Journal of Urban Technology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cjut20

Flexible and Resource-Recovery Sanitation Solutions: What Hindered Their Implementation? A 40-Year Swedish Perspective

Kristina Söderholm, Brenda Vidal, Annelie Hedström & Inga Herrmann

To cite this article: Kristina Söderholm, Brenda Vidal, Annelie Hedström & Inga Herrmann (2023) Flexible and Resource-Recovery Sanitation Solutions: What Hindered Their Implementation? A 40-Year Swedish Perspective, Journal of Urban Technology, 30:1, 23-45, DOI: 10.1080/10630732.2022.2100212

To link to this article: https://doi.org/10.1080/10630732.2022.2100212

Published online: 05 Aug 2022.

JOURNAL OF URBAN TECHNOLOGY
2023, VOL. 30, NO. 1, 23–45
https://doi.org/10.1080/10630732.2022.2100212

Routledge
Taylor & Francis Group

Flexible and Resource-Recovery Sanitation Solutions: What Hindered Their Implementation? A 40-Year Swedish Perspective

Kristina Söderholm [a], Brenda Vidal [b], Annelie Hedström [b], and Inga Herrmann [b]

[a]Division of Social Science, History Unit, Luleå University of Technology, Luleå, Sweden; [b]Division of Architecture and Water, Luleå University of Technology, Luleå, Sweden

ABSTRACT
Although Sweden pioneered in the development of resource-recovery sanitation solutions, and there has existed a political awareness of such solutions since the 1990s, their implementation has been slow. We adopt a historical (40-year) perspective and use the main journal of the Swedish sanitation sector as source material to go into depth why this has been the case. Central explanations emerge in terms of previously strong governmental control and continuously tightened environmental requirements that ceaselessly have expanded and strengthened the large-scale centralized sanitation system. In parallel, the sector has continuously been reminded of the shortcomings of alternative (and smaller) solutions and of the tension between recovery and treatment/risk management. The study highlights the possibility of achieving long-term and profound impacts from policy mixes, as well as the strong influence of the sum of challenges and choices over a long time, on today's perspectives and propensity for change.

KEYWORDS
Wastewater treatment; Sweden; history; urine diversion; resource-recovery sanitation

Introduction and Problem Definition

Increasing pressures of ageing infrastructure, demographic changes, heightened environmental awareness and climate change have raised concerns about the "lack of adaptation" of most of society's large-scale technological systems. The conventional centralized sanitation system is generally considered inflexible due to high capital costs and technological and institutional lock-ins. The inherent inflexibility of the centralized sanitation system is further explained by the difficulties to optimize the recovery of resources from a system originally designed with a different purpose, i.e., to improve urban hygiene and to control water pollution (McConville et al., 2016; Hoffmann et al., 2020). In Sweden, public sanitation is widespread with close to 90 percent of the population connected to public sanitation systems. In urban areas, the connection rate is almost 100 percent, and only four

CONTACT Kristina Söderholm kristina.soderholm@ltu.se Luleå University of Technology, Division of Social Science, History Unit, SE-971 87 Luleå, Sweden.

out of a total of 290 municipalities have an access-rate to public sanitation that is less than 50 percent of the population (Swedish Government, 2018.34). Swedish sanitation is further heavily centralized.

Since the 1990s, alternative sanitation solutions that are more diverse in terms of, e.g., source separation (e.g., urine diversion [UD]), decentralization, and hybridization (e.g., combined local grey water treatment and off-site black water treatment), have been identified as important paths in addressing pressing global challenges like rapid urbanization, eutrophication, and climate change (Hoffmann et al., 2020; Capodaglio et al., 2017; Sitzenfrei and Rauch, 2014; Sharma et al., 2013; Brands, 2014; Sharma et al., 2010; Larsen, 2011). Still, there is a lot left to be desired in terms of the pace at which these solutions are implemented. A lot of research has been produced that tries to understand the background, and methods to remedy the inertia, where most have dealt with alternative sanitation solutions taking place at the micro level and less with the macro-level dynamics that shape how sanitation is managed (for an overview, see Hoffmann et al., 2020). Important macro-level dynamics in this context concern the interactions between institutions, actors, and technology at the national and/or regional level, such as how policy mixes could support the diffusion of alternative solutions. Such interactions and effects are usually processes taking place over several years, and nothing that can easily be studied without adopting an historical perspective. Similarly, a large-scale technological system, such as the centralized sanitation system, is the sum of several, long-standing incremental changes, decisions, and efforts. It is, therefore, difficult to understand in depth—such as concerning its propensity for change—without a longer historical perspective.

In this article, we will use a historical (40-year) perspective to try to go into depth both on the reasons behind the inertia in establishing alternative sanitation solutions in Sweden, and on the long-standing dominance of the centralized sanitation system. Sweden is an interesting case in this context because it was an early pioneer in UD, and the political awareness of alternative sanitation solutions have been significant. Still the adoption rates have been slow, and the centralization of the Swedish sanitation system is continuously expanding. As source material for our study, we have used the main sector journal of the Swedish water and wastewater sector from 1974 to 2015, i.e., *VAV-nytt* [Water and Wastewater Treatment News] (1974–2001, four issues/year), later changed to *Svenskt vatten* [Swedish Water] (2002 and onwards, four issues/year). The publisher was/is the sector organization VAV [the Swedish Water and Wastewater Treatment Plant Association] founded in 1962, whose members include *all* the municipal water utilities to which 90 percent of the Swedish population is connected. Based on this extensive source material, four central themes have emerged which explain the difficulties in establishing alternative sanitation solutions and for the lengthy "lock-in" of the centralized sanitation solution. These include: (a) *previous strong national intervention*; (b) *long-term challenges related to the centralized solution*; (c) *challenging existence for small plants and on-site systems due to tightened environmental requirements and neglect*; and (d) *the great environmental mobilization of the late twentieth century*.

Method and Analytical Framework

The source material has been analyzed using a classical historical method based on the perception of the source as a material for producing knowledge that is not previously known, and where the critical examination and analysis of the source material are central to determining what kind of knowledge can be gained from it, and what value this knowledge has. *VAV-nytt/Svenskt vatten* is a distinct sector journal, which we consider a highly valuable source material in this context. Hence, the readers as well as the authors of the journal articles (including presentations/comments/discussions) are to the largest part representatives of the sanitation sector in terms of practitioners, officials, and politicians from the local to national level, mainly from the public sector, in addition to a smaller proportion of researchers and private enterprises in terms of suppliers. In other words, stakeholders are represented from different levels and in terms of regulators, developers, and implementers. This is reflected in the character of the journal which, hence, covers both technical, economic, organizational, political/regulative aspects of the management of sanitation. Taken together with the fact that the journal has had a permanent and regular publication over the studied period (1974–2015, forming a total of 160 un-digitalized journal issues), we consider this a valuable source material.

Through the analysis of the journal issues, our ambition was to seek to identify, with as open mind as possible, themes with explanatory value for the difficulties in establishing alternative sanitation solutions and for the lengthy "lock-in" of the centralized sanitation solution. The analysis was carried out by an historian of technology who prior to the analysis had in-depth knowledge of the early (late nineteenth- and early twentieth-century) implementation of the centralized sanitation system in Sweden; however, not particularly concerning the expansion of the centralized sanitation system versus alternative sanitation solutions over the last 50 years. Hence, the basic analysis was conducted by a researcher with essential socio-technical and historical understanding of the centralized sanitation system but without a pre-understanding of "what should" explain its inertia and dominance in recent decades.

In the choice of the sector journal as main source material, we are aware of a potential built-in bias for the central sanitation solution in many texts since it has been/is dominant. However, we experience that this source material, largely formulated by and directed to the sector (in a wide sense) itself where the inertia of the centralized sanitation solution (and the parallel opt-out of alternative sanitation solutions) took place, offers a broad (if not complete) insight into the most central explanatory themes over the period studied. This narrative has been supplemented with information from some public reports and other literature (and a few interviews) to offer a more complete picture of certain processes and development paths. Especially the most comprehensive theme of the study—long-term challenges related to the centralized solution—has been supplemented with public reports and other literature for this reason.

Our analysis is inspired by the socio-technical transition literature (Geels, 2002) in an attempt to sort, evaluate, and contextualize the reasons for difficulties in establishing alternative sanitation solutions and for the long-term dominance of the centralized sanitation system, i.e., why a socio-technical transition in line with the often-expressed political agenda has not occurred. The multi-level perspective (MLP) framework attempts to deal with the complexity and resistance of large systems to change. It posits analytical and heuristic levels on which processes interact and align to result in socio-technical system transformations; niches (micro-level), regimes (meso-level), and landscape (macro-level) (Geels, 2005).

