BONUS RETURN
Reducing Emissions by Turning Nutrients and Carbon into Benefits
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x	PU	Public.
	PP	Restricted to other project partners.
	RE	Restricted to a group specified by the consortium.
	CO	Confidential, only for members of the consortium.

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EXECUTIVE SUMMARY

This series of three Policy Briefs are a deliverable under BONUS RETURN Task 6.5 and aim to provide real-world examples of successful policies or programs that have served to accelerate implementation of eco-technologies and practices that reduce nutrient losses and encourage reuse. Briefs are focused on successes in each of the three BONUS-RETURN Case Study Basins – Fyrisån (Sweden), Vantaanjoki (Finland), and Słupia (Poland).

The final versions of the policy briefs, including graphics and layouts, as well as the translated versions into local languages (Finish, Swedish, and Polish) can be found on BONUS RETURN's website.

1 INTRODUCTION

The degradation of the Baltic Sea is an ongoing problem, despite investments in measures to reduce external inputs of pollutants and nutrients from both diffuse and point sources. Available technological and management measures to curb eutrophication and pollution flows to the sea have not been adapted adequately to the contexts in which they are being applied. Furthermore, measures are often designed based on single objectives, thereby limiting opportunities for multiple benefits.

In addition, there is a general sense that measures to address the deterioration of the Baltic ecosystem are primarily technologically-driven and lacking broader stakeholder acceptance – the "experts" who define these measures have little engagement with industry, investors, civil society and authorities. This problem is magnified by governance and management, taking place in sectoral silos with poor coordination across sectors.

As a result, research shows that regional institutional diversity is presently a barrier to transboundary cooperation in the Baltic Sea Region (BSR) and that actions to achieve national environmental targets can compromise environmental goals in the BSR (Powell et al. 2013). The regional dimension of environmental degradation in the BSR has historically received weaker recognition in policy development and implementation locally. However, developments in recent years suggest a new trend with growing investments in environmental protection supporting social, economic, and territorial cohesion.

The BSR is an environmentally, politically and economically significant region and like other regions globally, its rapid growth needs to be reconciled with the challenges of sustainable development in a global setting that demands unprecedented reductions in GHG emissions. This poses a truly wicked problem exacerbated by the fact that many of the challenges in the BSR will also magnify in a changing climate. In order to navigate the uncertainties and controversies associated with a transformation towards a good marine environment, BONUS RETURN will enact an innovative trans disciplinary approach for identifying and piloting systemic eco-technologies.

The focus is on eco-technologies that generate co-benefits within other interlinked sectors, and which can be adapted according to geophysical and institutional contexts. More specifically, emphasis is placed on eco-technologies that reconcile the reduction of present and future eutrophication in marine environments with the regional challenges of policy coherence, food security, energy security, and the provision of ecosystem services.

1.1 Project Objectives

The **overall** aim of BONUS RETURN is to improve the adaptation and adoption of eco-technologies in the Baltic Sea Region for maximum efficiency and increased co-benefits.

The **specific objectives** of the project can be divided into six categories presented below. These categories are interlinked but for the purpose of providing a step-wise description, the following overview of each category proves useful. BONUS RETURN is:

1) **Supporting innovation and market uptake of eco-technologies by:**
- Contributing to the application and adaptation of eco-technologies in the BSR through an evidence-based review (systematic map) of the developments within this field.

- Contributing to the development of emerging eco-technologies that have the capacity to turn nutrients and carbon into benefits (e.g. bio-energy, fertilizers), by providing an encompassing framework and platform for rigorous testing and analysis.
- Developing decision support systems for sustainable eco-technologies in the BSR.
- Contributing to better assessment of eco-technology efficiency via integrated and participatory modelling in three catchment areas in Finland, Sweden and Poland.
- Contributing to methodological innovation on application and adaptation of eco-technologies.

2) Reducing knowledge gaps on policy performance, enabling/constraining factors, and costs and benefits of eco-technologies by:

- Assessing the broader socio-cultural drivers linked to eco-technologies from a historical perspective.
- Identifying the main gaps in the policy environment constraining the implementation of emerging eco-technologies in the catchments around the Baltic Sea.
- Informing policy through science on what works where and under which conditions through an evidence-based review (systematic map and systematic reviews) of eco-technologies and the regional economic and institutional structures in which these technologies evolve.

