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Image Source: Wikimedia Commons. March 26, 2015. Riga fertilizer terminal (Latvia). Photo Credit: Kārlis Dambrāns. https://commons.wikimedia.org/wiki/File:Riga_fertilizer_terminal.jpg

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Urban biocycles – connecting built and natural environments with people

More than half of the world's population now lives in urban areas. While trying to solve the world's environmental challenges, it is also important to focus on cities. Cities rely on extensive imports of water, food, energy, and materials that come not only from regional and rural areas, but from around the world. Cities follow a linear metabolism and function largely like an organism, taking in high-value resources and releasing low-value waste. If we draw a parallel with a biological organism, where different inputs boost metabolism and the output is input to another organism, in ecology this process is called syntrophism, meaning that the well-being of an organism depends on growth factors and cross-feeding. In cities, resource recovery and reuse are low, and increasing consumption leads to more pressure on resources and subsequently pollution, deforestation, and loss of land and biodiversity. As a result, today's cities are not sustainable, even though knowledge and technology exist to transform cities into more sustainable areas. One major obstacle is the institutional framework inherited from an earlier era, which often acts as a barrier to the necessary changes and, at best, provides minimal support for them.

A circular urban metabolism is a key to the future development of sustainable cities. In terms of environmental sustainability, resources should be circulated within the smallest possible geographical area.[1] At the same time, this model can be enhanced by expanding and strengthening the connection with rural areas (i.e. resource providers), creating a larger cycle to benefit both sides. It is recognized that urban agriculture and greening of the cities (e.g., gardens, parks, green walls and roofs) enhance well-being and food security while creating opportunities for the effective use of

biological resources and closing their loops within cities.[2] For example, the highly industrialized city of Kitakyushu in Japan is aiming to establish a so-called SDGs social farm within the city boundaries.[3] At the social farm, food waste will be composted and reused to grow crops using technologies that keep resource efficiency at the highest levels. Workers in charge of the cultivation are people with disabilities and the elderly. They also invite the younger generation to get involved in agriculture to break the widespread perception that farming is a low-status profession. Their concept recognizes that the circular economy is not only about resources and materials but also about people!

Nutrient recovery from excreta (i.e. urine and feces) is another example of a biocycle that can be easily applied in local circulation. Excreta accounts for only 1% of the volume of wastewater from households, yet it contributes to the majority of pathogens, as well as 90% of nitrogen, 80-90% of phosphorus, and about 50% of organic matter.[4,5] While these constituents are the main substances of concern in terms of disease outbreak [6] and water pollution from wastewater, they are also an important source of nutrients for agriculture. The most logical way to recover nutrients from wastewater streams is to capture excreta from the rest of the wastewater. Separate excreta collection can be done in cities and require low flush toilets (i.e., vacuum toilets). This concept is new at the urban scale and thus not yet widespread, largely due to the traditional centralized wastewater infrastructure and corresponding institutional framework. In centralized systems, nutrients from excreta are diluted with other wastewater streams, complicating recovery and reinforcing the linear trend.

The EU-project SiEUGreen (www.sieugreen.eu) demonstrates how excreta and organic household waste can be converted into biogas, liquid and solid fertilizer, or biochar for urban agriculture. Cities are nutrient hotspots for agriculture and offer opportunities for new cycles. Following the syntrophic principle from nature, waste or energy from a city can ideally provide resource input for agriculture in the surrounding rural area where food for the city is produced. Thus, the future circular cities can become hubs in a green economy and produce nutrients for both urban and ex-urban agriculture. At the same time, water pollution can be nearly eliminated, greenhouse gas emissions reduced (e.g. through biogas production) and carbon sequestered in biochar. However, in researching and putting into practice the organic and inorganic the circulation of materials in cities, we must not forget the citizens. People must participate in a circular transition aimed at improving well-being that is decoupled from resource use.[7]

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