From Wastewater Treatment Plants to Resource Plants

The transition to a circular economy is crucial in building a sustainable society. Today, almost half of our climate impact and 90 percent of water scarcity issues are linked to the way we extract resources and produce goods and food.

In this context, nutrients such as phosphorus and nitrogen are key. Without them, global agricultural output would be cut in half. Wastewater from households and industries contain massive amounts of both phosphorus and nitrogen, but today, this is a problem rather than an asset. Wastewater treatment plants put great effort into discarding sludge even though this sludge is rich in phosphorus, and nitrogen is released from the plants as nitrous oxide (N20) which has a huge climate effect.

With a different approach, the opportunities are enormous. Phosphorus, listed by the EU as a critical raw material, can be recovered from the sludge and brought back into the loop, securing an endless supply. Nitrogen can be captured from wastewater streams and used to produce fertilizer, replacing today's greenhouse gas-heavy production.

This way, the wastewater treatment plants of today will be the resource plants of tomorrow. This scenario is well within reach. However, it requires key alterations in national and international legislation and regulation. **Please read on** to see our suggested solutions that enable lawmakers and public utility companies to address several problems at once and build a sustainable future.

Proposals in short

- Governments should change the stated purpose of urban wastewater treatment plants, making the enabling of increased circularity a main objective.
- Governments should task a national authority with coordinating control at source of hazardous substances and providing a central function for know-how and active support on issues around wastewater and resources.
- Governments should, at the appropriate level, strive to introduce legislation on quota obligations for commercial fertilizer, requiring an increasing percentage of phosphorus and nitrogen in the products to be of secondary origin.
- Governments should introduce legislation on milestone targets for the recycling of phosphorus and nitrogen from wastewater for agricultural purposes.

- Governments should strive to introduce legislation on requirements for the assessment and limitation of nitrous oxide (N20) emissions from wastewater treatment plants.
- Governments should allocate funds for full-scale pilot facilities for extracting nitrogen from wastewater with the explicit purpose of producing raw material for fertilizer production.
- Governments should strive to increase incentives for a transition to circular handling of key resources, specifically by ensuring that the quality of the product should always be the key regulatory factor and not its origin.

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1. Resource flows

In modern society, few flows can compare to the volumes of the water and wastewater sector. Using Sweden as an example, the average Swede uses between 120 and 140 kg of water every day, and that contributes to a flow of 300 kg of wastewater. At the same time, wastewater contains a number of valuable resources; materials which can be captured and put to use in an increasingly circular economy, paving the way for a sustainable society.

Companies and organisations in the water and wastewater sector can contribute to society in several ways above and beyond those which are regulated, encouraged or even possible today. Unlocking this potential means changing the conditions and purposes under which the industry operates. These changes affect the way the industry can direct its efforts towards increasing circularity, through modernised legislation and regulation, innovative systems, processes, and organisations.

Wastewater and sewage sludge are largely untapped resources today. Traditionally, they are regarded as problematic waste. Hence, the usual purpose of wastewater treatment plants is reduced to handling this perceived problem by simply purifying the water, from a limited waste perspective.

The introduction of circular principles leads instead to substantial potential for reducing climate gas emissions by bringing resources back into the loop. Lawmakers and business leaders around the globe can seize this opportunity and turn wastewater treatment plants into resource plants, creating climate benefits as well as jobs, tax revenue and wealth.

Proposal: *Governments should change the stated purpose of urban wastewater treatment plants, making the enabling of increased circularity the number one objective.*

2. Control at source of hazardous chemical substances - upstream efforts

Our future society is built on sustainable resource flows and our collective ability to use these resources effectively. Wastewater treatment with a circular focus enables reuse, recovery and circulation. Transforming treatment plants into resource plants turns waste into value.

For this to succeed, hazardous or otherwise undesirable substances need to be phased out upstream to the largest possible extent. Many countries do this with some measure of success. However, stepping up these efforts would substantially increase our ability to put the resources that flow through wastewater treatment plants to use again. The increasing scarcity of clean water highlights the need to make use of every drop.

The quality of what flows into the treatment plants also determines the degree to which the resulting sludge can be used directly as fertilizer in agriculture. Sweden, with its uniquely ambitious upstream certification named “Revaq”, still only uses one-third of its sludge in the

fields, while the rest is wasted; all too often as construction material in infrastructure projects for which there is really no need. Regulatory pressure on the quality of the sludge will only increase as we take necessary action to rid our loops of hazardous substances such as PFAS.

Modern society's obvious need for high-quality upstream efforts puts it squarely in the realm of common responsibility: Authorities, industry, and retail all need to do their part, as well as individual consumers. Today, the phasing out of harmful chemicals from industries, and to an even larger extent from consumer products, is too slow. This has created a situation where wastewater treatment companies have had to assume the lion's share of the responsibility upstream.

Asking wastewater treatment plants, at the very end of the chain in today's system, to compensate for the lack of responsibility of every actor further up is neither sustainable nor reasonable.

However, to elevate the quality of efforts upstream, many parts of society need support in acting and building competence.

