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Chapter 17

Resource recovery 2050 and beyond: water in a climate-neutral and cyclic economy

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It is hard to believe but in my youth in the 1960s, in the villages and the cities in Flanders, Belgium, sanitation was simply and only a matter of direct drainage of the sewage to the rivers and simple transporting (sometimes still by horse wagon) of the night soil to the fields. Gradually, we have seen the evolvement of technologies to make sewage and night soil 'less offensive' to the citizen. In the past decades, the notion that not only humans, but also the whole environmental system, needed to be respected has become part of the mindset. Thus, advanced technology to treat more and more thoroughly has been installed. The counterpart of this evolution is that wastewater and wastes have become stigmatized as 'total disorder and absolute danger'. Hence, the line of full 'disintegration of wastes' excluding any type of recovery has been predominant in urban planning and management.

Today, we are experiencing the indications that some tipping points of the carrying capacity of the planet have been passed. We have become aware that we all, as citizens and consumers, have major interest in approaches which deal with the recycling of urban resources. Yet, we have also experienced that biological agents, even in their very rudimentary form of viruses, can – even in our times of technological supremacy – cause pandemics. Hence, all recycling will require careful attention in terms of safety. Safe recycling should have positive impacts on urban sustainability and economy and help to abate climate change. In this context, we will have to rethink a great many of our current urban infrastructures and processes. Although predicting the future is risky, some dreams can be formulated for the wastewater in the sense that they may help to set research and development in that direction.

First of all, the water present in sewage will be made fit, not to just discharge as now is most often the case, but to re-use at a very substantial level for process and even drinking water purposes. A perfect example that this is possible, and with the knowledge and the consent of the consumer, can be found in Wulpen, Belgium. Indeed, for several decades, the drinking water produced by the local water company contains up to a level of 50% recycled water, and this without any problem in terms of quality (Dewettinck *et al.*, 2001). Of course, there are still many aspects of grey pollutants and pathogens that need to be monitored and if possible eliminated, but the overall pressure on the utilities to bring forward the effective closure of the water cycle will continue to increase. We will see more and more full treatment, followed by reverse osmosis to capture the 'H20' and transport of the brines to proper deposits or to the sea.

Secondly, the current line of which the microbes are predominantly set up to 'destroy' and to make unwanted molecules 'disintegrate' will become reversed to a system which will focus on the unique biosynthetic capacity of the microbes. Indeed, from urban wastes and wastewaters, a number of building blocks such as ammonia, CO_2, and minerals can be captured in a way that makes them adequate for reuse. Of course, the overall process system will right from the beginning have to be focused on the aspect of 'clean' recovery. Anaerobic digestion, ammonia stripping, and phosphate precipitation will be the upfront key processes; activated sludge, nitrification, denitrification, and anammox will become of secondary use. The generated clean resources will be upgraded using microbial processes, but the special feature will be that the latter will represent so much demand that value will be supplemented to them. To be more specific, by adding quality organic carbon or quality energy in the form of hydrogen gas, one can upgrade the aforementioned building blocks into microbial biomass (De Vrieze *et al*., 2020). The quality organic carbon can be a carbohydrate generated by a crop grown to produce such carbohydrates for wastewater upgrading (for instance a starchy crop not demanding heavy fertilization nor pest control). The quality hydrogen can be generated by electrolysis of water; the hydrogen being part of the H_2-based economy as depicted for the near future by Van Wijk *et al*. (2017). The microbial biomass thus harvested will contain the nutrients delivered via the wastes. Yet, the harvested microbial biomass will qualify to enter cleantech industrial process and value chains (for instance, having gasification as a corner stone) and thus become part of the production of food, feed, organic fertilizer, and biodegradable polymers.

The treatment of what we currently call 'wastes' will be fully revised: the first step will be dedicated to capturing and generating clean and safe building blocks; the second step will deal with upgrading the latter to new products accepted by the consumer who will request a sustainable urban society.

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