In niches, innovations of a more radical nature can avoid the often-skewed competition between existing and novel technologies and have the possibility to be developed in interaction with a limited number of users. Such niches protect against established technologies and create possibilities for learning where incremental innovations, e.g., learning in production that lowers costs, can over time make the new technology competitive with respect to the established socio-technical "regimes" (Kemp et al., 1998). Geels (2002) describes a socio-technical regime as consisting of existing production and consumption systems with strong "lock-in" in terms of common values and mutual dependence between important social groups, such as end-users, suppliers, and the political and educational systems. Any changes therefore tend to happen through a gradual configuration and reconfiguration based on what is happening within the regime, in different competing niches and on what is sometimes called the "landscape level" (Geels, 2014). At the landscape level, comprehensive ecological, cultural, geopolitical, and macroeconomic changes may take place which affect all regimes, and these can refer to emergencies, natural disasters, or technological trends (e.g., digitalization). Taken together, it is the interaction between what is happening at the landscape level, e.g., increased awareness of climate change and what causes it, and in various underlying niches, that creates prerequisites for a socio-technical transition. Promising experiments and radical innovations in niches are often dependent on changes at the landscape level to disseminate. Correspondingly, if there are no responses in niches to the changes that occur at the landscape level, no rapid change can take place.

While the MLP framework provides guidance about the gradual changes that need to happen among niches, the regime, and the landscape levels, it provides insufficient guidance about how this interaction actually occurs in practice and what "intervention points" there are for policy instruments (if there is a political will) to stimulate a certain type of development in a certain direction. Still, for public policy to facilitate necessary transitions towards a more sustainable society and achieve challenging climate policy goals, there is great need for a deeper understanding of the dynamics of transition processes, including the preceding time-consuming, complex interactions.

This article is an attempt to contribute to an expanded understanding of these dynamics through a long-term (40-year overview) perspective of a cross section through niches, regimes, and landscape when it comes to the "lock-in" of the centralized sanitation system in Sweden in parallel to politically driven visions for sustainable development and alternative sanitation solutions. Before we go into more detail on the four central themes with explanatory value in these matters, we offer a brief overview of alternative sanitation solutions in Sweden and other western countries. At the end of the article, the explanatory values of the various themes are summarized and discussed through the lens of the socio-technical transition literature.

Alternative Sanitation Solutions in Sweden and Other Western Countries—An Overview

Alternative sanitation solutions have in part been developed and implemented in Sweden since the 1990s, in parallel with the upcoming recycling and sustainability discourses. Hence, in the mid-1990s, several high-profile UD pilot projects (such as in eco-villages) were launched in Sweden. In fact, Sweden is the birthplace of the modern UD toilet, and

Swedish experience has served as an important source of inspiration for the increasing global support of UD (Fam and Mitchell, 2013). The main drivers for UD implementation in Sweden, as in many other industrialized countries, are typically related to the mitigation of problems with eutrophication in the receiving waters and the meeting of new legislation and environmental goals. In low-income areas, including rural, peri-urban, and urban settings around the world, main drivers are often associated with the lower costs of UD systems, alongside the possibility of obtaining a high quality, fast-acting fertilizer and improved sanitation conditions (Kvarnström et al., 2006; Lüthi and Panesar, 2013; Simha and Ganesapillai, 2017).

Since the late 1990s, however, the diffusion of UD has declined considerably in Sweden. McConville et al. (2016) explain the overall marginalization of source separation in Sweden today by the lack of knowledge development along with a weak interchange between knowledge development and entrepreneurial activity. Fam and Mitchell (2013) to a greater extent depart from a macro perspective and as a negative force in this context, point at the dominance of top-down initiatives in the organizing of UD systems in Sweden from the late 1990s—due to increasing political awareness and national funding for sustainability initiatives—in contrast to the typically bottom-up social organizing of UD systems in Sweden in the years before.

In the late 1990s, UD was to some degree politically supported by municipalities that were sometimes funded by the so-called Local Investment Program (LIP), a national investment program during the period 1998 to 2002 of SEK 6.2 billion for the transition to sustainable development. Still, only about 10 percent of the LIP funding went to the water- and wastewater field, and then mainly to measures in the centralized sanitation system, such as investments in drinking water, storm water, wastewater treatment plants, and sewage networks in urban environments. All in all, LIP financed UD- WC and -dry toilet systems in 10 Swedish municipalities, alongside so-called filter units and "package plants" in a few municipalities. The lack of community involvement in these projects later revealed challenges for end-users in organizing and managing the new technology, particularly when it came to measures in individual wastewater facilities for a group of individual property owners, which were less successful than measures relating to single-family households (Swedish EPA, 2005). In the evaluation of the LIP program in 2005, it was found that because of the program, in several municipalities there was now good basis for larger-scale investments in alternative sanitation solution facilities. Still, it was of critical importance with central decisions in the short term that promoted the development, such as in the form of financial instruments, supporting regulations, R&D initiatives, and technology development (Swedish EPA, 2005). Such national support, however, never really did become a reality. Overall, the politically driven vision for sustainable development behind the initiatives of LIP, nutrient recycling, UD, etc., of the late 1990s, shifted to issues related to climate change in the 2000s.

In other European countries, such as Germany, Switzerland, and the Netherlands, concerns over the conventional centralized systems' loss of valuable nutrients, inflexibility, and sometimes resource (water and energy) inefficiency have grown since the 1990s. This has in turn given way to a new paradigm with a focus on re-using the resources found in wastewater and implementing alternative sanitation solutions. The main drivers behind this development also have to do with new requirements on emerging pollutants removal, or dealing with the uncertainties that climate change introduces in the water systems (Swart and Palsma, 2013; Larsen et al., 2009; Londong, 2013). In these countries, alternative sanitation solutions did not, however, take off, due to the extended acceptance of already known systems and technologies, and the lack of knowledge and uncertainties surrounding the alternative solutions (Londong, 2013; Swart and Palsma, 2013). Alternative sanitation solutions, such as black water and urine-source separation have mainly developed through research and pilot projects, and showcases by universities and water companies (Londong, 2013; Boller, 2013; Swart and Palsma, 2013; Sievers et al., 2016; Morandi and Steinmetz, 2019).

The Netherlands experienced a rather successful role of the Dutch Foundation for Applied Water Research (STOWA) in the initial phases of the early development of alternative sanitation solutions a few years into the twenty-first century. This Foundation broadened the research field and included new stakeholders. STOWA further chaired the creation of a "Coordinating Body" where institutes and water boards were represented: more than half of the water boards in the Netherlands became involved in over 40 research and pilot projects, including vacuum and urine diverting toilets and biogas production from black water. Although STOWA was important, the driving forces were the local parties such as housing associations, water boards, and companies. Drivers are still needed to promote further advance of the sector in the Netherlands, such as a marketplace for nutrients from wastewater fractions (Swart and Palsma, 2013; STOWA, 2006).

Australia experienced a different initial development and implementation of resource-recovery sanitation solutions. The main drivers in the Australian context were both several pollution episodes in the 1980s in Sydney and Melbourne associated with wastewater effluents causing severe episodes of algal blooms, and later water scarcity caused by two decades of long-term drought. These pollution episodes created broader awareness of the impacts of insufficient wastewater treatment. Hence, driven by concerns about nutrients discharge, Melbourne Water decided to retrofit a major treatment plant to produce recycled water for reuse in agriculture. Extended drought conditions that started to affect the state of Victoria in the late 1990s and the consequent water crisis became a further driver for the use of recycled water. Still, the existing dominance of centralized systems meant that the water utilities had less knowledge and experience about new resource-recovery solutions despite them often being the preferred option discussed in workshops (such as between state governments, water utilities, and stakeholders) on community-based water recycling (Fam et al., 2014; Gardner and Sharma, 2013). The implementation of alternative sanitation solutions still today encounters constraints and are often met with skepticism at first by the established traditional mindset of the authorities due to the lack of acceptance and knowledge, as well as the uncertainties surrounding the new solutions (Chapman, 2019).

Below, we introduce and discuss the four central themes in a Swedish 40-year perspective, as these offer explanatory value for the difficulties in establishing alternative sanitation solutions and for the lengthy "lock-in" of the centralized sanitation system.

Previous Strong National Intervention

The centralized and public sanitation system was continuously expanded during the entire period investigated in this study (as well as before this and still today).

However, in the 1970s, the expansion was particularly intensive as a result of strong national intervention. On the one hand, the national intervention included increased governmental responsibility for infrastructure development in general (as well as for the environment in the case of the wastewater system), and on the other hand, it included imposing increased responsibility on the part of the municipalities for arranging water services (including sanitation).

