Chapter 1
Microbial World for Sustainable Development

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Abstract Increasing population and decreasing sustainability of natural resources is a global concern; indiscriminate use of natural resources has led to a large-scale exploitation of nature. Change in lifestyle and urbanisation is also a major cause for various conditions such as pollution, greenhouse effect etc. It needs an immediate measure with regard to curb the damage being caused to nature. Sustainability of natural resources is a major concern. A wise and applicable step at this time could provide the privilege to upcoming generations to live an efficient life. Microorganisms being ubiquitous have both harmful and beneficial role. Though microbes are a cause of major pathogenic ailments, efficiently harnessing microbes towards a developing role could help in achieving the major sustainable development goal (SDGs). The presence and usefulness of microbes in almost every field like agricultural, industry, health, education, pharmaceutical and environment is undeniable which can positively regulate nation's economy, whereas a single outbreak of pathogenic microbes could destroy the economy. A microscopic creature is potent enough to cause global disaster, but the misbalance spread by mankind in nature could be balanced by efficient use of these microscopic creatures. Thus, it depends on mankind how these microbes need to be handled with efficiency, in order to attain the best results and help fulfil the goals adopted by United Nations member state to make this planet a better place for us and upcoming generations.

Keywords Sustainability · Bioenergy · Education · Bioremediation · Ecosystem · Economy

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1.1 Introduction

Life without higher organisms is feasible, but without microbes is not. It is not exaggeration to mention that life originated from microbes and every one life springs from microbes (Kuhad 2012; Bhatt et al. 2021a, b; Bhandari and Bhatt 2020; Kumar et al. 2017). Microbes play an integral role in various aspects of life. One can consider microbes beyond any imagination altogether the possible regions (Khati et al. 2018). Microbes if exploited judicially can mark a major effect in overall development, i.e. sustainable development (Kuhad 2012). Brundtland in 1987 stated that sustainable development generally meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland 1987; Bhatt and Nailwal 2018).

To collaboratively make an endeavour during sustainable development, around 193 countries agreed to different sustainable development goals (SDG), which is a UN's sponsored effort for a sustainable economic development of the planet. These goals are classified into five (5) subgroups: People, Planet, Prosperity, Peace and Partnerships (Bhatt and Bhatt 2020). The SDGs goals are the answer that could permit financial and societal development, however now no longer on the fee of environmental damage (Bhatt and Maheshwari 2020). Rather, those efforts emphasise at the environmental safety with the aid of using stopping and controlling the illegal exploitation of herbal resources (Akinsemolu 2018).

The World Health Organisation (WHO) has stated certain areas for sustainable development goals (SDGs) as shown in Fig. 1.1.

- No poverty.
- No hunger.
- Good health and wellbeing.
- Education.
- Clean water and sanitation.
- Affordable clean energy.
- Economic growth.
- Industrial innovation.
- Reduce inequality amongst countries.
- Sustainable cities and community.
- Climate change.
- Life below water.
- Life on land.
- Peace and justice.
- Global partnership for development.

Microbes are capable of fulfilling all the above stated goals of SDGs. Microbes are omnipresent and also the predominant forms of life on the earth (Goel et al. 2020). Microbes are the backbone of the ecosystem, with many applications that can contribute in sustainable development. Microbes manifest spectrum of evolutionary,

