Mark	-	N				
Markaryd	-	N				
Mellerud	-	oo	Y	Y	N	
Mjölby	-	N				
Mora	Norra Dalarna Vatten & Avfall	oo	N			
Motala	-	oo	N			
Mullsjö	Mullsjö Energi	N				
Munkedal	Munkedal Vatten AB Västvatten AB	N				
Munkfors	-	N				
Möln达尔	Möln达尔 stad	N				
Mönsterås	-	oo	Y	N		
Mörbylånga	-	oo	Y	Y	N	
Nacka	Nacka Vatten och Avfall	o	N			

Y = Yes, N = No. Contacted: ° only municipal administration, oo only municipal utility, ooo both.

Municipality	Municipal utility	Step 1	Step 2	Step 3	Step 4	Cases
Nora	Samhällsbyggnad Bergslagen	N				
Norberg	Norra Västmanlands Kommunalteknikförbund	N				
Nordanstig	MittSverige Vatten & Avlopp AB	oo	N			
Nordmaling	-	N				
Norrköping	Nodra AB	oo	N			
Norrälje	-	ooo	Y	Y	Y	1
Norsjö	-	N				
Nybro	Nybro Energi AB	oo	Y	N		
Nykvarn	-	N				
Nyköping	-	o	Y	N		
Nynäshamn	-	ooo	N			
Nässjö	Nässjö Affärsvärk	oo	N			
Ockelbo	Gästrike Vatten AB Ljusdal Energi AB	N				
Olofström	Olofströms Kraft AB	ooo	Y	N		
Orsa	Norra Dalarna Vatten & Avfall	oo	Y	N		
Orust	-	oo	Y	N		
Osby	Skåne Blekinge Vattentjänst	ooo	N			
Oskarshamn	-	oo	Y	N		
Ovanåker	Helsinge Vatten	N				
Oxelösund	Oxelö Energi AB	N				
Pajala	-	N				
Partille	-	N				
Perstorp	Nordvästra Skånes Vatten och Avlopp AB	N				
Piteå	PIREVA	oo	N	N		
Ragunda	-	N				
Robertsfors	-	N				
Ronneby	Ronneby Miljö & Teknik AB	oo	N	N		
Rättvik	Dala Vatten och Avfall AB	ooo	Y	N		
Sala	-	N				
Salem	-	N				
Sandviken	Sandviken Energi AB	oo	Y	N		
Sigtuna	Sigtuna Vatten & Renhållning	N				
Simrishamn	-	oo	N			
Sjöbo	-	N				
Skara	Skara Energi AB	oo	Y	N		
Skellefteå	-	N				
Skinnskatteberg	-	N				
Skurup	-	oo	N			
Skövde	-	oo	Y	N		
Smedjebacken	Wessman Barken AB	o	N			
Sollefteå	-	N				
Sollentuna	Sollentuna Energi och Miljö AB	N				
Solna	Solna Vatten AB	N				
Sorsele	-	N				
Sotenäs	Sotenäs Vatten AB Västvatten AB	o	Y	N		
Staffanstorp	-	N				
Stenungsund	-	N				
Stockholm	Stockholm Vatten och Avfall AB	N				
Storfors	-	N				

Y = Yes, N = No. Contacted: ° only municipal administration, oo only municipal utility, ooo both.

Municipality	Municipal utility	Step 1	Step 2	Step 3	Step 4	Cases
Storuman	-	N				
Strängnäs	SEVAB	oo	Y	N		
Strömstad	-	N				
Strömsund	-	N				
Sundbyberg	Sundbyberg Vatten och Avfall AB	N				
Sundsvall	MittSverige Vatten & Avlopp AB	ooo	Y	N		
Sunne	-	N				
Surahammar	Surahammars Kommunalteknik AB	N				
Svalöv	Nordvästra Skånes Vatten och Avlopp AB	N				
Svedala	PIREVA	oo	N			
Svenljunga	-	oo	Y	N		
Säffle	-	N				
Säter	-	N				
Sävsjö	Njudung Energi AB	N				
Söderhamn	Söderhamn Nära	N				
Söderköping	-	o	Y	N		
Södertälje	Telge Nät AB	oo	Y	N		
Sölvesborg	Sölvesborg Energi	N				
Tanum	-	N				
Tibro	-	N				
Tidaholm	-	N				
Tierp	Tierps Energi & Miljö AB	oo	Y	N		
Timrå	MittSverige Vatten & Avlopp AB	N				
Tingsryd	-	N				
Tjörn	-	N				
Tomelilla	-	N				
Torsby	-	o	N			
Torsås	-	N				
Tranemo	-	N				
Tranås	-	N				
Trelleborg	-	ooo	Y	Y	N	
Trollhättan	Trollhättens Energi AB	o	Y	N		
Trosa	-	N				
Tyresö	-	N				
Täby	-	o	Y	N		
Töreboda	-	oo	Y	N		
Uddevalla	Udevalla Vatten AB Västvatten AB	ooo	Y	N		
Ulricehamn	Ulricehamn Energi AB	N				
Umeå	VAKIN	ooo	N			
Upplands-Väsby	-	N				
Upplands-Bro	-	ooo	Y	N		
Uppsala	Uppsala Vatten	ooo	Y	N		
Uppvidinge	-	N				
Vadstena	-	N				
Vaggeryd	-	o	Y	N		
Valdemarsvik	-	N				
Vallentuna	Roslagsvatten AB	N				
Vansbro	Dala Vatten och Avfall AB	N				
Vara	-	oo	Y	Y	N	

Y = Yes, N = No. Contacted: ° only municipal administration, oo only municipal utility, ooo both.

Municipality	Municipal utility	Step 1	Step 2	Step 3	Step 4	Cases
Varberg	Vatten och Miljö i Väst AB	ooo	Y	N		
Vaxholm	Roslagsvatten AB	ooo	Y	N		
Vellinge	VA SYD	oo	N			
Vetlanda	Njudung Energi AB	N				
Vilhelmina		N				
Vimmerby	Vimmerby Energi & Miljö AB	oo	Y	N		
Vindeln	VAKIN	N				
Vingåker	Sörmland Vatten	oo	Y	N		
Vårgårda		N				
Vänersborg		oo	Y	Y	N	
Vännäs		N				
Värmdö		ooo	Y	N		
Värnamo		ooo	Y	Y	N	
Västervik	Västervik Miljö & Energi AB	o	Y	N		
Västerås	Mälarenergi AB	oo	Y	Y	Y	1
Växjö		o	N			
Ydre		N				
Ystad		ooo	Y	N		
Åmål		N				
Ånge		oo	Y	N		
Åre		N				
Årjäng		oo	Y	N		
Åsele		N				
Åstorp	NSVA	N				
Åtvidaberg	Åtvidabergs Vatten AB	N				
Älmhult		N				
Älvtdalen	Norra Dalarna Vatten & Avfall	ooo	Y	N		
Älvkarleby	Gästrike Vatten AB	N				
Älvsbyn	Älvsbyns Energi	N				
Ängelholm		ooo	Y	N		
Öckerö		N				
Ödeshög		N				
Örebro		ooo	N			
Örkelljunga		N				
Örnsköldsvik	Miljö och Vatten i Örnsköldsvik AB	ooo	Y	N		
Östersund		oo	N			
Österåker	Roslagsvatten AB	ooo	Y	N		
Östhammar	Gästrike Vatten AB	N				
Östra Göinge	Skåne Blekinge Vattentjänst	o	N			
Överkalix		N				
Övertorneå		N				

Y = Yes, N = No. Contacted: ° only municipal administration, oo only municipal utility, ooo both.

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