Under the motto "big is beautiful," from the early nineteenth century to the mid-1970s, the Swedish national government took major responsibility for infrastructure development from prioritizing large-scale projects with a strong influence from urban planners and decision makers. It concerned strong governmental control by force and extensive government financial support, standardization, and large-scale, centralized solutions. Apart from the sanitation system, there was also a massive expansion of electrified railways, road infrastructure, and a major public housing initiative (Söderholm and Wihlborg, 2015). The large sanitation systems provided a completely new line of work for planners at all levels of government ministries, such as the Swedish Environmental Protection Agency (EPA), county administrative boards, and municipalities while creating demand for more infrastructure consultants and engineers.

Major public infrastructure projects further required the mobilization of capital and know-how, where The Municipal Reform of 1971—with a large number of small administrative units merging into larger municipalities—can be seen as one way to create a sufficiently large foundation for community planning and major investments (Erlingsson et al., 2010). Hence, in parallel to the great infrastructural development, there was a general trend towards more decentralized governmental decision-making in Sweden ever since the 1950s (Lafferty and Meadowcroft, 2000), with infrastructure becoming a central issue for municipal governance, and with corps of experts and officials at their disposal (Kaijser et al., 1988). The responsibility of the municipalities for arranging water services (including sanitation) has been gradually increased within this context. The criterion has been to arrange water services "in a larger context" (often assessed at 20–30 properties) if needed "due to sanitary inconvenience" (Swedish Government 1955:314, Law on public water and wastewater treatment plants), or "regarding health protection" (Swedish Government 1970:244, Law on public water and wastewater treatment plants). The county administrative boards experienced a tangible upturn in connection with the municipal mergers, from their mission to stimulate and, if needed, force coordinated solutions among municipalities, not least when it comes to centralized sanitation. Hence, in this way, the Swedish technical and political elite had a joint project (Drangert and Löwgren, 2005).

Alongside the increased responsibility imposed on municipalities for arranging water services (including sanitation), extensive government subsidies were granted. Especially throughout the 1970s, these constituted an important component in Swedish municipal wastewater treatment planning (Drangert and Löwgren, 2005). Hence, after the Swedish EPA was established in 1967, and the Environmental Protection Act went into effect in 1969, the governmental subsidy system was aimed at stimulating high-grade biological/chemical treatment (biological and chemical phosphorus treatment: Swedish Government 1968:308). The Swedish national government was a forerunner in stimulating such far-reaching treatment. Most wastewater treatment plants around the world (including in Europe) still lack such treatment. Moreover, the emission levels that the

Swedish wastewater treatment plants must comply with are today often considerably tougher compared to what the EU directive stipulates.

Normally, in the 1960s, a 50 percent investment subsidy was granted by the Swedish national government for high-grade biological/chemical treatment and for pumping stations and sewer pipes. During the budget years 1971/72, 1972/73, and 1973/74, it was possible to get subsidies up to 75 percent of the total investment costs. Directing the subsidies to sewer pipes, pumping stations and large-scale, high-grade biological/chemical treatment, stimulated centralized sanitation solutions, i.e., joint solutions for nearby communities as well as for connecting more remotely located facilities, such as outdoor swimming pools and campgrounds to a community's wastewater treatment plant (*VAV-nytt* 1975: 1, 3). Altogether, the national government invested around SEK 1.5 billion (equivalent to about SEK 8 billion in today's monetary value) in the expansion of large-scale municipal wastewater treatment plants, whereupon the proportion of Swedes connected to public sanitation systems increased dramatically (Swedish EPA, 2018: 3).

Publicly owned sanitation facilities have continued to increase even after the 1970s. The possibility to privatize water and sanitation services was indeed dealt with in a timely manner in the early 2000s in connection to the preparatory work of the replacing Law on public water services (Swedish Government 2006:412). The investigation, however, found that access to water and sanitation services was a basic need/prerequisite for a satisfactory standard of living and, consequently, water services constituted a natural monopoly not suitable for privatization and commercialization. The "natural" municipal responsibility was placed in paragraph 6 of the law (Swedish Government 2006:412) and was further extended by including the environment as one criterion. Paragraph 51 in turn states that it is the responsibility of the county administrative board to supervise the fulfillment of the municipal responsibility to arrange and maintain water services where needed.

Overall, the Law (Swedish Government 2006:412) offers the opportunity to expand public sanitation, but it also implies that the municipality can be forced to expand public water services regardless of costs. Since public sanitation to a large extent is developed in urban areas and cities, issues about the municipal responsibility to arrange water services are mainly raised in "conversion areas" (here meaning areas with old summer houses at commuting distance to larger cities converging to year-round living), in densifications outside existing areas of operation, and in connection with exploitation. There are still a total of about 950,000 properties in Sweden that are not connected to public sanitation, out of which about 450,000 are recreational properties, often with inefficient private on-site sanitation systems (Swedish Government 2018:34).

Long-Term Challenges Related to the Centralized Solution

The extensive expansion of centralized large-scale sanitation during the 1970s gradually caused problems, both related to the geographic expansion of the network, and the constantly increasing amount of wastewater to be processed. Since the municipalities to a high degree focused on joint wastewater treatment solutions for "nearby" communities, the expansion largely concerned laying sewer-pipes of record lengths in a short time followed by wastewater pumping stations. Thus, there were many new technical problems to be solved. This is reflected in the sector journal *VAV-nytt* all through the 1970s; the journal was practically filled with technical instructions and information about ongoing investigations, operational studies, standardization processes, etc. for the long sewers, the pumping stations, and wastewater treatment plants (e.g., *VAV-nytt* 1974: 1, 5; *VAV-nytt* 1977: 1, 3). Among other things, in 1978, the sector organization VAV appointed a working group for the purpose of compiling instructions for the design of wastewater pumping stations. This working group concluded that the operational interruption frequency was 2.1 operational interruptions per pumping station per year, where the causes of these were insufficient scope of preventive maintenance, operational procedures, operating conditions, and external circumstances (*VAV-nytt* 1982: 2, 7).

Problems with the pumping stations continued during the 1980s, in part simply because they were increasing in numbers, but also because the equipment involved had become increasingly complicated and the operating personnel's competence was often not high enough. For this reason, in the mid-1980s, the sector organization VAV, in cooperation with the Swedish Construction Research Board, developed a three-day training program for these personnel (*VAV-nytt* 1987: 1, 9). Prior to this, VAV had also developed a continuing education course for sewer pipe-installers (*VAV-nytt* 1982: 4, 5). The background was a field study of 112 two-year-old stretches of sewer pipes made of PVC and concrete conducted by a private consult in 1979. The study showed that already after two years of operation, the sewer pipes showed major defects where deficient installation (sewer pipe-laying) was given as the main reason (*VAV-nytt* 1979: 3, 3). By the mid-1980s, the education course for sewer pipe-installers had been conducted about 30 times with a total of 750 participants from over 60 municipalities. Henceforth, the course would be given also in the training of sewer pipe-installers at upper secondary schools (*VAV-nytt* 1984: 3, 10).

The problems with the ever-larger sewer networks also included the fact that hydrogen sulfide, which is very harmful to health, was formed in the wastewater when it stayed in the sewer pipes for a long time (and could leak out). For instance, in the municipality of Linköping there were many problems with this because the sewer network there branched widely in all directions. Thus, ever since the mid-1970s, the sanitation management of Linköping had been working with measures to prevent the formation of hydrogen sulfide (*VAV-nytt* 1979: 1, 6f; 1980: 2, 5).

Increased Regulation of Wastewater

The treatment requirements for wastewater have increased continuously over the studied period, with peaks in the mid-1970s and early 1980s. The mid-1970s saw the crest of the heavy expansion of 1965–1975, with the government subsidies for high-grade biological/chemical treatment.[1] However, the Swedish authorities continuously increased the environmental requirements on municipal wastewater treatment, and during permit processes the authorities often insisted that the biological wastewater treatment installations should be supplemented with chemical treatment (*VAV-nytt* 1978: 1; 3; *VAV-nytt* 1980: 1, 5).

Especially in the early 1980s, the Swedish EPA pressed the issue of chemical treatment and in several cases of permit reviews regarding wastewater treatment plants appealed the decision of the Concession Board for Environmental Protection, to the Supreme Court, such as regarding the wastewater treatment plants of the towns of Skellefteå, Halmstad, Härnösand, and Arboga. The Supreme Court, in part with reference to the now withdrawn government subsidies,[2] either rejected the EPA's request or postponed (in the case of Halmstad) the final decision for five years (*VAV-nytt* 1980: 3, 3; 1981: 4, 2). The sector organization VAV was hesitant about the need for chemical treatment, and in 1980, a research collaboration between the Swedish EPA, VAV, and SWEP (Wastewater Works Evaluation Project) was initiated to study how different types of operations influence results and the economy at municipal wastewater treatment plants with biological-chemical treatment (*VAV-nytt* 1980: 4, 7; 1981: 2, 8). Furthermore, the annual "VAV Day" in 1981 had the heading "Do We Treat Wastewater Too Much?" Because of the highly topical subject, the conference had many participants. The Swedish EPA's general director Valfrid Pålsson attended in person. He noted that the normal requirement for the municipal wastewater treatment plants would probably remain biological and chemical treatment, with the possibility for deviation from the normal requirement if the municipality could show that, e.g., chemical treatment would have extremely modest effects in relation to the costs (*VAV-nytt* 1981: 2, 2). In 1982, VAV noted that now the government considered that in addition to full biological treatment, phosphorus reduction would become a general requirement (*VAV-nytt* 1982: 2, 4). And in 1984, the Supreme Court finally ruled in line with the EPA on chemical treatment in the case of the Kungsbacka Wastewater Treatment Plant. The sector organization VAV determined that the decision could be interpreted such that now also requirements for chemical treatment would be set on all municipal wastewater treatment plants along the west coast of Sweden (*VAV-nytt* 1984: 4, 4).