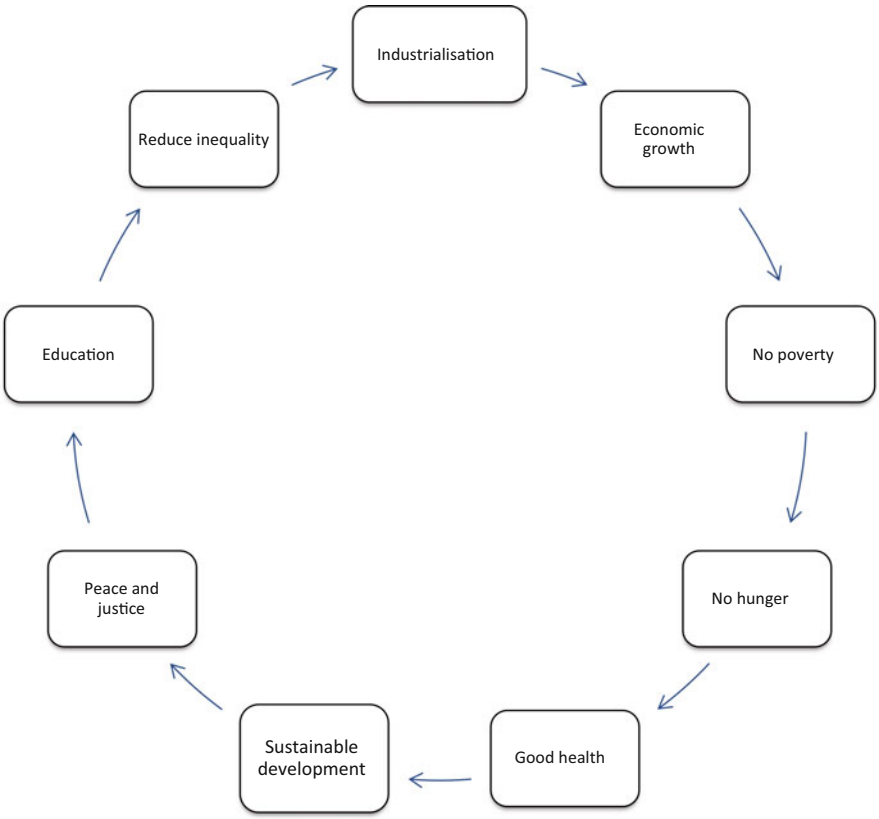

Fig. 1.1 Interlinked sustainable development goal (SDGs): The SDGs are somewhat interlinked; fulfilment of one will lead to attainment of many other SDGs

functional and metabolic diversity (Kumar et al. 2020; Suyal et al. 2019a, b; Bhatt and Maheshwari 2019).

Microbes omnipresence all over the environment, and therefore, their diverse and versatile nature makes them vital agents of planetary system. They have the tendency to facilitate and regulate biogeochemical cycles and consequently use biological materials and waste products. Microbes are also responsible for producing greenhouse gases, viz. carbon dioxide and methane, and are, therefore, necessary determinants of global climate change. In addition to this, they perform essential roles in soil structure and fertility and within the quality and productivity of land, seas, lakes and rivers. Microbes, therefore, are also key members of the committee of stewards of planetary health and property (Timmis et al. 2017).

1.2 Microbes and the Sustainable Development Goals

1.2.1 No Poverty, Economic Growth and Industrial Innovation

Eradication of poverty may also help in attaining various other SDGs directly or indirectly. Mass educating the economically backward class for generating income utilising microbes may also play a pivotal role in eradication of poverty. Various techniques such as using microbes to produce fermented food products may help in raising income, economic development and eradicating hunger. However, the role of microbes in SDGs is shown in Table 1.1. The economic growth can be efficiently made via microbes by medicine, vaccine production and lowering disease rate thereby improving economy (Drexler 2010). Various industries such as food and beverages and chemical synthesis can efficiently exploit microbial population for development (Adesulu and Awojobi 2014).

Table 1.1 Role of microorganisms in accomplishing SDGs

SDGs	Microorganism	Role	Reference
Life below water	*Aspergillus niger*	Decolourisation of pulp and paper industry water	Ahmad et al. (2018)
	Bacillus and *Pseudomonas*	Reduce metal toxicity	Ahmad et al. (2018)
Life on land	*Bordetella avium*	Degrade naphthalene	Abo-State et al. (2018)
No hunger, no poverty, economic growth	*Pseudomonas fluorescence*	Enhance root and shoot growth	Johansson et al. (2004)
	Bradyrhizobium	Enhance soil nutrient content (N,P,S)	Johansson et al. (2004)
	Vigna radiata	ABA production (plant growth under stress)	Ahmad et al. (2013)
No hunger, industrial innovation	*Lactobacilli*	Dairy production	Pereg and McMillan (2015)
Clean energy	*Chlorella vulgaris*	Biobutanol and biohydrogen	Srivastava (2019)
	Shewanella oneidensis	Produce electricity	Lal (2013)
Human health, economic growth	*Streptomyces*	Aminoglycoside antibiotic production	Finkelstein et al. (1996)
Human health, industry application	*Serratia marcescens*	Biotin production	Shimizu (2008)
	Propionibacterium shermanii	Vitamin B12 production	Shimizu (2008)

1.2.2 Good Health Wellbeing, Clean Water and Sanitation

Humans harbour growth of various microorganisms known as human microbiome. These microbes play various essential metabolic and physiological roles such as the intestinal microbiome helps in digestion and absorption of food. Various essential nutrients that are not synthesised in the body and not included in diet are also provided by the microbes. Various recent researches also suggest that microbiota may also influence brain function (Sampson and Mazmanian 2015). By various activities such as decomposition, environmental cleanup can be efficiently maintained, and thereby enhancing good health and wellbeing can be strengthened by intake of probiotics, antibiotics and vaccine.

1.2.3 No Hunger

Microbes play an inseparable part in agriculture by enhancing yield by *Bacillus thuringiensis* (Bt) crops. Various fermented products are produced via microbial activity. Microbes play an exceptionally important role in eradicating hunger positively regulating agricultural practices. Microbes enhance crop yield and soil fertility and play vital role in controlling plant pathogens. Soil fertility and in turn crop productivity can be enhanced by using arbuscular mycorrhizal symbiotic fungi and phosphate-solubilising and nitrogen-fixing microbes (Johansson et al. 2004).

