Circular Economy Explainer

> Humans and micro-organisms have central roles to play in enabling a circular economy, in which wastes are the key resources for new processes, technologies and innovation. Only by embracing this collaboration, in which all citizens are stakeholders, can societal, economic and environmental resilience be ensured for future generations.
>
> *Dr. Maria Tuohy, National University of Ireland, Galway*

Key Points

- Exploitation of material resources and increased pressure on natural ecosystems, have raised concerns over potential future resource risk and supply failures worldwide.
- The circular economy conceptualises the integration of economic activity with environmental concerns and can contribute to several of the United Nations (UN) Sustainable Development Goals (SDGs). Microbiology is essential for the development of the circular economy, including in the areas of plastic and food waste.
- Although supporting policies have flourished in recent years, these are still loosely connected and more synergy could be created.

In an increasingly expanding global economy, within a resource-constrained environment; concerns over the exploitation and possible future scarcity of natural resources are rapidly rising. In recent years, interest in a circular model that looks beyond the current linear 'take-make-waste' industrial model, has surged among scientists, policy makers and business actors. The circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems.

Micro-organisms are crucial in creating a circular production cycle for plastics,where these can be re-used, recycled and upcycled through their conversion into biodegradable polymers. Microbial components also affect anaerobic digestion – the process by which organic matter such as animal or food waste is broken down to produce biogas and biofertiliser. Finally, the nutritional versatility of micro-organisms can be exploited for biodegradation of pollutants, a process termed as bioremediation.

Circular Economy and the Sustainable Development Goals

In 2015 the United Nations (UN) adopted the Sustainable Development Goals (SDGs), a set of targets for the world to achieve by 2030. The circular economy is tightly connected to many of the 17 SDGs; indeed, implementing the circular economy and the SDGs at large, must go hand in hand.

Goal 2: Zero Hunger

One of the biggest current agronomic challenges is to develop sustainable intensive agriculture to meet rising demands in food production, without contributing to ecosystem degradation. Biological waste can be used as fertiliser to improve soils and increase agricultural yields. Microbes can remove harmful chemicals from waste, before it is applied as fertiliser and are a key element of soil nutrient cycles.

Goal 3: Good Health and Wellbeing

The potential of microplastics to harbour diseases means that reducing the amount of plastic pollution into the environment may benefit human health and wellbeing. Similarly, food waste represents a public health challenge, as landfill leaks can release toxic chemicals into the ground and the water supply.

Goal 12: Responsible consumption and production

Reusing and recycling materials helps move towards more sustainable cities and communities, where products and materials do not have a single use before ending up in landfill and the environment. The use of microbial processes can also help industry and innovation move away from harmful processes and chemicals.

Goal 13: Climate Action

Recycling, reusing and repurposing decreases the need to extract virgin resources to make products. This means less energy is consumed to manufacture and transport products and their packaging. As a result, less carbon dioxide and other greenhouse gas emissions are generated. However, the cost of reusing certain material increases down the waste hierarchy, and there may come a point where the environmental benefits gained from processing them no longer outweigh the cost of using new materials.

Goal 14 and 15: Life below Water and Life on Land

14 LIFE BELOW WATER

15 LIFE ON LAND

The ocean plastic crisis compels us to address fundamental problems in global waste and recycling practices. By considering the entire lifecycle of products and creating an effective after-use plastics circuit, the circular economy can drastically reduce the leakage of plastics into natural systems (in particular the ocean) and other negative externalities. This is in turn can reduce the negative impact of microplastics and other pollutants on biodiversity.

Box 1. Sustainable Development Goals relevant to the Circular Economy

2 ZERO HUNGER	Nutrient availability and yield increase	3 GOOD HEALTH AND WELL-BEING	Pathogens, contaminants and chemical leaching	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Recyling, fossil fuel expenditure and consumption
13 CLIMATE ACTION	Greenhouse gas emissions	14 LIFE BELOW WATER	Floating plastic density and marine life	15 LIFE ON LAND	Land degradation, plastic density and biodiversity

Microbes in Waste Management

Tackling plastic waste

Over the period of 1950–2015, cumulative production reached 7.8 billion tonnes of plastic – more than a tonne of plastic for every person alive today. The vast majority (79%) is accumulating in landfills or in the natural environment. There is little evidence on the low concentration long-term impacts of microplastics on human health, especially as these systems are complex and under multiple pressures. This is especially true for non-marine environments such as rivers and soils, where most plastic pollution starts out. Furthermore, a lot of microplastic research is done with simple-shaped plastics and at very high high concentrations, making translating the results into real world impacts a difficult task.

Micro-organisms can both help to produce plastic, which more easily breaks down in the environment and to degrade different types of plastics under certain conditions. An important breakthrough was recently made in the case of polyethylene terephthalate (PET), with an efficient degrading enzyme isolated and characterised from *Ideonella sakainensis*, a bacterium isolated from a dumping site. Nevertheless, the interactions between micro-organisms and plastic are still poorly known and the investigation of the microbial ecology of plastic materials is a fundamental step to identify strains with potential degrading abilities.