Problems with Sludge

Alongside the increasing treatment requirements and the continuously growing number of households connected to the sewage systems, the volume of sludge increased rapidly. The main application for the use/disposal of sludge were on farmland or as fill for landscaping (landfill covers, topsoil along highways, etc.) (*VAV-nytt* 1988: 1, 7). One part of the vision from the very start of the great expansion of municipal wastewater treatment in the 1960s and 1970s, was to use the sewage sludge as fertilizer and soil improvement on farmland. This was a low-cost solution for sludge disposal that also brought benefits to farmers. And yet, this practice was not free of controversy, as there was hesitance from both the public and some farmers about using human waste as fertilizer.

The different views on the value and utility of man's own by-products have persisted throughout history and across the world. Whereas East Asian civilizations historically have been generally positive towards agricultural application of the by-product, European countries have possessed more of an ambivalent attitude, leaning more towards "dispose" than "recycle". Although the nineteenth century witnessed an increase in the practice of utilizing the by-product as fertilizer in several countries in Western Europe, this changed when water-based sanitation systems started to be introduced from the second half of the nineteenth century and onwards. This created a disconnection between humans and human waste and reduced the opportunity to use it as fertilizer. Raw excreta volumes from outhouses decreased, and instead new problems started to arise related to the discharge of untreated wastewater into waterways (Olsson et al., 2018).

Despite the hesitance from a growing number about using sewage sludge on farmland, it was not until the 1970s that public guidelines were launched in Sweden regarding how to hygienize the sewage sludge in order to reduce the risks related to pathogens. The 1970s and early 1980s saw an ever more intensified discussion about the possible risks related to other contaminants in the sludge, especially heavy metals and different forms of organic micropollutants, which in time led to increased focus on the need to reduce emissions of heavy metals up-streams (Olsson et al, 2018). During the heavy expansion during the period 1965-1975, with the government subsidies for high-grade biological/chemical treatment, there had never been any discussions on reducing emissions up-stream (Drangert and Löwgren, 2005).

The sector organization VAV worked on the intention to use sewage sludge on farmland. For instance, in the mid-1970s, VAV participated in experiments at the technical agriculture experimental station in Uppsala for the purpose of developing spreading equipment for wastewater sludge on fields because existing manure spreaders had proven to have poor capacity and were too weakly constructed (*VAV-nytt* 1975: 3, 3). Dewatering of the sludge was another important development field, of which VAV further organized a conference in the mid-1970s (*VAV-nytt* 1975: 3, 3). This was indeed highly relevant in case the sludge was to be incinerated, an option discussed at the time. Still, this was considered problematic as it would increase the risk of air pollution and new residual products (ash) that must be deposited (*VAV-nytt* 1988: 1, 8).

By the late 1980s, the “sludge on farmland” situation had intensified considerably due to a now loud public debate, especially from the mid-1980s when the Swedish “environmental guru” Björn Gillberg publicly criticized the major wastewater treatment plant in Gothenburg regarding its emissions of heavy metals. This was followed by a Greenpeace action with the same message (contaminants in sludge from the Gothenburg plant), something which in turn forced the Swedish Farmers’ Association to recommend their members not to apply sludge to fields (*VAV-nytt* 1989: 3, 10). Hence, this debate strongly affected Swedish food consumers. *VAV-nytt* refers to a front-page article in the largest Swedish newspaper *Dagens Nyheter* on November 13, 1987, stating that the agricultural use of sludge could become “an environmental bomb as devastating as DDT”. This newspaper article is referred to as “a biased account in the campaign” being conducted to stop agricultural use of sludge (*VAV-nytt* 1987: 3, 1).

In parallel to the public sludge-debate in the late 1980s, the Swedish EPA prepared new general advice for the handling of sludge from wastewater treatment plants, and in connection to this concluded that there was no significant environmental risk connected with using sewage sludge on farmland (*VAV-nytt* 1987: 1, 6; 2, 4f). This was followed by an important statement by the sector organization VAV, the Municipalities Association, and the Farmers’ Association concerning sludge deliveries to farmers in April 1987. The opinion of VAV was that reuse of sludge “must still be correct” as it is nonetheless “the result of effective environmental protection” (*VAV-nytt* 1988: 1, 8).

However, the consensus was short-lived, and already in February 1989, the chairman of ARLA Foods (an association of dairy farmers) declared that the organization would stop the use of sludge on farmland as of the spring of 1990: “Unfortunately we have ended up in a state of opinion where our environmental profile is not the sharpest. One example is the sludge issue. It can become a new symbolic issue and for that reason it is important to act quickly and decisively” (*VAV-nytt* 1989: 1, 3). The sector organization VAV responded repeatedly during the late 1980s by pointing out that (1) no effects on health or the production capacity of farmland could be detected from spreading sludge; (2) sludge from major treatment plants in general had considerably lower levels of hazardous substances than septic tanks (for a small number of families), and further; (3) Swedish sludge as a rule had considerably lower levels of undesirable substances than that in other countries (*VAV-nytt* 1989: 2, 12; 1989: 2, 1ff; 1989: 2, 17; 1989: 3, 9).

National authorities, in turn, changed position on the issue several times over the 1990s. Hence, in the 1990 government budget proposition, the Minister of the Environment, Birgitta Dahl, stated that additional restrictions concerning sludge could be expected (*VAV-nytt* 1990: 1, 5). And in 1996, the then-environmental minister, Anna Lindh, declared that: "We must have life cycle … i.e., the sludge will [and can] be used … and all the experts say that sludge works." She found it "too bad" that major actors such as ARLA kept the sludge from going out onto the fields (*VAV-nytt* 1996: 4, 20ff).

The uncertain sludge situation had major effects on the sector organization VAV as well as on individual municipalities and plants. The Gothenburg wastewater treatment plant, to cite one example, reduced its disposal of sludge to agricultural fields from about 50 percent in the mid-1980s, to about 20 percent in the mid-1990s (*VAV-nytt* 1995: 2, 18). This was solved in part by instead storing sludge in a cavern originally intended for oil storage (*VAV-nytt* 1989: 2, 17). A lot of development work was carried out by sewage managers and wastewater treatment plants, e.g., alternative technology solutions for storage of sludge were investigated (e.g., *VAV-nytt* 1994: 2, 16). At the same time, quality assurance was considered possible so that the sewage sludge could take place on farmland, and the sector in line with this itself developed stricter guidelines through a certification system which started in 2002 as a development project and was developed into a complete certification system called Revaq in 2008. Revaq, which is run by the sector organization VAV and a steering group in which the Swedish Farmers' Association and the Swedish Food Federation participate,[3] today ensures the quality of about 40 wastewater treatment plants' work with upstream measures for sludge quality improvement and recycling of nutrients to enable sludge to be spread on farmland (there are just over 2,000 municipal water and sewerage plants in Sweden). Although the ambition behind Revaq was to establish a long-term plan for dealing with sewage sludge, it has not resolved the issue yet. Not only is the rate of Revaq- connected plants small, Swedish grain mills will in general not accept grains that have been fertilized with sewage sludge, even if it is Revaq-certified, for fear of consumer backlash.

Furthermore, since the launch of Revaq, concerns have been growing about ["new"] contaminants previously not in focus, particularly pharmaceuticals and microplastics. The consequence is that, despite the "upstream work" being highly effective (notably in terms of reducing heavy metal contents in the sludge), the future of sewage sludge application on farmland is looking bleaker. Notwithstanding, and although other countries in Europe have begun to abandon the practice, in Sweden, national policy remains committed to farmland application of sewage. As for the possibility of landfilling the sludge, it has been partly banned in Sweden from 2005 (landfilling of sewage sludge is now only allowed if it has been processed through composting). Hence, there is an urgent need to find new methods of dealing with the sewage sludge (Swedish Government, 2020: 3).