Proposal: *Governments should task a national authority with coordinating control at source of hazardous substances and providing a central function for know-how and active support on issues around wastewater and resources.*

3. Secure recirculation of phosphorus and nitrogen

Without the nutrients phosphorus and nitrogen, farmers would not be able to grow the amount of food we need. Despite this, Europe and many other regions and countries around the world depend on imports, while wasting phosphorus and nitrogen that we already have.

In our cities, we have enormous amounts of phosphorus and nitrogen literally beneath our feet: in the sewage systems. But instead of putting it to use, we waste the vast majority, for example by covering discontinued landfill areas with it.

When nitrogen is removed from wastewater using today's biological methods, it is simply released back into the atmosphere, mostly as N2. At the same time, new nitrogen compounds for fertilizer are produced by capturing nitrogen, N2, from the air, using a process invented more than 100 years ago which leads to substantial carbon emissions.

New technology makes it possible to extract very pure phosphorus from sludge of poor quality instead of letting it go to waste. Other innovations have given treatment plants easy ways to recover the nitrogen from wastewater in solid form, which can be used immediately in the production of fertilizer. This process leads to a powerful reduction of greenhouse gas emissions, both at the plant and as production of nitrogen compounds for fertilizer is replaced by raw material straight from wastewater.

When this happens, the wastewater plant has become a resource plant, supplying markets with commercially viable materials while substantially lowering carbon emissions.

Countries that make this transition also become more resilient, as their dependence on imports is gradually replaced by recycled nutrients from their own wastewater. What was once a problem has been turned into a huge opportunity.

However, the low costs of production using new materials is a tangible obstacle to such a transition, as it tilts the playing field to the disadvantage of innovations that do not mitigate climate change. For this reason, politicians must act to usher in functional markets for recycled nutrients, increase demand, and ensure incentives for businesses and treatment plants to invest in new green technology.

Proposals: *Governments should, at the appropriate level, strive to introduce legislation on quota obligations for commercial fertilizer, requiring an increasing percentage of phosphorus and nitrogen in the products to be of secondary origin.*

Governments should introduce legislation on milestone targets for the recycling of phosphorus and nitrogen from wastewater for agricultural purposes.

4. Nitrous oxide: The number one climate challenge for wastewater treatment plants

The single largest climate impact of today's wastewater treatment plants is linked to the removal of nitrogen by biological methods. In addition to being vulnerable to several factors for functionality, biological nitrogen removal leads to large emissions of nitrous oxide, N2O, a powerful greenhouse gas also known – and used – as laughing gas.

Its effects on climate change is around 300 times as potent as carbon dioxide, making it one of the most important greenhouse gases. According to research published by the Intergovernmental Panel on Climate Change (IPCC) in 2020, global emissions of nitrous oxide are in fact higher than even the most pessimistic climate scenarios.

Several Scandinavian studies from 2020 show that nitrous oxide emissions from individual wastewater treatment facilities may be 10 times higher than previous calculations have indicated. Additionally, increasingly tougher regulation on the share of nitrogen which must be removed from the wastewater in order to curb eutrophication will lead to even more emissions of laughing gas unless new methods are introduced.

This puts pressure on governments to act, as they have to make sure that the treatment of wastewater does counteract efforts towards other obligations, such as maintaining healthy marine environments and contributing to lower carbon emissions. The challenge can be addressed by making new use of the nitrogen in wastewater. Countries which are early in implementing modern chemical methods for nitrogen removal will benefit from increased control over emissions as well as establishing a circular industry and replacing imported nitrogen fertilizer compounds with local production.

Research into large-scale solutions is being conducted in several countries. One example is the collaboration between innovation company EasyMining, a subsidiary of the Ragn-Sells Group, and the municipal wastewater treatment company of Danish capital Copenhagen. The method

causes nitrogen compounds to crystallise and precipitate, making it suitable for fertilizer production, while cutting nitrous gas emissions to zero. An adjacent facility turns the raw material into commercial fertilizer. This chemical method can replace biological treatment at a lower operating cost thanks to the decreased need for energy and making sure that the nitrogen is circulated instead of released.

Proposals: *Governments should strive to introduce legislation on requirements for the assessment and limitation of nitrous oxide, N2O, from wastewater treatment plants.*

Governments should allocate funds for full-scale pilot facilities for extracting nitrogen from wastewater with the explicit purpose of producing raw material for fertilizer production.

5. Quality above origin: Securing critical resources

The European Union lists phosphorus as a critical raw material. The list, updated in 2020, now comprises 30 raw materials considered highly important to the EU economy combined with a high risk associated with their supply. Securing recirculation of our existing phosphorus is therefore of particular importance.

However, EU regulation still prohibits the sale of nutrients recovered from waste for conventional and organic farming as well as animal feed. To unlock the potential for circulating nutrients, this regulation needs to be updated to reflect a pivotal principle: The quality of a product should be the deciding factor in regulating its sale and use, as opposed to its origin. This way, our economic system would no longer tip the scales in favour of extracting virginal resources, paving the way for a sustainable, circular economy.

Proposal: *Governments should strive to increase incentives for a transition to circular handling of key resources, specifically by ensuring that the quality of the product is the key regulatory factor as opposed to its origin.*