3) Providing a framework for improved systematic stakeholder involvement by:

- Developing methods for improved stakeholder engagement in water management through participatory approaches in the case study areas in Sweden, Finland and Poland.
- Enacting a co-enquiry process with stakeholders into opportunities for innovations in eco-technologies capable of transforming nutrients and pollutants into benefits for multiple sectors at different scales.
- Bringing stakeholder values into eco-technology choices to demonstrate needs for adaptation to local contexts and ways for eco-technologies to efficiently contribute to local and regional developments.
- Disseminating results and facilitating the exchange of learning experiences, first within the three catchment areas, and secondly across a larger network of municipalities in the BSR.
- Establishing new cooperative networks at case study sites and empowering existing regional networks by providing information, co-organizing events and engaging in dialogues.

4) Supporting commercialization of eco-technologies by:

- Identifying market and institutional opportunities for eco-technologies that (may) contribute to resource recovery and reuse of nutrients, micro-pollutants and micro-plastics (e.g. renewable energy).
- Identifying potential constraints and opportunities for integration and implementation of eco-technologies using economical models.
- Facilitating the transfer of eco-technologies contributing to win-win solutions to multiple and interlinked challenges in the BSR.
- Linking producers of eco-technologies (small and medium enterprises – SMEs), to users (municipalities) by providing interactive platforms of knowledge exchange where both producers and users have access to BONUS RETURN's envisaged outputs, existing networks, and established methodologies and services.

5) Establishing a user-driven knowledge platform and improved technology-user interface by:

- Developing an open-access database that maps out existing research and implementation of eco-technologies in the BSR. This database will be intuitive, mapped out in an interactive geographical information system (GIS) platform, and easily managed so that practitioners, scientists and policy-makers can incorporate it in their practices.

- Developing methodologies that enact the scaling of a systemic mix of eco-technological interventions within the highly diverse contexts that make up the BSR and allows for a deeply interactive medium of knowledge.

1.2 Project Structure

BONUS RETURN is structured around six Work Packages that will be implemented in three river basins: The Vantaanjoki river basin in Finland, the Słupia river basin in Poland, and Fyrisån river basin in Sweden.

Work Package 1: Coordination, management, communication and dissemination.
Work Package 2: Integrated Evidence-based review of eco-technologies.
Work Package 3: Sustainability Analyses.
Work Package 4: Environmental Modelling.
Work Package 5: Implementation Support for Eco-technologies.
Work Package 6: Innovative Methods in Stakeholder Engagement.

1.1 Deliverable context and objective

The current deliverable (D 6.5) is part of WP (6). The objectives of WP () are to:
"serve as the platform to enable a co-enquiry process between stakeholders and the project. At the regional level the 40 municipalities connected to the Race for the Baltic will act as a sounding board to provide input to the EBR in WP2. Stakeholder platforms will be established at the case study sites to support the identification of eco-technologies for analysis in WP3, WP4 and WP5. These platforms will serve as opportunities to further test, develop, adapt and use the eco-technologies based on the assumption that their effectiveness depends on context, as defined by institutional, economic, social and bio-physical barriers and opportunities. WP6 will thus contribute to understanding historical drivers, policy instruments and governance structures and local needs with regards to implementation of the selected eco-technologies in the three case study sites. WP6 will be responsible for developing and facilitating an innovative game system, using the empirical materials generated throughout the project to support the co-learning environment and more specifically mediating the interactions and critical reflection between the WPs and between the project and stakeholders" (DoW BONUS RETURN).

This deliverable includes the unedited versions of the policy briefs in Poland, Finland and Sweden. The final versions as well as the translated versions will be available on the project's website in January 2020.

1.2 Outline of the report

The report is divided into the policy briefs from each of the cases in the following order: Poland, Finland and Sweden. Each brief has a different focus which has been selected based on consultations with key stakeholders in each case. Each brief has an introductory text, followed by a main text with several sections highlighting different aspects of the respective topics. The briefs conclude with recommendations.

Słupsk Bioenergy Cluster is creating a new paradigm for a Local-scale circular economy in renewable energy production and waste recycling in Poland

[INTRO TEXT]

Municipal officials and local business leaders in the Polish city of Słupsk aren't waiting for the benefits of the circular economy in renewable energy production and waste recycling to come to their corner of the Baltic Sea Region. They are making it happen now from the ground up and demonstrating how these transitions can be designed and operationalized at the city-county level.

In 2020, the "Słupsk Bioenergy Cluster" will reach a critical milestone when completion of a new energy distribution system will link 20 participating businesses and city facilities, 40,000 electricity users, and 120,000 wastewater customers, all part of an innovative renewable energy sharing and waste recycling system.