Various microbes specifically effect various aspects of plant growth, e.g. Strains of *Pseudomonas aeruginosa* increases accumulation of dry matter, nodule formation, grain yield and protein content. Various strains of *Azospirillum* increase drought tolerance and enhance root and shoot growth in maize seedlings. *Pseudomonas fluorescens* provides good root and shoot growth and increases tolerance to salinity for cucumber plant. *Bradyrhizobium* species enhances nitrogen, phosphate, sulphur and yield of soybean grain. Microbes also enhance the plant growth by increasing phytohormone productivity and plant growth regulators by 60 times (Camerini et al. 2008). Microbial synthesised phytohormone can regulate physiological plant processes both under normal and stress condition. Auxin synthesised by Pseudomonas and Rhizobium strain helps in tolerating osmotic stress in *Vigna radiate (*Ahmad et al. 2013*)*. Abscisic acid (ABA) helps in growth under stress induction of photoperiodic flowering. Plant growth can also be enhanced by biological control of plant pathogens by competition for nutrients, producing antibiotic, hydrolytic enzymes, siderophores etc. (Glick 2012).

1.2.4 Education

By teaching, research and innovation microbes even play an important role in education field. Education forms the basis of various other SDGs. Mass educating people in turn generates growth opportunities, economic development, improvement in living conditions, good health and research. Education can provide growth opportunities to economically backward classes and find employment. Steps are now being taken to establish new teaching methods for numerous technologies such as environmental technology fermentation technology, food biotechnology and immunology, so that students can easily understand the present and potential use of microbiology and biotechnology for better livelihoods and environmental security (Simonneaux 2000).

1.2.5 Affordable Clean Energy

Bioenergy and biofuel are turning to be good alternate sources of energy, for example *Shewanella oneidensis* exploits organic matter to produce utilisable electricity (Lal 2013). Various wastes such as sewage sludge and municipal solid are being utilised by numerous fungal species including *Trichoderma* and *Aspergillus* to produce bioenergy (Elshahed 2010).

Fossil fuel burning possesses a great threat to environment and mankind. In order to curb this, inefficiency biogas and biomass-based energy are good alternatives that are both cost-effective and environment friendly. The third-generation biofuels can be developed by using microalgal population and curbing the environmental hazards, e.g. *Chlamydomonas reinhardtii* produce ethanol. *Chlorella vulgaris* produce biobutanol and biohydrogen (Srivastava 2019).

1.2.6 Reduced Inequality

Women, who make up half of the world's population, often have half the ability to work and account for more than half of the workforce in fields such as health care (Kaushik and Kapila 2009). Restricted access to education is a big setback for women across the globe. Women need sexual and reproductive health and hygiene knowledge as insufficient education on sexually transmitted diseases such as chlamydia, herpes, gonorrhoea, AIDS and syphilis possesses a higher risk of contracting them (Dehne and Riedner 2001). Therefore, empowerment of girls and women is urgently needed. Indeed, encouraging the completion of formal education, encouraging women to engage in higher education or to learn new skills and raising women's awareness of their rights can contribute to their growth (Penner 2015). It is possible to manage gender disparity by supporting women's education and

making women qualified enough to earn a living. This can be managed through the advancement of agricultural, food and dairy and land management activities by women from rural areas. The general importance of various microorganisms both in pathogenic and non-pathogenic aspect is to be provided to women, in particular, for their involvement in agriculture, dairy and medical fields. The knowledge of microorganisms such as *Pseudomonas*, *Rhizobium*, *Trichoderma*, *Bradyrhizobium*, *Azospirillum*, *Lactobacillus*, yeasts etc. should be imparted to women in agriculture in order to increase crop productivity as well as to make various food and dairy products (Pereg and McMillan 2015).

1.2.7 Sustainable Cities and Communities

Proper solid waste disposal system to avoid clogged drains, floods and the spread of waterborne diseases is a primary necessity for the durable and sustainable growth of society. An expensive method is the disposal of agricultural waste. Proper waste management and dispersal is efficiently maintained by using microbial population. The development of green concrete wall and bioremediation curl pollution. The bioconversion of solid waste into useful products such as biofuel, biogas and animal feedstock, as well as its agricultural uses, is a resourceful, green and sustainable way to handle waste products. The composting of solid waste is an efficient and economically viable process in which different microorganisms such as *Pseudomonas*, *Bacillus*, *Microbispora*, *Actinobifida* and *Thermoactinomycetes* are being used to convert their organic constituents into usable end products. Compost can be used as crop manure, thereby improving its productivity and contributing to green growth (Finstein and Morris 1975).