When it comes to smaller Swedish treatment plants, intended for a maximum of 2,000 PE, which we will focus more on in the next section, the sludge is often transported to larger treatment plants because it is considered the most economically advantageous option. At longer transport distances, such as in northern Sweden, the sludge can be taken care of on site at the smaller treatment plants. Methods for local disposal consist of, e.g., composting, or long-term storage in so-called sludge lagoons. The sludge can thereafter be used as construction soil. Of the smaller plants, only a very limited number of plants spread sludge on farmland at the beginning of the 2000s, and the situation should not be different now. In fact, sludge from smaller plants is generally not suitable for spreading on farmland as it is often of poorer quality in terms of nutrient content and it is not as desirable as sludge from larger plants. This sometimes causes problems for the larger plants in receiving sludge from the smaller plants (Swedish Government, 2020: 3).

Challenging Existence for Small Plants and On-Site Systems due to Tightened Environmental Requirements and Neglect

While the centralized sanitation solution has been strongly stimulated by the prevailing large-scale thinking, the smallest wastewater treatment plants in the smallest communities did not suffer only from fitting poorly into the template, but had a harder time meeting the new emissions regulations (*VAV-nytt* 1978: 4, 6). Steep requirements for treatment were solved more easily in the larger plants—it was easier and cheaper to control and improve technology, as well as to expand. High-grade biological/chemical treatment in small installations was extremely expensive (Marklund 2018). In addition, the flow and pollution variations were normally "significantly" greater for smaller plants (this refers to the sizes 10–500 PE or 100–2000 PE) than for larger plants (*VAV-nytt* 1977: 1, 13; 1988: 2, 5), meaning there was great need for frequent sampling, especially for plants providing service to fewer than 200 persons (*VAV-nytt* 1975: 3, 3). The large variations further meant the small plants were difficult to design. Also, they lacked attention from the scientific wastewater treatment field (VAV-nytt 1988: 2, 5). The limited research that the sector organization VAV could engage in concerned their primary area of activity, i.e., the centralized, large-scale solutions. Although the Swedish Construction Research Board partly engaged in developing solutions other than the centralized solution up until the late 1980s,[4] the research in the sector was thereafter generally weakened in Sweden in favor of research at the universities and technical colleges (Marklund, 1994).

As the smaller wastewater treatment plants of the 1970s and 1980s often were managed and owned jointly by individual property owners who lacked operational and maintenance competence, they were often constructed in a far too complicated manner, and in great need for careful monitoring and care to function satisfactorily. It was not easy for the property owners to choose the right model of package plant in the 1970s as there were numerous plants on the market due to the tightened environmental requirements. Altogether, the problems associated with the smaller plants in the form of maintenance difficulties, challenges in meeting environmental requirements, and a general lack of research to remedy the situation, meant that a system with wastewater pumping stations and pressure mains often was perceived as a more flexible solution. Even if the capital costs were often higher for the connecting pipelines than for a small package plant, the lower operating costs for the connecting pipelines were considered an offset to this (*VAV-nytt* 1977: 3, 6; 1978: 4, 6; 1979: 1, 6f; 1980 2, 2f; Marklund, 2018). An overall central motivation for the expansion of the centralized sanitation system in the 1970s, was to relieve small local receiving waters from insufficient and mal-functioning private on-site sanitation systems, and to handle increased treatment requirements more easily (*VAV-nytt* 1978: 4, 6).

The problems with insufficient on-site sanitation systems persisted during the entire investigation period. In the mid-1990s, about half a million single-family houses for permanent residence and an equal number of summer cottages were considered to have private wastewater treatment installations, usually one's own at one's own property, and typically in some form of septic tank (Swedish EPA, 1994) (*VAV-nytt* 1994: 2, 17). In the late 1990s, the sector organization VAV noted an awakened interest among policy actors and the sector for on-site sanitation systems (*VAV-nytt* 1999: 2, 43ff), but saw a somewhat split role of the organization in the respect that VAV in ethical terms "obviously" had responsibility for these installations. On the other hand, on-site sanitation systems were not included in the responsibility of the municipal wastewater utilities that fund VAV (*VAV-nytt* 1998: 6, 12; 1999:2, 43ff). Still, some in the sector wanted VAV to assume a greater responsibility for on-site sanitation installations —"the forgotten wastewater treatment sector"—that accounted for a large percentage of the phosphorous release to water and posed a risk to human health. The proponents reasoned the engagement of VAV with the argument that its members possessed the necessary know-how. Hence, it was a problem that no one took responsibility for the technical development of on-site sanitation installations (*VAV-nytt* 1999: 1, 9; *VAV-nytt* 1999: 2, 44).

In response to the awakened interest, VAV initiated the "Small Wastewater Solutions" project in 1998, which in part resulted in the establishment of an ombudsman for the smaller installations (*VAV-nytt* 1999: 1, 37). This also induced some collaboration between the Municipalities Association, the Swedish EPA, and VAV, where the issue of responsibility for small-scale wastewater solutions was at the forefront (*VAV-nytt* 1999: 2, 43ff). An important explanation for the growing interest of both VAV and public authorities for the on-site sanitation systems, was that the requirements for better water and wastewater treatment had continuously increased in conversion areas since the 1970s, due to generally increased shower, wash, and WC standards. Often, attempts had been made to solve this through local infiltration of wastewater, which in turn entailed increased risks of contamination of the groundwater (*VAV-nytt* 2000: 4, 80; SV, previously *VAV-nytt*, 2007: 1 25).

There was detailed reporting in the early 2000s about projects where the sector participated. The projects investigated, tested, and evaluated various forms of small wastewater systems, such as in the Stockholm archipelago for the purpose of reducing transports and nutrient load on the sea while at the same time supplying more nutrients to agricultural land (*VAV-nytt* 2000: 3, 38f). In another project, 14 on-site sanitation systems (eight different types) were evaluated at the lake Bornsjön. Results showed that, in principle, it was always better with larger sanitation systems where personnel could monitor and control the process better (*VAV-nytt* 2001: 4, 40ff). A few years later, in 2008, phosphorous was considered a greater problem and about 20 percent of the Swedish phosphorous that ended up in the already heavily polluted inland sea, the

Baltic Sea,[5] was now considered caused by on-site sanitation systems (*Svenskt Vatten* 2008: 6, 8f). That same year, 2000 of the roughly 20,000 on-site systems within Värmdö municipality were inventoried, which showed that as many as two-thirds of the property owners were not managing their installations properly. If the situation was similar nationwide, that meant that up to 600,000 of the country's one million on-site sanitation systems had deficient treatment at the time (*Svenskt Vatten* 2008: 2, 25ff).

When the Swedish Agency for Marine and Water Management was established in 2011, it took over the role from the Swedish EPA of monitoring and guiding authority for wastewater systems <200 PE. Still, the difficulties for property owners to get advice on suitable wastewater treatment from either authorities and/or contractors were repeatedly pointed out it in the sector journal during the following years. It was generally considered both simpler and cheaper for property owners to await inspection than to act on their own initiative as the legislation was interpreted differently by different actors (*Svenskt Vatten*, previously *VAV-nytt*, 2013: 2, 28). This was attributed in part to the municipalities' lack of overall guidelines, and to the fact that there was no authority with responsibility for the role between municipal water services and on-site sanitation systems. Hence, municipalities had to find strategies themselves for reaching out with information and motivating property owners to take remedial measures (*Svenskt Vatten* 2012: 5, 6ff; *Svenskt Vatten* 2012: 5, 28; *Svenskt Vatten* 2013: 2, 28f).

In 2013 and 2014, the phosphorous load from the on-site sanitation systems for about one million people was judged to be as great as the load from all the municipal wastewater treatment plants which serviced about eight million people (*Svenskt Vatten* 2013: 2, 28). The Agency for Marine and Water Management was further criticized in the sector journal for not cooperating enough with the Swedish EPA, and for proposing requirements that were not compatible with what the Swedish EPA had recently proposed. Also, the Agency was criticized for "going after" all wastewater systems for up to 200 persons, i.e., not only the very worst on-site sanitation systems but also the municipal ones, even though their contribution to eutrophication was/is very small compared to that of those on-site. According to the sector organization VAV, it was an extensive control apparatus and bureaucracy in combination with shortage of resources that "for decades" had put the brakes on the work with on-site sanitation systems, and now the agency's proposals would increase the problems (*Svenskt Vatten* 2013: 2, 28f; 2014:2, 28). In the 2010s, the sector journal further typically provided information on municipalities with water and sanitation issues in the outer areas, which to a great degree concern identifying so-called 6 § areas, i.e., areas where the municipalities were obliged to provide services according to the Water Service Act Law (Swedish Government 2006:412). Sometimes the county administrative boards enjoin municipalities to connect groups of properties to the general wastewater system (Marklund, 2018; *Svenskt Vatten* 2014: 4, 54ff; 2015:5, 6f). Hence, the centralized sanitation solution continues to grow.