The Cluster is the brainchild of Słupsk Waterworks (Wodociągi Słupsk), the publicly-owned agency that operates the Słupsk Wastewater Treatment Plant (WWTP), and leverages the plant's 20-year track record of success in pollution reduction, sludge composting and reuse, and biogas energy production. This brief looks at how this innovative Cluster is serving as a living laboratory for small cities seeking to make the transition to a circular economy model founded in low cost, shared renewable energy production and waste recycling.

Building on a solid foundation - Słupsk Waterworks is one of Poland's top performers

Słupsk is located in northern Poland, near where the Słupia River drains into the Baltic Sea. The city population is approximately 90,000 and it serves as the administrative center for the surrounding county containing an equal number of additional residents.

The Słupsk WWTP is considered by many to be the reference WWTP in Poland. In addition to its core function of providing the highest standard of sewage treatment, it has been a leader in biogas generation as well as sludge composting and reuse for more than 20 years. A profitable byproduct is a successful brand 'BIOTOP' fertilizer, high in phosphorus, and certified for field application, thereby returning nutrients from wastewater to the same catchment providing an early example of a circular economy for wastes here.

The diversification of the plant's functions is part of the reason why Słupsk WWTP ranks as the third cheapest to run of Poland's 47 WWTPs that serve more than 75,000 inhabitants. This feature alone is an important factor in attracting and retaining businesses in the region.

Always striving to be more than a wastewater plant, Słupsk Waterworks thinks of itself as a regional hub for innovation in services and waste recycling that promotes economic development and environmental quality. They pursue an ambitious development vision which aims to achieve a "Zero Sewage" (pollutant removal, water recovery), "Zero Emissions" (GHG reduction), "Zero Waste" (resource recovery, organic recycling), and "Zero Wasted Energy" (energy efficiency, renewable energy cluster).

And it was this kind of leadership and proactive planning that led Słupsk Waterworks to take on its largest project to date – the development of the "Słupsk Bioenergy Cluster."

The Słupsk Bioenergy Cluster

In 2015, the City of Słupsk was having a hard time providing reliable power to major energy users. They also wanted to expand the development of renewable energy in the form of wind and solar photovoltaics – new sources of power that can be difficult to integrate into old transmission systems. Słupsk Waterworks stepped in to meet this challenge as its managers saw an opportunity to leverage the tremendous community asset they had created. The Słupsk WWTP was already making electricity and heat through the generation of biogas from its sludge residual, and saw the potential in generating much more. So, they called on businesses in the area, many of which were already producing their own solar and wind energy to join them in meeting the regional need.

At its core, the idea was simple: You give us your waste and we all make more power together. The Cluster would combine energy users with energy suppliers and have all of them send their wastewater (and even their biomass wastes such as lawn clippings) to the Słupsk WWTP. By joining forces, they set out to produce more reliable, renewable electricity and heat at low costs as well as recycle more local nutrients recaptured from the sewage sludge.

The Słupsk Bioenergy Cluster was officially formed in October 2017 with 19 founding members, both generators and users of energy, all of which were waste producers (see inset box). Słupsk Waterworks was established as the managing coordinator of the initiative as well as a contributing energy partner.

The scope of the Cluster is defined by its generation of electricity, heat and biofuels in both conventional and renewable energy installations. But its holistic approach also has them working on the distribution, balancing and storage of energy for members, waste recycling and local reuse, energy efficiency and renewable vehicle/transport system improvements across the Cluster, and research, marketing and education programs related to spreading their model to other regions.

While much has been accomplished, the fruits of the Cluster won't be fully realized until its distribution system linking all partners is completed in 2020. An early challenge identified by the partners was the need to build their own electric grid capable of handling renewables and to 'work around' the area's major established energy (primarily coal-based) suppliers who won't allow them to use their transmission lines. But as the aim of the cluster is not to put energy into the main system, but to supply the cluster members with renewable energy from a reliable source, the system was designed to be self-sufficient with regard to energy production and use.

What are the potential circular economy gains?

Słupsk Waterworks reports that there is currently a queue for joining the Cluster and there are already plans for opening the partnership to new entrants once the distribution network is built. The driver for businesses and customers is access to stable, renewable-sourced, cheaper energy. Słupsk

WWTP plays the unique role of merging sludge-generated Biogas (for returning into the Cluster system as heat) and sludge composting (with its resulting recycled phosphorus fertilizer product) into the primary energy scheme. It is a strong example of how whole-system thinking can lead to new opportunities to craft circular economy solutions.

The Słupsk Bioenergy Cluster provides a framework for overcoming many of the multidimensional barriers affecting new circular economy innovations. First, it is grounded in the capabilities of Słupsk Waterworks and their 20 years of technical experience at the WWTP. Second, it has worked hard to earn the support and financing of local and national government institutions as well as from the European Union thereby easing the transitions in policy and infrastructure investments needed for the Cluster concept to succeed. Lastly, the effort is highly coordinated between municipal officials and business partners in an open collaboration based on well-articulated goals and responsibilities. It is for all of these reasons and more that the Polish Ministry of Energy has twice now recognized the Cluster as a national model.