1.2.8 Global Climate

Global climate can be efficiently controlled by microbes by controlling pollution and various biogeochemical cycles like nitrogen, carbon and phosphorus cycles. Various poisonous gases, e.g. released by various human interventions and processes such as fossil fuels burning and the processes of industrial development, are the main global climate change players. With different biotic and abiotic variables, microorganisms are involved in the recycling of elements. Many natural and engineered systems, such as wastewater treatment, agriculture, remediation, production of biofuels and metabolite production and mineralisation, are important (Bodelier 2011).

The marine microbial populations are one of the key regulators of carbon dioxide concentration in the environment. They are even responsible for recycling nutrients that are further used in marine food webs. Microbes are majorly responsible for decomposition of organic matter which in turn releases carbon dioxide (CO_2), methane (CH_4) and other gases into the atmosphere, thereby indirectly regulating

global climate. Methanogens such as certain archaea produce large amount of CH_4 into environment (Cavicchioli 2019).

1.2.9 Life Below Water

Various industrial effluents discharged into the water bodies and surface run off from agricultural lands contain harmful chemicals which when reach water bodies may cause harmful effects to both life on land and life under water. Oil spills are one of the most common issues prevailing in oceans. Crude oil contains potential carcinogen products. Microbes play an efficient role in bioremediation and removal of harmful effluents and clearing oil spills, e.g. *Aspergillus niger* is used for decomposition of pulp and paper and wastewater. Microbes such as *Bacillus* and *Pseudomonas* are used at metal contaminated site to reduce toxicity and concentration of pollutants. Microbes control marine population by controlling pathogenic outburst, producing oxygen. As the most important contributor to global climate change, the combustion of fossil fuels may also be controlled by the use of microorganisms as a source of biofuels or as part of biofuel processing technologies (Ahmad et al. 2018).

1.2.10 Life on Land

Microbes have ubiquitous role on land in almost every field. Microbes stabilise the soil structure, permit nutrient uptake via way of means of plants, manage pests and diseases, decompose natural cloth and degrade dangerous chemicals, in addition to being a hallmark of the soil health. Increasing population and demands of humans has led to increase in destruction of forest, loss of biodiversity and increased pollution. Microbes could play an important role in limiting these effects such as microbes could increase agricultural yield. Microbes increase the soil content or quality by nitrogen fixation and phosphate solubilisation.

Microbes also help in bioremediation by degrading polyaromatic hydrocarbon, e.g. *Bordetella avium* MAM-P22 can degrade naphthalene (Abo-State et al. 2018).

1.2.11 Peace and Justice

In general, one cannot think about the connection of microbes with peace and justice; however, microbes contribute significantly to the preservation of a stable society. The occurrence of poverty, insufficient access to food and illiteracy have an adverse impact on children's growth. A significant contributing factor to the emotional wellbeing of children has been implicated in food insecurity (Chilton et al. 2007).

By countering bioterrorism, improving sources of nutrition, improving environmental conditions, introducing green technologies and improving national and international infrastructure would eventually lead to the growth of society and the prevalence of peace and justice (Bhatt and Maheshwari 2020).

1.2.12 Global Partnership for Development

Policy mechanisms must contribute to the social, economic and environmental needs of microbiology in order to achieve a sustainable future. The most important areas which need urgent attention are the use of microbes in agriculture, pharmaceutical science, biofuels and fermented food. Without active cooperation and partnership between nations, sustainable development is not viable. In order to make globalisation more efficient, more distinct, wider and intercontinental agreements are needed (Bhatt and Maheshwari 2020). Only by globalisation and breaking land barriers can the advantages of microbes and microbial technology reach the masses (Chambers et al. 2004; Finkelstein et al. 1996; Shimizu 2008; Rawat et al. 2019; Suyal et al. 2018; Mishra et al. 2020; Zhang et al. 2020). This green technology must be used to improve the ideals of equality and social justice.

1.3 Conclusion

It is not an exaggeration to state that the SDGs laid if fulfilled at this point of time slowly and steadily would definitely make this planet worth living for the upcoming countless generation. It is not an individual or national concern; it needs a global effort to curb the gap created in global sustainable development. A carefree approach towards nature would definitely end the upcoming generations sooner or later. Though microbes appear to be very insignificant with regard to their size, they are potent enough to be both a boon and a curse. It just needs a constructive approach, and microbes alone proves to be a great factor in achieving all sustainable development goals. Significantly, microbes contribute to enhance green production technologies, improve crop productivity and provide earning livelihood to needy people. However, it is now believed that these perspectives and better knowledge might help young people to make efforts in achieving sustainable development goals.

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