The Great Environmental Mobilization of the Late Twentieth Century

Combined, the extensive sludge- and emissions-related challenges connected with the major wastewater treatment expansion from the 1960s and onwards, meant the sector was relatively well equipped to meet the approaching environmental mobilization of the late 1980s and early 1990s in terms of the Brundtland commission, the sustainability discourse, Agenda 21, the Rio Declaration, and the increased focus on life-cycle assessment (LCA). At that point (early 1990s), some in the public debate seriously question the centralized sanitation solution in favor of alternative, smaller scale and "environmentally sound" technologies. In *VAV-nytt*, the issue was deemed "hot political stuff," both locally and in the Swedish national parliament. Several municipalities made early decisions on far-reaching changes in-line with the new discourse, such as the towns/cities of Tanum, which prohibited water toilets, Västervik, where water toilets were prohibited outside urban areas, and Oxelösund, Halmstad, and Malmö, where existing treatment systems were supplemented with wetlands and ponds. The issue was brought up in the leadership of Sweden's largest political party, the Social Democrats, who wanted to introduce UD toilets for the purpose of improving the environment as well as creating 90,000 new jobs (this was included in the party program but was never realized) (*VAV-nytt* 1994: 2, 27ff).

The criticism of the centralized sanitation solution in the early 1990s was that it could entail hygienic risks in the receiving waters, that it did not recycle nutrients in wastewater, and that it was not "eco-friendly" and resource efficient. Still, the sector was quick to turn the debate to its advantage by promoting wastewater as a resource containing both nutrients and energy that ought to be exploited (*VAV-nytt* 1992: 3, 38ff). Hence, in a lengthy article in *VAV-nytt* about the various eras of wastewater treatment technology—the public health era from the 1850s to the 1930s, the environmental protection era from the 1930s and on—it was determined that we are now in the so-called life-cycle era. The life-cycle concept, it was concluded, was not new to wastewater treatment technology. Hence, since the start of the modern wastewater technology history in the mid-1800s, the driving force with roots in the agrarian society was about returning the nutrients in wastewater to food production, to agriculture. Still, reuse had been forgotten during the environmental protection era when wastewater instead came to be seen only as a disposal problem (*VAV-nytt* 1994: 2, 11).

In line with the societal environmental mobilization, by the mid-1990s, the sector started to highlight wastewater treatment plants as 'leading environmental companies.' Sweden now had the world's most advanced wastewater treatment system, and the sector was well equipped when faced with stricter requirements to secure water supply and reduce environmental impact. The hygienic problems that existed in, e.g., southern Europe were unknown in Sweden. "Even so, wastewater treatment plants are often considered a source of pollution instead of the environmental protection installation it actually is" (*VAV-nytt* 1994: 2, 13ff). The sector saw Agenda 21 as a "reawakening for the wastewater treatment plants' environmental work," and an opportunity for the wastewater treatment operation to clarify its environmental work and share with the municipalities and others the know-how that existed in the sector. The sector organization VAV started a research project with the purpose of giving its members guidance on how Agenda 21 could be used to bring wastewater treatment issues into the municipal decision-making process sooner, and to put forward their competence in these matters (*VAV-nytt* 1994: 2, 21ff).

Although the alternative sanitation solutions in the mid-1990s were being emphasized by certain groups in society as more environmentally sound and preferable to the conventional system, several articles in *VAV-nytt* reflect that the wastewater treatment sector did not yet consider this a realistic alternative. In contrast to the conventional system that was built to protect people from sanitary irregularities, the alternative systems were not yet tested for longer time-periods and in several "eco-villages," hygiene had even become a problem because of the alternative technology. For one thing, more people were exposed to toilet waste with dry systems than with conventional systems, one in every family when dry systems were used versus one in ten thousand with conventional systems (*VAV-nytt* 1994: 2, 27ff; 1995: 2, 37). In 1995, *VAV-nytt* reported on Åkesta eco-village in Västerås where containers for the biological toilets were in shafts under the houses. From these, fecal matter was carried in buckets up a steel stairway and passed living spaces before coming out of the houses. There had been such major problems with flies that they resorted to insecticide and then buried the fecal matter as waste in the forest. When it comes to the diverted urine, groundwater infiltrated the pipes for urine transport between the houses and the urine tank, so the farmer had to empty the tank 10–15 times more often than if only urine had been in the tank (*VAV-nytt* 1995: 2, 37). Alternative solutions in the form of dry and close-to-nature solutions could work well on a small scale with the right planning and care, the sector organization VAV concluded, but there was an inherent weakness in that the households themselves would have to take more responsibility and do more work. And was it even more ecological? It could just as well be the conventional system. Hence, the water quality in local receiving water bodies in the outer-town areas had improved steadily for decades due to the conventional solution (*VAV-nytt* 1995: 2, 33).

In particular, the issue of UD was criticized in *VAV-nytt* in the mid-1990s. The gist of the criticism was that there were too many questions related to the big infrastructural requirements that three waste streams (urine, fecal matter, and graywater) would impose on the buildings. How will fecal matter collection and treatment, and urine collection, transport, and storage (awaiting spreading on farmland) come about (*VAV-nytt* 1995: 2, 33)? There were further only two variants of porcelain toilets with water flushing for separation of urine and fecal matter on the Swedish market (*VAV-nytt* 1995: 2, 37). On a longer term, it was not ruled out that UD would compete with the conventional system in sparsely populated areas, the sector organization VAV believed. Still, it was highly uncertain whether UD systems entailed higher or lower energy use than a conventional system. Research was also lacking on several decisive points, such as how the urine was to be stored to prevent the release of ammonia and bacteria to the atmosphere (*VAV-nytt* 1996: 2, 50ff; 1995: 2, 37). Environmental minister Anna Lindh stated in an interview in *VAV-nytt* that there was nothing that got wastewater treatment people as distraught as when UD comes up. Still, she believed it would be necessary in the future and therefore wanted to test it on a larger scale (*VAV-nytt* 1996: 4, 20ff).

The UD issue was still topical in the sector journal in the late 1990s. In 1999, readers were informed of a report from SLU [Swedish University of Agricultural Sciences] presenting UD as "very interesting in the countryside if there are farmers who are interested in the urine." Still, it could not yet be recommended in larger communities (*VAV-nytt* 1999: 1, 40). In 2003, Håkan Jönsson (researcher in "LCA technology" at SLU) wrote in an opinion piece that Sweden ought to invest in UD technology because it provided business opportunities "now" (around 2000) when the interest in source separating systems was rapidly increasing internationally. Jönsson referred to a German study investigating the use of UD in a new, larger housing area, and a China study of an area where about 100,000 source-separating toilets had been installed in recent years. According to Jönsson, Swedish solutions could contribute in solving the world's wastewater problems as Sweden was "at the forefront" in source-separating wastewater (SV, previously *VAV-nytt*, 2003: 1, 40ff).

Problems persisted into the 2000s in finding farmers who were interested in the nutrients from wastewater, and the handling and transport were still difficult and expensive (*VAV-nytt* 2003: 2, 40f; *Svenskt Vatten* 2004: 2, 34). Even if urine separation was in theory an advantageous solution for nutrients recovery it was hard to make it work in practice in the mid-1990s as well as 10 years later. There was no alternative to the conventional wastewater treatment technology where stringent requirements on hygiene, environmental protection, durability, economy, and safety in function were met. VAV considered it best to keep working with the conventional centralized system (*VAV-nytt* 1995: 2, 20f; 2003: 3, 28f).

Source separation is mentioned also in later years in the sector journal, if not nearly as intensively as in the late 1990s. In 2007, e.g., there was a report of an experiment with waste disposal on the initiative of an Environmental Office in Gothenburg, to find a new alternative route for the return of plant nutrients (*Svenskt Vatten* 2007: 3, 29f). In 2012, the readers of the sector journal were, in turn, told that Örebro municipality emphasized source-separation as an alternative to the conventional system in conversion areas (*Svenskt Vatten* 2012: 5, 6ff), and in 2015, that the Swedish Agency for Marine and Water Management argued that a transformation to more source-separating technology ought to happen in the future. In that year, the sector journal further reported on experiences with source-separating technology in the Netherlands (Noorderhoek) and Germany (Hamburg Wasser), including biogas-producing reactors that process wastewater (blackwater) from vacuum toilets (*Svenskt Vatten*, April 2015, International Special, 23ff).