Recommendations for Further Action

The design of the Slupsk Bioenergy Cluster and its transition from idea to functional infrastructure exposes a number of policy and regulatory changes needed to advance similar decentralized, energy-waste reuse systems in the Baltic Sea Region.

- The locked-in position of large, traditional fossil-fuel based energy companies present serious challenges to the integration of distributed, renewable energy sources. The Słupsk Bioenergy Cluster has been required to construct a parallel energy distribution network for its partners. National policy changes are required to provide new local producers of renewable energy better access to the existing energy market.

- All levels of government can do more to stimulate cooperation platforms such as the Słupsk Bioenergy Cluster through incentives for development of local energy production from renewable sources. For example, encouraging the integration of waste recycling in the energy production system through enhanced tax system incentives would help guide the energy sector toward more circular economy solutions.

- Beyond the local level, faster and effective implementation of European Union regulations (i.e. "RED II" directive (2018/2001) "on the promotion of the use of energy from renewable sources") and initiatives (i.e. Clean Energy for all Europeans Package, so called "Winter Package") into national legal systems and their implementation would ease the scaling-up of models such as Słupsk Bioenergy Cluster. There is presently a gap between supportive, aspirational goals in EU policy and local innovation.

[3 Highlight Boxes]

Ministry of Energy Certificate Program designed to reward and encourage more energy and waste reuse clusters in Poland

The concept of energy clusters was first introduced in Poland in 2016 in new national legislation related to renewable energy development designed to bring Polish law into compliance with EU policy and regulations. Energy clusters aim to stimulate the development of environment-friendly decentralized energy systems that can improve local energy security and maximize economic development. To promote this concept, the Ministry of Energy has undertaken a program of energy cluster development with a national contest for effective energy clusters as a significant part of the program.

For the contest participants the benefits recognition by the Ministry are significant and include, (1) eligibility to participate in financing calls that are dedicated to the certified clusters only; and (2) recognition by the large traditional energy operators in Poland, who are often not eager to deal with small renewable-based entrants to their market. In turn, the Energy Ministry benefits through diversification of the country's energy sources, increases in the renewable energy share, and learning more about legal, administrative and practical barriers to the development of renewable energy solutions.

Of the 115 applicants in the first contest coordinated by the Ministry, Słupsk Bioenergy Cluster was one of only 10 awarded the highest Certificate of Distinction

Box with list of founding Slupsk Bioenergy Cluster partners:

Przetwórstwo Rybne ,,Łosoś" Sp. z o.o.; Łosoś, food production – canned fish

1. Pomorska Agencja Rozwoju Regionalnego S.A.; PARR; regional development agency
2. Scania Production Słupsk S.A.; Scania; car manufacturing – bus and coach production
3. Hydro-Naval Sp. z o.o.; Hydro-Naval; metal production - production of large metal constructions for oil and marine sectors
4. LEANN Stańczyk S.A.; LEANN, metal production - production of metal constructions and advanced metal processing
5. Wodociągi Słupsk Sp. z o.o.
6. Miejski Zakład Komunikacji Sp. z o.o.. MZK; transportation, Słupsk municipal transport company
7. Kamir Sp. z o.o.; Kamir, metal production - advanced metal processing
8. Urząd Miejski w Słupsku; City of Słupsk
9. Stako Sp. z o.o., Worthington Industries Group; Stako; low pressure welded steel and high pressure composite cylinders
10. Fiskars Polska Sp. z o.o.; Fiskars; metal production – tools
11. BALTIC WIND Sp. j. Marianna Mazur Marek Dawidowski; BALTIC WIND; wind farm operator
12. PAULA FISH Sławomir Gojdź Sp.j.; PAULA FISH; transport – international refrigerated transport
13. SABA Rejsy po morzu Marianna Mazur Marek Dawidowski S.C.; SABA; wind farm operator
14. VIKING ENERGY Sp. j. Marianna Mazur Marek Dawidowski; VIKING ENERGY; wind farm operator
15. Jantar Sp. z o.o. ZPZ Stolon; Jantar Stolon; food production – mashed potato production
16. ENGIE EC Słupsk Sp. z o.o.; ENGIE; energy production and distribution
17. M&S Okna i Drzwi Sp. z o.o.; M&S Okna i Drzwi; wood manufacturing – door and window production

BIOTOP Fertilizer

Since 2004, the Słupsk WWTP has produced a crop fertilizer from composted sludge at the facility (90% of the sludge is composted). The product is highly desired for its high nutrient content, particularly phosphorus at 3% (as P_2O_5). BIOTOP is used primarily by large agricultural businesses in Słupsk County, thereby returning a portion of wastewater generated in the area back into local food production in a closed loop.

