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Expanding the agricultural - sanitation circular economy: opportunities and benefits

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An expanded circular economy between agriculture and sanitation waste (sewage) can recycle essential resources for agriculture through the recovery of water, biomass, and nutrients from sewage at scale. Doing so can help to increase or maintain soil productivity and support agricultural outputs; produce heat and power; reduce Green House Gas (GHG) emissions; and minimise stresses on water reserves.

Technical experts from the UK, China and USA working on water, sanitation and agriculture systems convened an international UN Food System Summit Dialogue on 12 May 2021. The workshop identified the opportunities and risks for rapid implementation of resource recovery from public sewage systems. Technologies are available for rapid scale-up to recover carbon (C), nitrogen (N), phosphorus (P), water and energy, addressing multiple UN policy objectives.

The policy benefits of large scale resource recovery from a circular economy between agriculture and sanitation include climate change mitigation (UN Sustainable Development Goal (SDG) 13) and adaptation (SDG 12), reversing land degradation (SDG 15), maintaining food production (SDG 2 and 12), improving rural livelihoods (SDG 10), water resources protection (SDG 6), and improved urban sanitation (SDG 6) and public health (SDG 11). The benefits also apply to the UN conventions on Climate Change, Combatting Desertification, Biodiversity, and the UN Protocol in Water and Health.

Preliminary estimates of the potential benefits include up to a theoretical maximum of 12% reduction in anthropogenic greenhouse gas emissions from global mineral fertiliser production and use. Resource recovery could provide up to 12% of the annual maximum for C sequestration in global agricultural soils. These benefits occur through full recovery of N, C and P resources from the 104 Mt C y^{-1} dry weight of global sewage produced each year. Sanitary wastewater estimated at 7769 km^3/y has the potential to alleviate substantially some of the agricultural water demand of 2784 km^3/y on clean water resources.

Sustainable agricultural solutions to meeting global agricultural demands

Modern farming practices depend on large inputs of fossil fuel energy for cultivation, freshwater irrigation and mineral N and P fertiliser production. The UN FAO report in 2015 on **Status of the World's Soil Resources** notes estimated losses of soil organic matter of 25-30% in temperate regions and higher in the tropics from land conversion and tillage for agriculture. At the same time, technology exists to transform urban sanitation systems and rapidly scale-up the recovery of energy, water, N, P, and C from sewage to support more sustainable agricultural practices. This has the potential to improve soil fertility for food security, reduce energy-intensive mineral fertiliser production and dependency on fertiliser imports, sequester C and N, and to achieve negative GHG emissions.

Risks and implementation challenges for sanitation resource recovery

The composition of sewage depends on urban and industrial development – often resulting in the presence of hazardous chemicals and pathogens in wastewaters and sludges. This creates a challenge for the safe reuse of sewage. Risks include, for example, metals, e-tech elements and pharmaceuticals that may bio accumulate or contribute to antimicrobial resistance in the environment, along with pervasive and persistent pathogens. In general, these risks can be mitigated either by adequate treatment or by exclusion from the sewage system. Quantification is needed to improve understanding of these risks, enabling us to derive permissible levels of application, appropriate forms of treatment, and other mitigation measures, to ensure that agricultural demands can be met in a safe and sustainable manner.

Whilst logistical issues of transporting recovered resources originating from sewage to farms pose some challenges, the costs of operating sanitation systems designed for a circular economy could be at least partially offset by the value of the resources captured - as already practiced for energy recovery from wastewater treatment processes in many countries including China, USA and UK.

Recommendations

A circular economy between agriculture and urban sanitation systems has the potential to help ensure future global food security whilst offering additional benefits such as climate change mitigation. To support such a transformational shift in the utilisation of sewage as a resource, this requires:

- Co-production of sanitation development pathways for acceptable resource reuse with relevant stakeholders (public, farmers, sanitation engineers and regulators) to encourage users to be local problem solvers;
- Mitigation strategies for the risks identified especially application of recovered resources to agricultural land - these will vary by region, the source of the sewage, and the technologies currently deployed;
- Long-term over-arching governance and regulation designed to support the circular economy;
- Transportation and infrastructural challenges to be addressed to ensure the safe movement of recovered resources from sewage to farms;
- Research groups and industry to work together in partnership with regulators to collaborate and address the identified risks and opportunities, supported by appropriate funding.

Moreover, a multi-disciplinary understanding of the proposed transition to circularity is required to achieve a 'just' transition to a sustainable agricultural food system for all. This will require focussed research effort and engagement with stakeholders to help plan for and underpin the transition. The resulting new knowledge needs to be made available and accessible for use by all interested parties, whilst acknowledging the country- and regional specific challenges that exist.

Further information

This policy brief follows a UN Food System Summit Dialogue held on the same subject. Full details can be found in the dialogue report **'Is a Circular Economy approach a 'risk free' means of meeting future global food demand in a sustainable manner?'**

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