Discussion and Conclusions

From delving into the Swedish sanitation sector journal, *VAV-nytt/Svenskt Vatten*, we have gained a deeper understanding of the interactions and processes that have preceded and reinforced the centralized sanitation solution in Sweden ever since the 1970s. Not least, we have seen a strong example of policy intervention for (if not transition per se) a major and long-term upgrading/development of the centralized sanitation system. In the 1960s and 1970s, the Swedish centralized sanitation system, due to strong national intervention, underwent large-scale development steps in terms of improved biological and chemical treatment steps. An interplay of different policy areas was involved, including municipal and environmental reforms, large-scale infrastructural visions, government control, and extensive state subsidies. This included important resources to solve technical and environmental challenges that inevitably arose in parallel with the expansion. Overall, this is important guidance on how policy actions can catalyze resources to spur progress and stimulate development in a certain direction, thus recognizing intervention points that ultimately lead to a broader sustainability transformation. When the negative environmental effects of the centralized sanitation systems were realized in the 1950s and 1960s, Sweden already had an efficient machinery for rapid and large-scale infrastructural expansion that could be redirected towards the large-scale improvement of the centralized sanitation system in terms of biological and chemical treatment steps. Here, it is important to point out that the major national policy instruments used then, are still available for use today.

Transition has not taken place when it comes to alternative sanitation solutions, and it is in the recapitulation of interactions in practice (and the possible absence of these) between niches, the regime, and the landscape level in the Swedish case of wastewater treatment over a period of 40 years that we can understand the lack of such a transition on a deeper level. Hence, although there was a possible "intervention point" for policy in the direction of alternative sanitation solutions in the late 1980s and 1990s, in terms of a strong sustainability discourse with important undertones of recycling, and a parallel public debate which seriously questioned the centralized sanitation system, there was already (and still is) a tension in the regime leading to an inevitable lock-in towards the centralized sanitation solution. This tension is between nutrients and resource recovery on the one hand, and containment, treatment, and risk management of the wastewater streams on the other, outermost crystallized in the challenging sludge issue but with obvious consequences for all resource-recovery contexts in the wastewater sector. The tension is further connected to strong perceptions of where human feces belong and do not. In this context, even if the alternative sanitation solutions would have worked well hygienically and technically in the early 1990s (i.e., in time for the possible intervention point), due to the tension there was a problem in finding farmers interested in the recovered resources as it could negatively affect their ability to sell their farm products. Hence, the alternative sanitation solutions lacked obvious advantages over the centralized solution, even in terms of resource-recovery.

The dominance of the centralized sanitation solution in terms of treatment and risk management was continuously reinforced over the studied period, due to the long-term overcoming of many health and environmental challenges. This was continuously highlighted in the sector journal, along with the recycle-heritage of the conventional system, and how it would still be if only the agricultural sector drew its bit. In parallel, the shortcomings of the alternative (and smaller) solutions were constantly highlighted over the period. Important challenges to be addressed for alternative sanitation solutions to have a greater impact in Sweden as well as internationally, include creating a marketplace for nutrients from wastewater fractions and linking new sanitation solutions (e.g., greywater or urine separation) with conventional wastewater infrastructures (Morandi and Steinmetz, 2019). Policy intervention is thus appropriate in both the market and technology development fields. Policy would be needed to create a "niche" for the new solutions as it is really only then these can be developed and improved. In other words, it is not always possible to wait for new technology to improve, it needs to be partially protected (expanded) to get a chance to improve, i.e., not only through research but also from learning-by-doing, and learning-by-using (see, e.g., Kemp et al., 1998; Wilson, 2012).

In Sweden, policy has not intervened adequately to achieve this. For instance, LIP was a very broad (technology-neutral) investment in sustainability, whereby the actual investment in alternative sanitation solutions was limited in both scope and time, not least in comparison with what the STOWA projects in the Netherlands seem to have achieved at about the same time (STOWA, 2006). Also, even though the evaluation of LIP in 2005 suggested a follow-up, in reality the political forces that pushed for alternative sanitation solutions some 30 years ago in the name of recycling are weaker today and have partly devolved into the climate issue, and with increased focus on energy aspects alongside the circular economy (Swedish Government 2020:3).

Overall, to argue in this context that it is mainly about the lack of acceptance and knowledge of the alternative solutions, or technical lock-in, which is often done in the literature, is to simplify, at least in the Swedish case. Hence, with the tension between recovery and treatment/risk management in the regime still highly relevant—alongside the remaining needs for promising experiments and radical innovations on alternative sanitation solutions—the challenges related to achieve the transition towards alternative sanitation solutions are indeed more complex and would benefit from a more mission-oriented policy (Maccucato, 2018) on a par with that which existed, especially during the 1970s and 1980s, in the upgrading/development of the Swedish centralized sanitation system.

Notes

1. The investments in high-grade biological/chemical treatment are reflected in the continued expansion and centralization of the wastewater treatment system. Hence, in 1974, 540,000 new individuals were connected to biological-chemical treatment at the same time as the number of treatment plants decreased by 65 (*VAV-nytt* 1975: 1, 3). In 1975, 25 high-grade biological/chemical treatment plants were constructed and about 40 treatment plants were shut down (*VAV-nytt* 1977: 2, 7).
2. The government subsidies for sewer systems and wastewater treatment plants ceased through the so-called savings bill (1978/79:95).
3. An employer and industry organization for companies that produce food and drink in Sweden.
4. Statens råd för byggnadsforskning, usually called Byggforskningsrådet (BFR), was a former Swedish agency that existed from 1960 until 2000. BFR was a research board that conveyed funding for research within the fields of construction and urban planning. As of January 1, 2001, BFR's mission was taken over by the Swedish research council Formas.
5. The Baltic Sea is severely affected by eutrophication (much due to emissions of phosphorus) and is one of the world's most polluted seas. It borders Denmark and Sweden to the west, Finland, Russia, Estonia, Latvia, and Lithuania to the east, and Poland and Germany to the south. With its 2,400 kilometers, Sweden's coast is one of Europe's longest. Since the end of the 1980s, the border countries have agreed to reduce nitrogen emissions to the Baltic Sea.

Notes on Contributors

Kristina Söderholm is a professor in the History Unit of the Division of Social Sciences at Luleå University of Technology, Sweden. Her main scientific interests are related to the historical (twentieth century—present) construction of large infrastructural systems in order to draw lessons for today's challenges in making the systems more resource efficient and sustainable.

Brenda Vidal is a PhD candidate in urban water engineering in the Division of Architecture and Water at Luleå University of Technology, Sweden. Her main scientific interests are the function and sustainability of small wastewater treatment systems in a context of paradigm shift and resource recovery.

Annelie Hedström is a professor in the department of Civil, Environmental and Natural Resources Engineering at Luleå University of Technology, Sweden. Her main scientific interests are related to the development of resource efficient, robust and sustainable systems for municipal and domestic wastewater management.

Inga Herrmann is an associate professor in the department of Civil, Environmental and Natural Resources Engineering at Luleå University of Technology, Sweden. She is also serving a two-year term as the chair of the International Water Association's expert group for small water and wastewater systems.

ORCID

Kristina Söderholm http://orcid.org/0000-0001-5712-0589
Brenda Vidal http://orcid.org/0000-0002-6463-7284
Annelie Hedström http://orcid.org/0000-0001-9541-3542
Inga Herrmann http://orcid.org/0000-0003-0520-796X

References

M. Boller, "Source Control and Source Separation: The Swiss Experience," in T. A. Larsen, K. M. Udert, and J. Lienert, eds, *Source Separation and Decentralization for Wastewater Management* (London: IWA, 2013) 440–446.

E. Brands, "Prospects and Challenges for Sustainable Sanitation in Developed Nations: A Critical Review," *Environmental Reviews* 22 (2014) 346–363.

D. Chapman, Melbourne Water, Personal Interview (February 14, 2019).

A. G. Capodaglio, A. Callegari, D. Cecconet, and D. Molognoni, "Sustainability of Decentralized Wastewater Treatment Technologies," *Water Practice and Technology* 12: 2 (2017) 463–477.

J.-O. Drangert and M. Löwgren, *Förändring eller Kontinuitet? Faktorer som Påverkat Va-Systemens Utveckling i Linköping och Norrköping under Perioden 1960*–1990 [Change or Continuation? Factors that Influenced the Development of the Water Systems in Linköping and Norrköping during the Period 1960–1990],: Report 2005: 1 of Urban Water Research Program (Gothenburg: Chalmers University of Technology, 2005). (In Swedish)

G. Ó. Erlingsson, E. Wångmar, and J. Ödalen, "Kommunsammanläggningarna 1952–1974. Hur Blev de Politiskt Möjliga? [Municipal assemblies 1952–1974. How Did they Become Politically Possible?]," *Scandinavian Journal of Public Administration* 14: 3-4 (2010) 3–36. (In Swedish)

D. Fam and C. Mitchell, "Sustainable Innovation in Wastewater Management: Lessons for Nutrient Recovery and Reuse," *Local Environment* 18: 7 (2013) 769–780.

D. Fam, C. Mitchell, K. Abeysuriya, and A. Mellick Lopes, "Emergence of Decentralised Water and Sanitation Systems in Melbourne, Australia," *International Journal of Water* 8: 2 (2014) 149–165.

T. Gardner and A. Sharma, "Development of Decentralized Systems in Australia," in Larsen, Udert, and Lienert, *Source Separation and Decentralization for Wastewater Management* (2013) 447–454.