The Polish Independent Center for Certification regularly tests BIOTOP for compliance with chemical standards similar to the REVAQ system used in Sweden. This helps ensure low heavy metal concentrations in the resulting fertilizer, but is not without concern. Many countries are looking to ban all wastewater sludge reuse on farmlands due to concerns about emerging contaminants such as pharmaceuticals and microplastics, which may cause Słupsk Waterworks to have to innovate and adapt again to meet new pollution reduction goals.

GRAPHICS TO INCLUDE:

- Flow Chart: "Circular Economy in City of Słupsk – Concept of Biorefinery Słupsk"
- Aerial photo of Słupsk Waterworks facility (?)
- Map of Słupsk showing all SBC partners

3 POLICY BRIEF FINLAND

The Role of Gypsum Soil Amendments in Reducing Phosphorus Mining and Coastal Nutrient Loads in Finland

[INTRO TEXT]

Phosphorus (P) loading in the form of runoff from agriculture fields in southern Finland is the largest threat to water quality and marine living resources in this area of the Baltic Sea. Decades of attempts to control P losses through traditional farming methods have proven inadequate, but a new opportunity has emerged. The use of gypsum as a soil amendment on agricultural fields not only reduces runoff pollution by 50%, but simultaneously reuses an industrial waste product and reduces demand for virgin mined phosphorus.

The practice is currently the subject of extensive piloting and research in Finland to document its effectiveness and identify any negative side effects. The large-scale application of gypsum to coastal drainage areas in Finland, Sweden, Denmark and Poland has been modelled to generate approximately 10% of all needed phosphorus reductions called for in the HELCOM Baltic Sea Action Plan. This Policy Brief summarizes the state of assessment of this farming technique and next steps for its acceptance.

[MAIN TEXT]

Norwegian-based chemical company Yara International had a problem at its mine in Siilinjärvi in central Finland. Large quantities of gypsum (calcium sulfate dehydrate) were piling up – a waste byproduct of the company's extraction of phosphorus fertilizer from apatite rock. Globally, the availability of this virgin and low-cadmium phosphate in Finland is a rare economic asset as most phosphate mining occurs outside of Europe, primarily in geopolitically sensitive regions, and most of the mined phosphate is high in cadmium. This creates both a product scarcity and security risk with the world's current reliance on mined phosphorus fertilizers.

At the same time, phosphorus losses in the form of runoff from agricultural fields in southwestern Finland are also a major problem for the Finnish government which has pledged its commitment to reduce pollution and restore water quality in the Baltic Sea. Together, Yara's need to dispose of its gypsum waste coupled with a government policy priority to reduce phosphorus pollution has encouraged Finnish innovation with potential application to coastal areas not only along the Baltic Sea region, but around the world.

Solving agricultural runoff of phosphorus is key to restoring the Baltic Sea in Finland

Runoff losses of phosphorus from agricultural fields are considered by HELCOM (Baltic Marine Environment *Protection Commission)* to be one of the major sources of nutrient load to the Archipelago Sea and Gulf of Finland. Traditional Best Management Practices such as buffer strips, constructed treatment wetlands and fertilizer use reduction regimes, as well as environment-friendly cultivation practices have proven insufficient to restore water quality.

The problem is serious, but not unique to Finnish waterways. Throughout the Baltic Sea catchments, efforts to reduce nutrient pollution from agriculture fall far behind more successful responses in areas such as wastewater treatment. Both magnitudes and targeting of the traditional mitigation measures have been insufficient and at times inadequate. Another part of the problem lies with the difficulty in adopting new ecotechnologies and practices, particularly those focused on circular solutions designed to reduce, recover, reuse, and recycle nutrients. The relatively low cost of phosphate rock-based fertilizer, farmer reluctance to chance new practices, decreased social acceptability towards the use of sewage sludge in croplands, and entrenched government policies, all play a role in suppressing ecotechnology advancement in agriculture.

How is it progressing? Gypsum application can support the transition to a circular economy for phosphorus

Yara International's waste byproduct challenge spawned the need to find an economically viable reuse option for its gypsum. When applied to farm fields, gypsum acts to improve soil structure which in turn enhances phosphorus binding to soil and reduced leaching, leaving phosphorus fertilizer available to growing plants and keeping it out of waterways. Application methods are simple and utilize traditional farming equipment and farmer acceptance of the practice has been high.