Tackling food waste

Food waste is rich in starch, fat, protein and cellulose. It shows a high potential to produce methane by anaerobic digestion due to its high organic content. A 2013 study by the Ellen MacArthur Foundation highlighted the potential value that could be derived from processing food waste with anaerobic digestion: one, mitigating the problem of steeply rising landfill costs; and the other, receiving revenues from sales and subsidies for renewable energy. However, nutritional needs and metabolic pathways of microbes in anaerobic digestion are still largely unknown. In order to allow anaerobic digestion to meet its full potential, we must have a standardisation process which encourages the redirection of waste to landfill to waste to re-use.

Box 2. Moving away from the throwaway society

Without a significant shift in human behaviour, technological solutions will be ineffective at addressing the plastic waste problem. Microbiologists have warned that we should not look upon biodegradable plastics as a magical solution that excuses us from our environmental responsibility. The use of sustainably managed biobased resources is one part of the culture change we must undergo as a society. Rather than offering a solution to continue to throw away, bioplastic represents a new end-of-life management option for plastic waste, that provides value through bio-based fertiliser, biogas or chemicals. [T. Narancic, K. O'Connor, 2018]

Circular Economy Policy

The following UK strategies include measures aimed towards achieving a more circular economy: the Industrial Strategy, the Bioeconomy Strategy, the Waste Management Plan and the Synthetic Biology Strategic Plan.

One of the key policies of the 25 Year Environment Plan is to reduce all single-use plastic and unavoidable plastic waste by 2042. The latest progress on the plan includes the introduction of microbeads bans, and the setting out of plans to ban plastic straws, cotton buds and stirrers. The Scottish government developed a strategy in 2016 to move the country towards a more circular economy, aligning its economic and environmental objectives. The Welsh government is currently seeking views on a strategy to make a "low carbon, zero waste Wales that uses a fair share of resources". Northern Ireland is investing £23million into making recycling easier and improve the quality of material being recycled.

In Ireland, the National Policy Statement on the bioeconomy sets out strategic objectives and a framework for more sustainable production and consumption. Ireland's policy is also driven by the European Strategy for Plastics in a Circular Economy, which aims to transform the way plastic products are designed, produced, used and recycled in the European Union (EU). The most challenging goals laid out include those of ensuring that, by 2030, all plastic packaging in the EU should be reusable or recyclable in a cost-effective manner, and that more than half of all plastic waste generated in Europe be recycled.

While progress is being made with governments adopting new policies, innovators developing new technologies and industry committing to transform their business models; large scale action and impact is still lacking. Further effort to shape policy that meets societal, environmental and economic needs will be essential in ensuring the transition to a circular economy.

Box 3. A Sustainable Future

To mark the Society's 75th anniversary, we are embarking on a project that will celebrate and champion the role of microbiology in addressing the world's biggest challenges, within the global framework of the United Nations Sustainable Development Goals.

The 'A Sustainable Future' project focuses on three areas where the contribution of microbiology in achieving the goals is particularly significant. These include antimicrobial resistance, the circular economy, and soil health. If you have expertise in one of these areas and would like to share your work with us in the form of a case study please contact us at policy@microbiologysociety.org

Further Reading

Carus, M., and Dammer, L. The 'Circular Bioeconomy' – concepts, opportunities and limitations. I*ndustrial Biotechnology*. 2018; 14.
Ellen MacArthur Foundation. What is the circular economy; 2019. https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy
Food Waste Resources Portal. WRAP. www.wrap.org.uk/content/food-wasteresources-portal.
HM Government. Bioeconomy strategy: 2018 to 2030; 2018. https://www.gov.uk/government/publications/bioeconomy-strategy-2018-to-2030
Narancic, T., and O'Connor, K. Plastic waste as a global challenge: are biodegradable plastics the answer to the plastic waste problem?. *Microbiology*. 2019; 165.
Parliamentary Office for Science and Technology. Plastic Food Packaging Waste; 2019. https://post.parliament.uk/research-briefings/post-pn-0605/

Image credit: Tunatura/iStock

Microbiology Society Explainers The Microbiology Society highlights important issues relating to microbiology, to policy-makers and the general public. It does this through a range of activities, including events and issuing topical briefing papers. Through its diverse membership, the Society can offer impartial, expert information on all areas of microbiology. Find out more at microbiologysociety.org

Thanks are due to Kevin O'Connor (University College Dublin) for his advice.

Contact:

Policy Team,
Microbiology Society,
14-16 Meredith Street,
London, EC1R 0AB, UK
Tel. +44 (0)20 3034 4870
email policy@microbiologysociety.org

The Microbiology Society remains solely responsible for the content of this briefing. Issue date:

MICROBIOLOGY SOCIETY