The waste crisis: essentiality of the circular economy

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The waste crisis: the overloading of microbial recycling capacity

1. ***Nature's Circular Economy.*** Let us consider for a moment a planet without micro-organisms (https://www.youtube.com/watch?v=80tPR5HH9Zo). When plants, insects, higher animals, and humans would die they would not decompose. These materials would just remain and take up space. We would find these residues of former life piling up everywhere. We would not be able to put a spade in the ground without finding all such remnants, much to our despair. The planet would become a massive waste dump, an ever-increasing global landfill. What a morbid way to demonstrate that microbial activity mediating the recycling of all living matter, is the central motor in the circular economy!

We may not think of it so much, but the toxic carbon monoxide (CO) that our fires and combustion engines produce would accumulate and poison us, if the microbes would not consume and grow on it. We know that a major part of atmospheric carbon dioxide (CO_2) is fixed by the microscopic forms of life in the oceans, which simultaneously generate a massive amount of oxygen which allows us to breathe. And, year after year, the micro-organisms in our soils nicely recycle the nutrients present in the decaying plant material of last season, and thereby nourish and enable the young plants to grow in the spring again. Thus: microorganisms ensure that the planet remains green and productive.

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Of course, when we think of circular economy we tend to think of recycling paper, glass and metals. But the major machinery which, by natural evolution developed over millions of years, is driving the big wheels of recycling is composed of very intriguingly, diverse and yet effectively cooperating tiny micro-organisms. They are the true heroes of the cyclical economy. Yet they are not 'omnipotent': their capacities are just as those of each of us, quite limited, so they need to collaborate to achieve complete mineralization of waste products. But, their cooperation might get disturbed, for instance by new chemicals which we invent, and then they, which means we, are in trouble.

2. ***Microbes need help: Societal Circular Economy.*** Just consider for a moment that microbes lose the capacity to degrade a common material such as hair. In a few years, we would see hair everywhere. So: what would happen if we would introduce a compound which micro-organisms cannot degrade, like plastic? Correct: we might in a matter of decades have 'a sea resembling a soup of plastics' or widespread contamination with persistent fluorinated chemicals (anti-stick layers in frying pans or coatings of raincoats).

Which is indeed the current situation: https://www.nationalgeographic.com/magazine/2018/06/the-journey-of-plastic-around-the-globe/; https://news.un.org/en/story/2014/06/471492-plastic-waste-causes-13-billion-annual-damage-marine-ecosystems-says-un-agency .

Moreover, it is not only non- or poorly-degradable products that accumulate and pollute because of a qualitative difficulty in the collective, global metabolic activities of microbes; it is also a quantitative problem of too much waste. As the world population expands, it creates more and more waste which in turn requires more and more microbial recycling. This has led to a situation where many countries cannot or do not handle all their own waste, and instead export it to other countries, often low-medium income countries which may not always have efficient waste disposal systems. So the waste accumulates.

We have a waste crisis. How long unsustainable practices will continue of producing too much waste, not recycling it adequately or in timely fashion, and allowing it to pollute vulnerable ecosystems, depends upon political will, policy formulation and implementation, and rigorous monitoring of waste handling. Fortunately, the waste crisis is now receiving increasing attention with efforts in product design, manufacturing and recycling to develop zero waste practices. We are moving slowly but surely to a ***circular economy*** involving all stakeholders: politicians, industry, consumer and recycling/waste management authorities. Despite these positive trends, the questions are: will they be enough and in time? In other words, when are key tipping points, such as how much waste needs to accumulate through neglect before it creates damage to the environment that can no longer be repaired (e.g. pollution of groundwater used for drinking water by toxic leachates, solid waste accumulation in deep sea canyons)? In particular, much of the exported waste accumulating is shipped by sea, stored on coastal margins, and readily enters the global marine system, polluting it and perturbing vulnerable food webs. Rising sea levels due to global warming melting of glaciers and polar ice sheets will greatly magnify the problem of waste pollution of marine systems.

How does an optimistic future look?

1. If we are lucky, political action will radically reduce waste generation and export, and ultimately create a zero-waste society.
2. Microbial technologists are extraordinarily inventive people and will develop new processes based on microbial metabolic activities to treat waste more efficiently, so providing a means to enable a "push back" of the waste problem,
3. BUT: we still have the issue of existing waste, much of which is located at ecologically-sensitive locations and not undergoing treatment. Fortunately, microorganisms and groups of microorganisms can adapt themselves quickly to new environments. The first bacteria have already been found that can perhaps degrade some plastic materials. We will need to fully exploit them.

However, there is much to do, at the levels of policy and policy implementation, which requires much better international coordination – we must change from the policy of protecting our immediate environment to one of protecting the planet, technology innovation, and at the level of understanding and optimizing our microbial friends who ultimately will save the planet for us. We must be very careful that we keep the microbial waste conversion machinery in optimal condition or we might still end up in worldwide waste site.