Two large, independent pilot and research projects have been undertaken in Finland to assess the effectiveness and impact of gypsum application. Between 2016–2018, Project SAVE, a joint research project of the University of Helsinki the Finnish Environment Institute (SYKE), *worked with 55 farmers to apply and monitor gypsum usage on 1,500 hectares in the Savijoki River Basin. SAVE was part of the Finnish government's "circular economy key project" initiative and was funded by the Ministry of the Environment. Results from the project show that apart from improving soil structures, gypsum also* reduces erosion and phosphorus losses by approximately one-half to nearby waterways. On top of that, *it is easily applicable.*

The positive results of SAVE have encouraged more wide-scale pilot projects and assessment. A 3,500 hectare gypsum application effort is now underway in the River Vantaanjoki basin from 2018–2020 managed and funded by the John Nurminen Foundation, the Water Protection Association of the Vantaa River and Helsinki Region (VHVSY), the University of Helsinki and SYKE. The gypsum for this large project is being provided by Yara and field application is carried out by the local farmers. Funding is again being provided by the Finnish government and interest in the success of the practice has made it to the highest levels of policy consideration within the government.

Are there environmental and economic downsides?

From an environmental perspective, researchers in the SAVE and John Nurminen Foundation pilots have focused on assessing the potential negative impacts of sulfate loading. Approximately 18% of gypsum is comprised of sulfur and its application to fields poses the threat of excess sulfate loading to lakes and groundwater.

Sulfate is relatively abundant in seawater, so it is less a risk in the coastal drainage areas. In freshwater lakes, however, water with leached sulfate can increase phosphorus release from bottom

sediments, thereby exacerbating eutrophication. As a precaution, Finnish researchers are not recommending gypsum application in lake drainage basins. They are also applying the same precautionary principle to groundwater recharge areas. Studies are not showing this to be a major concern to date, but it remains an area of active research.

Beyond the known sulfate question, further research is also needed to evaluate the long-term effects of intensive gypsum applications, which are yet unknown. Some scientists see this practice as a rapid help for the acute excessive P runoff problem. This is not to replace a more sustainable, long-term reduction in soil P by decreasing the use of P fertilizer wherever it is agronomically feasible. For this, various ecotechnologies dealing with reducing, recovering and recycling carbon and nutrients are being developed and supported (see e.g. https://mmm.fi/en/recyclenutrients). Some of these ecotechnologies are being scrutinized, tested and simulated in the BONUS RETURN project https://www.bonusreturn.eu/ through systematic literature reviews, watershed modeling, serious game systems and testbeds.

Lastly, from an economic policy perspective, care needs to be taken not to have the excitement being generated by the early success of gypsum application lead to policy 'lock-in" where different technologies and approaches are hampered by a singular national focus on gypsum. This phenomenon is considered to be a major factor limiting the acceptance and implementation of single ecotechnologies.

The potential for large-scale application and impact

Project SAVE considers the practice of gypsum soil amendment to be applicable to ~540,000 hectares of farmland in the coastal river basins flowing to the Archipelago Sea, representing about ¼ of Finland's arable lands. Such a wide-scale application could reduce phosphorus loads to the Baltic Sea by 300 tonnes per year. Furthermore, if the same practice was applied in coastal catchments in Sweden, Denmark and Poland, a total annual reduction of 1,500–2,000 tonnes could be achieved. That's an astonishing 10% of all the P load reduction recommended by the HELCOM Baltic Sea Action Plan in one management effort.

In general, waste-derived nutrient products have had a difficult time competing in the market with traditional fertilizers. Gypsum application appears to have the potential to buck this trend by reducing the need for P extraction and solving a waste reuse challenge for Yara. Slowing the demand for P mining in Finland through gypsum application is in Europe's economic and security interests as it reduces reliance on imports from geopolitically sensitive regions.

Recommendations for further action

BONUS RETURN explored ecotechnologies to reduce, recycle and re-use the biomaterials of wastewater and agriculture. During the course of the project, gypsum emerged as a solution to address Baltic Sea eutrophication problem in the Finnish case study of Vantaanjoki. In collaboration with SAVE, this brief highlights the potential for upscaling gypsum in the Baltic Sea Region as a promising component of Baltic Sea protection actions.

