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Over all Benefits of Gift of Nature (Microbial Communities) to Sustainable Environmental Health

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Abstract: ***Background***: Microorganisms are widespread in nature and are beneficial to life in producing oxygen in environment, decomposing organic material, medicine, providing nutrients for plants, and maintaining human health. The effects of microbes on their environment can be beneficial or harmful with regard to human observation. Microbes also regulates environmental health through interactions with plant microbiota, which actively participate in substance cycling (particularly the carbon and nitrogen cycles) and influence the overall energy flow in the biosphere. ***Review Results***: The most significant effect of the microbes on earth is their ability to recycle the primary elements that make up all living systems, especially carbon, oxygen, and nitrogen (N). Primary production involves photosynthetic organisms which take up CO_2 from the atmosphere and convert it to organic (cellular) material. The process is also called CO_2 fixation, and it accounts for a very large portion of organic carbon available for synthesis of cell material. Decomposition or biodegradation results in the breakdown of complex organic materials to other forms of carbon that can be used by other Organisms. Microorganisms are also highly involved in degradation, eradication, immobilization, or Detoxification of diverse chemical wastes and physical hazardous materials from the surrounding and transforming pollutants such as hydrocarbons, oil, heavy metal, pesticides, dye's and so on through enzymatic way and contributed to solve many environmental problems. ***Conclusion***: Thus, along with all these benefits, microbes greatly contribute in maintaining sustainability of environment. This review mainly focuses on beneficial impacts of microbes on environment and their role to maintain quality, health, and sustainability of environment and also encourage further efforts to study microbial ecology and protect the natural environment.

Keywords: Bioremediation Biofertilizer, Environmental Pollutants, Microbial Role Nutrient Cycling.

Review Paper

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INTRODUCTION

Microorganisms or microbes are microscopic organisms that exist as unicellular, multicellular, or cell clusters. Microorganisms are widespread in nature and are beneficial to life and composed of bacteria, archaea, fungi, protozoa, and viruses [1], and found everywhere in the biosphere, and their presence invariably affects the environment. Microorganisms are beneficial in producing oxygen in environment, decomposing organic material, medicine, providing nutrients for plants, and maintaining human health. They perform a key role and act as main engineers in governing all ecological processes. They act as universal catalyst and provide ecological transformations. Regardless of whether they influence human health and welfare favorably or unfavorably, microorganisms are capable of profound influences on life. The beneficial effects of microbes derive also from their metabolic activities in the environment, their associations with plants and animals, and from their use in food production and biotechnological processes.

Human activities and their effects on the environment and climate cause unprecedented animal and plant extinctions, cause loss in biodiversity endanger animal and plant life on Earth, Losses of species, as it was reported [2]. conversely, microorganisms are generally playing a crucial role in climate change, in maintaining a healthy global ecosystem and the biosphere. Their influence also goes the resilience of all other organisms and hence their ability to respond to climate change as well [3].

Microbial communities' roles can be considered as architects of soils of many ecosystems, including plant production, safeguarding of drinking water and carbon sequestration are also closely linked to microbial activities and their functional traits as it was reported [4].

Microorganisms also involved simultaneously in the production and consumption of GHGs in global warming. According to [5] 98% of GHGs was mainly due to increased carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).Thus microorganisms are part of a large global carbon cycle and extract carbon from non-living sources and make it available to other living organisms, mostly from atmospheric carbon dioxide (carbon fixation).In similar way [6], indicate in his studies that methane consuming microorganisms are also crucial for maintaining a worldwide balance, as the methanotroph species are able to use this methane as an energy source.

