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Urine: The Potential, Value Chain and Its Sustainable Management

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Phosphorus and nitrogen are essential nutrients in crop cultivation and there is ever increasing demand for the use of them in food production. Phosphorus is a fossil mineral and it is estimated that there is only a limited time left to mine affordable and relatively easily extractable phosphate rock (Cordell et al. 2009; 2011). Furthermore, the production of nitrogen fertilisers is highly energy intensive (Viskari et al. 2018a, b). Therefore, we need to look for more efficient ways for nutrient reuse in agriculture. There are many nutrient rich biomasses that can be used as organic fertilizers in agriculture. These include animal manure and sludge, green manure, sewage sludge, septic tank sludge, different side streams from food industry and biowastes.

From the wastewater stream urine forms only about 0.6% by volume but holds about 80% of all the nitrogen and phosphorus (Van der Hoek et al. 2018), which reveals the importance of urine as a nutrient source. Globally, about 80% of the wastewaters are discharged to the environment without adequate treatment (World Bank 2020). In wastewater treatment process, in turn, the emphasis currently is in nutrient removal, not in nutrient recovery per se. Source separated human urine offers one option for nutrient reuse. Urine can be diverted from the solid excreta and it can be used as a liquid fertiliser. Fertilizer efficiency and use of source separated human urine has been studied and demonstrated already for decades. In many research studies the efficiency and safety of urine as a fertilizer has been shown promising results compared to the use of mineral fertilizers (e.g., Pradhan 2010; Viskari et al. 2018a).

As the fertilizer efficiency of source separated human urine has been demonstrated repeatedly, it has also been found to be an environment friendly fertilizer. Applying source-separation systems in rural areas, enables up to four times more phosphorus and over thirty times more nitrogen recovered compared to the current on-site wastewater treatment systems. Furthermore, eutrophication impact is reduced to one fifth. There is a risk, however, of increased soil acidification but it can be minimized with advanced urine spreading techniques. These include for example deep injection of the urine to the soil. Life cycle analysis (LCA) and environmental impact analysis (EIA) indicates that urine diversion and utilization as a fertilizer in agriculture protects the natural water bodies from waste pollution and eutrophication (Viskari et al. 2018a; Malila et al. 2019).

An issue of concern in urine reuse is the risk of spreading pathogens and harmful substances like heavy metals and pharmaceuticals to the environment. Urine contains only those substances that we are exposed to via our diet, inhalation or skin contact. Urine has been found to contain about 3000 different substances also naturally (Bouatra et al. 2013). In our studies, we found urine to contain the most common pharmaceuticals, hormones and some other micropollutants. Out of the total amount of 239 analysed organic compounds, such as phenolic compounds, phthalates, alkylphenols and ethoxylates, pesticides, PFC compounds, pharmaceuticals and hormones we were able to identify 30 compounds exceeding the detection limit of the analysis method. None of these were found in

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the soil or the barley grain at the end of the growing season when using urine as a fertilizer (Viskari et al. 2018b). Only exception was progesterone, which plants can also produce endogenously (Janeczko et al. 2013). Despite the fact, that source separated urine, when treated according to WHO (2006) guidelines, does not seem pose a risk to environment or human health (Table 1), there is still resistance and biased attitudes against the use of it. Therefore, the research communication is crucial in providing scientific and unbiased information about the characteristics of urine as a fertilizer.

Fertilizer use of source separated urine as such is feasible in the vicinity of the source, without long-distance transportation needs. This is not, however, always possible. Recent research studies are, therefore, concentrating more on management and treatment of urine on-site to concentrate it, decrease the volume or recovering the nutrients from it. Recovering the nutrients in energy and resource efficient way would enable more efficient utilization of the separated urine. There are many potential technologies to treat the urine for nutrient recovery (Figure 1). Recovering the nutrients from urine would also help in the acceptance of the fertilizers use as the original source of nutrients can no longer be seen in the actual fertilizer product.

Table 1. Summary of the amounts of micropollutants, pharmaceuticals and hormones found from urine. (Viskari et al. 2018b)

	Analyzed	Found exceeding the detection limit		
Micropollutant	#	Urine	Soil	Grain
Phenolic compounds	46	7	0	0
Phtalates	10	3	0	0
Alkyliphenols and ethoxylates	11	0	0	0
Pesticides (incl. triclosane)	93	1	0	0
PFC-compounds	24	0	0	0
Pharmaceuticals and hormones	55	19	0	1

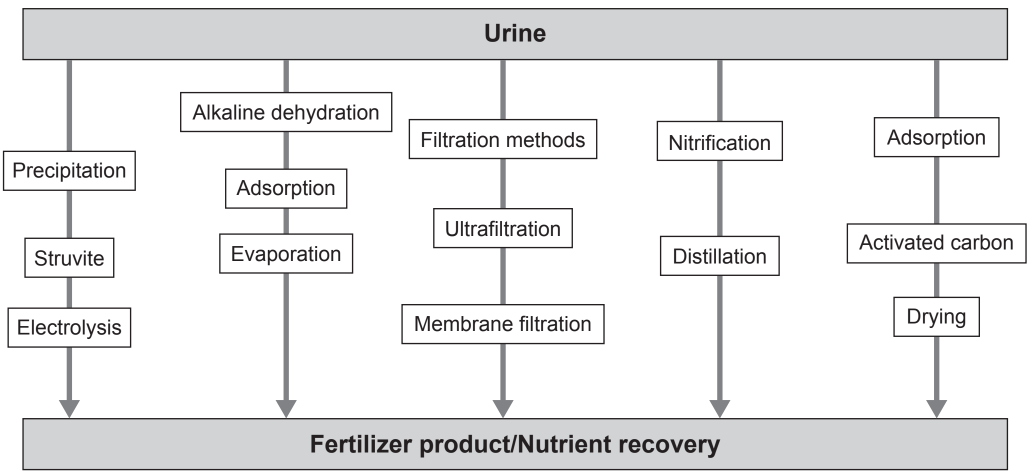

Figure 1. Examples of different methods and technologies under investigation to treat urine for nutrient recovery and fertilizer product development.

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