Project SAVE, the River Vantaanjoki project, and NutriTrade, a project of the European Union's Interreg Central Baltic Programme, have recently offered the following policy recommendations for further action to assess and encourage implementation of gypsum soil amendment across the Baltic region:

- Development of a national plan to implement the use of gypsum in the coastal areas of Southern Finland and to include gypsum in the country's agricultural support scheme.
- Inclusion of the costs of gypsum amendment as recoverable by farmers through government agricultural subsidies.
- Amendment of the EU Common Agricultural Policy (CAP) and HELCOM recommendations to promote gypsum application in the Baltic Sea catchments. The currently scheduled CAP reform for 2021 is a particularly important opportunity.
- Direct research on the economic, environmental and societal benefits of gypsum should be undertaken in countries outside of Finland.

GRAPHICS TO INCLUDE:
Map of Assessment of Feasible Area for Gypsum Treatment in Finland, Source: SYKE. Juha Riihimaki
Cover photo of gypsum being applied to farm fields. Source: Project SAVE or John Nurminen Fndn.

4 POLICY BRIEF SWEDEN

How will Swedish municipalities transition to a ban on spreading sewage sludge on croplands while still achieving high levels of phosphorus recycling?

[INTRO TEXT]

In 2018, the Swedish Government announced the launch of an inquiry into how to implement a ban on the decades-long practice of spreading sewage sludge on farmland combined with a nutrient recycling requirement. Sewage sludge contains significant amounts of phosphorus, a vital plant nutrient and scarce raw mineral. The move was portrayed as a means to both reduce the environmental and food safety risks of direct sludge application and to accelerate the transition to a complete circular economy for phosphorus.

Despite such laudable goals, the transition from concept to reality will not be cheap or swift for Swedish municipalities. About one-third of all sludge in Sweden is spread on farmland which makes it the most common form sewage sludge management in Sweden. In addition, it is a practice that is still expanding with growth of 36% between 2014-2016 alone. Cities like Uppsala have invested heavily in making their sludge quality acceptable for farmland use and those investments will be unrealized. Having considered themselves leaders in solving problems with sewage sludge, Uppsala is now being asked to innovate again.

This brief looks at the major impact that clear national policy directives can have on speeding up the transition to a circular economy, but also how those directives affect municipal infrastructure and planning.

[MAIN TEXT]

The changing opportunities and challenges with sludge

The debate over the use of human waste in farming is as old as agriculture itself with different cultures arriving at different and changing practices over time. This is true even between countries within Europe. For decades since the post-WWII establishment of widespread centralized wastewater treatment, Sweden had a policy of encouraging sludge reuse but it has not been without significant ongoing debate.

Beginning in the early 1980s and continuing through the 1990s, concerns began to grow around high concentrations of residual heavy metals such as copper and cadmium and organic micropollutants such as flame retardants in sewage sludge. The Swedish Farmers Association (LRF) began urging their members not to use sludge on their fields. The response was a sludge certification program called REVAQ (https://www.svensktvatten.se/vattentjanster/avlopp-och-miljo/kretslopp-och-uppstromsarbete/revaq-certifiering/), which was launched in 2008 to provide guarantees about the safety of sludge for farmers and the public. REVAQ has been considered a success and has encouraged the continued expansion of sludge reuse.

However, recently concerns about other pollutants have initiated a discussion as to whether the Revaq system is sufficient to ensure that sewage sludge is safe to use for fertilizer in crop cultivation. In particular, these concerns are focused on pharmaceuticals and microplastics in the wastewater and how they could affect the environment if they end up in the sludge.
It seems that with sludge, new problems emerge just as the previous ones appear to have been addressed. The 2018 Swedish Sludge Ban Inquiry is again a response to this trend, but one that seeks to end the debate by requiring a new technological means to end direct sludge application to farmland once and for all.

Uppsala's sludge treatment "success"

Few Swedish cities have been more responsive to the challenges and national debate over sludge application than Uppsala. A city of 200,000 people, Uppsala more than doubled in population between 1950-75 after its first wastewater treatment plant (WWTP) was built in 1945. This growth forced the city into a constant infrastructure program to both expand and improve its water treatment capacity. Uppsala rose to the challenge by developing a proactive approach and became a thought-leading municipality.

As early as the late 1970s, they pioneered and then shelved a sludge-derived fertilizer for retail sale. The early 1990s saw the investment in a system that enables the use of biogas produced from sludge as fuel for the city's public buses. After for quite some time having done 'upstream' work with individual households and local businesses to improve the quality of wastes coming into the WWTP, Uppsala became an entrant into the REVAQ certification program in 2013. The shift in focus on the quality of the influent the plant received, not the pollution that they ultimately discharged as effluent has contributed to the expanding acceptance of sludge application to farmland and producing secondary benefits of forcing dischargers to reduce their own pollution. These changes involved extensive regulatory programs and compliance monitoring as well as financial investments for the city and discharging businesses.