F. W. Geels, "Technological Transitions as Evolutionary Reconfiguration Processes: A Multilevel Perspective and a Case-Study," *Research Policy* 31: 8-9 (2002) 1257–1274.

F. W. Geels, "The Dynamics of Transitions in Socio-Technical Systems: A Multi-Level Analysis of the Transition Pathway from Horse-Drawn Carriages to Automobiles," *Technology Analysis and Strategic Management* 17: 4 (2005) 445–476.

F. W. Geels, "Reconceptualising the Co-Evolution of Firms-in-Industries and Their Environments: Developing an Inter-Disciplinary Triple Embeddedness Framework," *Research Policy* 43: 2 (2014) 261–277.

S. Hoffmann, U. Feldmann, P. M. Bach, C. Binz, M. Farrelly, N. Frantzeskaki, H. Hiessl, J. Inauen, T. A. Larsen, J. Lienert, J. Londong, C. Lüthi, M. Maurer, C. Mitchell, E. Morgenroth, K. L. Nelson, L. Scholten, B. Truffer, and K. M. Udert, "A Research Agenda for the Future of Urban Water Management: Exploring the Potential of Nongrid, Small-Grid, and Hybrid Solutions," *Environmental Science and Technology* 54: 9 (2020) 5312–5322.

A. Kaijser, A. Mogren, P. Steen, *Att Ändra Riktning: Villkor för Ny Energiteknik* [*Changing Direction: Conditions for New Energy Engineering*] (Stockholm: Allmänna förlaget, 1988). (In Swedish)

R. Kemp, J. Schot, and R. Hoogma, "Regime Shifts to Sustainability Through Processes of Niche Formation: The Approach of Strategic Niche Management," *Technology Analysis and Strategic Management* 10: 2 (1998) 175–198.

E. Kvarnström, K. Emilsson, A. Richert Stintzing, M. Johansson, H. Jönsson, E. af Petersens, C. Schönning, J. Christensen, D. Hellström, L. Qvarnström, P. Ridderstolpe, and J.-O. Drangert, *Urine Diversion: One Step towards Sustainable Sanitation*, Report 2006: 1 of EcoSanRes Publications Series (Stockholm Environment Institute, 2006).

W. Lafferty and J. Meadowcroft, *Implementing Sustainable Development: Strategies and Initiatives in High Consumption Societies* (Oxford: Oxford University Press, 2000).

T. A. Larsen, "Redesigning Wastewater Infrastructure to Improve Resource Efficiency," *Water Science and Technology* 63: 11 (2011) 2535–2541.

T. A. Larsen, A. C. Alder, R. I. L. Eggen, M. Maurer, and J. Lienert, "Source Separation: Will We See a Paradigm Shift in Wastewater Handling?" *Environmental Science and Technology* 43: 16 (2009) 6121–6125.

J. Londong, "Practical Experience with Source Separation in Germany," in Larsen, Udert, and Lienert, *Source Separation and Decentralization for Wastewater Management* (2013) 423–430.

C. Lüthi and A. Panesar, "Source Separation in Middle- and Low-Income Countries," in Larsen, Udert, and Lienert, *Source Separation and Decentralization for Wastewater Management* (2013) 447–454.

M. Maccucato, "Mission-Oriented Innovation Policies: Challenges and Opportunities," *Industrial and Corporate Change* 27: 5 (2018) 803–815.

G. Marklund, "Institutions and Appropriation in Swedish Technology Policy: The Case of STU's Grants to Process Control Technology for Pulp and Paper Production 1968–1991," Dissertation (Uppsala University: 1994).

S. Marklund, Luleå Municipality, Sweden, Personal Interview (May 12, 2018).

J. R. McConville, E. Kvarnström, H. Jönsson, and E. Kärrman, "Source Separation: How Ready is the Swedish Wastewater Sector for Technology Transition?" paper presented at the 13th IWA Specialized Conference on Small Water and Wastewater Systems and 5th IWA Specialized Conference on Resources-Oriented Sanitation (Athens, September 14–16, 2016).

C. Morandi and H. Steinmetz, "How Does Greywater Separation Impact the Operation of Conventional Wastewater Treatment Plants?" *Water Science and Technology* 79: 8 (2019) 1605–1615.

O. Olsson, M. Giełczewski, J. Koskiaho, and K Barquet, *D 6.3–Historical Review Report of the Research Project Bonus Return* (2018) <https://www.bonusreturn.eu/wp-content/uploads/2019/03/BONUSRETURN_D.6.3_CIRCULARITY_FROM_CONCEPT_TO_PRACTICE.pdf> Accessed November 20, 2019.

A. Sharma, S. Burn, T. Gardner, and A. Gregory, "Role of Decentralised Systems in the Transition of Urban Water Systems," *Water Supply* 10: 4 (2010) 577–583.

A. Sharma, G. Tjandraatmadja, S. Cook and T. Gardner, "Decentralised Systems: Definition and Drivers in the Current Context," *Water Science and Technology* 67: 9 (2013) 2091–2101.

J. C. Sievers, T. Wätzel, J. Londong, and E. Kraft, "Case Study: Characterization of Source-Separated Blackwater and Greywater in the Ecological Housing Estate Lübeck 'Flintenbreite' (Germany)," *Environ Earth Sciences* 75: 1428 (2016) doi:10.1007/s12665-016-6232-y. Accessed December 13, 2019.

P. Simha and M. Ganesapillai, "Ecological Sanitation and Nutrient Recovery from Human Urine: How Far Have We Come? A review," *Sustain. Environmental Research* 27: 3 (2017) 107–116.

R. Sitzenfrei R and W. Rauch, "Investigating Transitions of Centralized Water Infrastructure to Decentralized Solutions: An Integrated Approach," *Procedia Engineering* 70 (2014) 1549–1557.

K. Söderholm and E. Wihlborg, "Policy for Sociotechnical Transition: Implications from Swedish Historical Case Studies," *Journal of Environmental Policy and Planning* 17: 4 (2015) 452–474.

STOWA, *Anders Omgaan met Huishoudelijk Afvalwater* [A Different Approach to Domestic Wastewater], Final report 2006:18 of STOWA (Utrecht: STOWA, 2006). (In Dutch)

Svenskt Vatten (Swedish Water), numerous numbers (Stockholm: Svenskt vatten, 2002–2017).

D. Swart and A. J. Palsma, "The Netherlands: 'Nieuwe Sanitatie,'" in Larsen, Udert, and Lienert, *Source Separation and Decentralization for Wastewater Management* (2013) 431–438.

Swedish EPA (Naturvårdsverket), *Avlopp i Kretslopp – en Utvärdering av LIP-Finansierade Enskilda Avlopp, Vassbäddar och Bevattningssystem med Avloppsvatten* [*Wastewater Recirculation: An Evaluation of Small-Scale Systems Outside the Urban Central Systems, Reed Beds and Systems with Irrigation of Wastewater*] (Stockholm: Naturvårdsverket, 2005: 5406). (In Swedish with English summary)

Swedish EPA (Naturvårdsverket), *Wastewater Treatment in Sweden 2016* (Stockholm: Naturvårdsverket, 2018).

Swedish Government, *Lagen om Allmänna Vatten- och Avloppsanläggningar* [Public Water and Wastewater Facilities Act Law], Code of Statues, SFS 1955:314 (Stockholm: Swedish government, 1955). (In Swedish)

Swedish Government, *Kungl. Maj:ts Kungörelse om Statsbidrag till Avloppsreningsverk* [Royal Announcement of Government Subsidies for Wastewater Treatment Plants], Code of Statues, SFS 1968:308 (Stockholm: Swedish government, 1968). (In Swedish)

Swedish Government, *Lagen om Allmänna Vatten- och Avloppsanläggningar* [Public Water and Wastewater Facilities Act Law], Code of Statues, SFS 1970:244 (Stockholm: Swedish government, 1970). (In Swedish).

Swedish Government, *Lag om Allmänna Vattentjänster* [Water Service Act Law], Code of Statues, SFS 2006:412 (Stockholm: Swedish government, 2006). (In Swedish)

Swedish Government, *Vägar till Hållbara Vattentjänster* [Pathways to Sustainable Water Services], State public reports, SOU 2018:34 (Stockholm: Swedish government, 2018). (In Swedish)

Swedish Government, *Hållbar Slamhantering* [Sustainable Sludge Management],: State public reports, SOU 2020:3 (Stockholm: Swedish government, 2020). (In Swedish)

VAV-Nytt, numerous numbers (Stockholm: Svenska vatten- och avloppsverksföreningen, 1974–2001). (In Swedish)

C. Wilson, "Up-Scaling, Formative Phases, and Learning in the Historical Diffusion of Energy Technologies," *Energy Policy* 50 (2012) 81–94.