National policy transition

Just as Uppsala appears to have figured out how to permit, monitor and finance a system that makes large amounts of sludge available for farmland application, the Swedish government is now driving forward with national policy changes that might ban those systems.

In 2018 Sweden announced that it was launching an inquiry into the banning of sludge application on fields combined with a phosphorus recycling requirement.
Driven first by the realization that the country cannot ensure that sludge application to farmland does not come with hazardous chemical risks, the rationale behind the government's decision is also rooted in support for a circular economy for phosphorus. Incineration of sludge can solve the disposal problem, but to date has resulted in the loss of valuable phosphorus and other useful organic matter and trace nutrients. With new technology developments in this area, at last a high-grade phosphorus can now be recovered from the ashes. According to companies developing these technologies, the end result is a safe, non-toxic P fertilizer product that can be distributed broadly and expand the use of sludge-recycled P.

What's next for Uppsala and other Swedish cities?

The Swedish EPA hosted information-sharing and development workshops in April and July of 2019 aimed at defining the path forward for the sludge ban/P-recycling policy. A date for the release of legislation confirming the policy has not been announced.

Once established, the transition in Sweden to a system of sludge incineration with phosphorus recovery will take many years to implement. Germany projects that compliance with its recent similar move will take 12 years to implement, although incineration is already the most common form of sludge treatment in Germany which means that some of the infrastructure needed is already in place. Furthermore, participants in Sweden's ongoing consultative process reached consensus in April that this circular economy transition can only happen with increases in public funding, mostly likely through sewer user rate hikes.

For Uppsala and other cities, beyond the cost, the greatest challenge may lie in transitioning to a new sludge treatment system while not losing the proven pollution-reduction benefits generated by Revaq. Furthermore, circular phosphorus flows in a system based on sludge incineration will necessitate a high degree of coordination and communication across what is arguably a more complicated value chain that adds incineration, chemical pre-processing and fertilizer production as intermediate steps between WWTP and farm.

Recommendations for Further Action

Sweden's current effort to develop a new national policy directive around the reuse of wastewater sludge on cropland has the potential to speed up the transition to a circular economy for phosphorus. How the government implements such a change should consider the benefits of the existing management regime around sludge and actively engage municipal officials in the planning. The following policy recommendations are offered as a guide for the post-directive discussion between national and local scale officials.

- Do not throw out the REVAQ baby out with the bathwater. Uppsala and other municipal operators have proven the value of the current sludge certification program to reducing inputs of pollutants to wastewater treatment plans. It is crucial that a transition to 'end of pipe' sludge incineration not become an excuse for complacency in the important upstream work of cutting pollutant loads at their source.
- Remember that sludge is not sludge. Wastewater sludge can have different qualities pertaining to composition and potential contamination depending on the inputs and treatment processes used by the WWTP. This needs to be considered in policies developed around incineration processes and resulting fertilizer products.

- Broaden the perspective from phosphorus. Notably, the organic matter content in sludge is valuable as soil improvement, but this is obviously lost through incineration. Policy recommendations should leave space for technology options to develop that utilize the full range of societal value contained in sludge.

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Transition time in transportation as well?

This time of transition for Uppsala in the context of Swedish sludge treatment policies happens in parallel with technological shifts in the context of global technology trends. In the late 1990s in an effort to reduce the city's reliance on fossil fuels, the city's buses started running on biogas from sludge and food waste. The program was considered a great success and proudly advertised as an urban waste-to-energy solution.

Now, an important question moving forward is how this system that performs excellently in terms of life cycle greenhouse gas (GHG) emissions and circular resource utilization will be affected by ongoing trends in transport electrification. Uppsala – along with many other cities globally are looking to in coming years increasingly deploy battery electric buses, that – if powered by low carbon energy – not only can entail very low GHG emissions, but also have other important advantages when it comes to reduction of noise and local air pollution. At the same time, it is uncertain whether the local electricity grid in Uppsala currently can accommodate fast charging of a large fleet of electric buses. In other words, at least in a transition period, biogas-run buses will continue to play a key role in providing low-carbon public transport.

In conclusion, the path to a sustainable economy is rarely straight and often requires interim steps that include significant sunk capital costs along the way. Introduced at a point in time when electrified buses were not an option, the biogas-fueled buses in Uppsala were a massive improvement over diesel. In decades to come, policy makers may similarly praise Uppsala and other cities for their efforts to develop a safer sludge for farmland application as a necessary step on the way to incineration recycled contaminant-free phosphorus fertilizer.

GRAPHICS TBD

5 REFERENCES

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