Microbial Role in Nutrient Cycle

The most significant effect of the microorganisms on earth is their ability to recycle the primary elements that make up all living systems, especially carbon (C), oxygen (O) and nitrogen (N) [7]. Soil serves as a plant growth medium and a major source of plant nutrients for quality food production. Nitrogen (N), phosphorus (P), potassium (K), and iron (Fe) are essential nutrients in crop production. Since most of the world's soils are known to lack these nutrients according to [8], thus soil microbial consortium contributes a lot contrary to high demand for chemical fertilizers to meet the deficiency of nutrients. The potential of soil microbes was well documented by [9], regarding their contribution in nutrient recycling and reducing the use and impacts of synthetic fertilizers. These macro and micro elements occur in different molecular forms that must be shared among all types of life. Numerous studies have demonstrated the importance of microorganisms in contributing to host nutrition, fitness, and growth through the translocation of photo synthetically fixed carbon and inorganic nitrogen as it was stated by [10]. Different forms of carbon and nitrogen are needed as nutrients by different types of organisms. The diversity of metabolism that exists in the microbes ensures that these elements will be available in their proper form for every type of life. The beneficial effects of microbes derive from their metabolic activities in the environment, their associations with plants and animals, and from their use in food production and biotechnological processes. These elements occur in different molecular forms that must be shared among all types of life and their metabolic diversity exists in the microbes ensures that these elements will be available in their proper form for every type of life [11].

Microbes as Primary Production

Primary production is turning of carbon dioxide into organic material by higher plants, algae and cyanobacteria. Photosynthetic microbes account for roughly 50% whereas the other 50% of global primary production is by large, terrestrial plants. Primary production involves photosynthetic organisms which take up CO2 in the atmosphere and convert it to organic (cellular) material. The process is also called CO2 fixation, and it accounts for a very large portion of organic carbon available for synthesis of cell material.

The microbial food web consists of several microorganisms of which bacteria, phytoplankton, and protozoplankton plays a pivotal role in marine ecosystems as it controls energy as well as organic and inorganic matter transfer either to higher trophic levels or to the water-dissolved organic carbon [12], in his study reported that phytoplankton are the main primary producer of the microbial food web, which supports a part of ecosystem productivity by providing carbon to higher trophic levels. Other research findings reported by [13], suggested that phytoplankton as the most important source of DOC in marine environments through exudation, losses by cell damage, or lysis. In general flow of important amounts of carbon can pass through bacteria to higher trophic levels, which indicates the significance

Microbes as Decomposers and Biodegrading Agents

Environmental pollution through industrial development has led to the generation of a variety of lethal materials, especially recalcitrant classes such as polycyclic aromatic hydrocarbons, toxic dyes, pesticides, and heavy metals, which are now of critical environmental importance due to their harmful and mutagenic effects on humans, plants, and aquatic organisms [15]. The intensive use of pesticides, antibiotics, non steroidal anti inflammatory drugs and other chemicals, their disposal and consequent presence in various environments, are of great concern due to their ecotoxicological effects on different organisms. Such widespread use results in an increased concentration of these compounds in water, sediments and soil. According to [16], the above mentioned risks to humans related to organic pollutants has led to the development of effective strategies to detoxify or clean up these pollutants. One of the strategies ecofriendly to the environment is processes of biodegradation naturally performed by microorganisms, implying the decomposition of complex organic compounds into a more straightforward inorganic form [17]. These organisms will harness these organisms as a source of energy, while bioremediation according to [18], is a human engineering technology that reduces pollutants using microorganisms through techniques of natural attenuation, bio stimulation, or bioaugmentation to strengthen the ability of microorganisms. As it was reported by [19], in anaerobic and aerobic biodegradation mechanism extracellular and intracellular depolymerize enzymes are actively involved in biological degradation of polymers and microbial exoenzymes break down complex polymers, yielding short chains or smaller molecules like oligomers, dimers and monomers. These molecules are small enough to be water soluble, and can pass through the semi permeable outer bacterial membranes to be used as carbon and energy sources. Through microbial metabolic activities, organic molecules are eventually broken down to dead material and wastes, they release nutrients that can be recycled and used as building blocks by primary producers.

Microbes in Associations with Food Industry and Beverages

Microbes produce different food products thro ugh a process recognized as fermentation. Fermentation method is the biochemical change of simple sugars into favorable products such as alcohol, acid, carbon dioxide via a variety of metabolic pathways [20], and increase the quality safety and organoleptic properties of food and food preservation techniques as well.

For example [21]. *Lactobacillus spp. and Streptococcus spp*. ferment lactose to lactic acid during the manufacture of dairy. Lactic acid bacteria such as *Lactobacillus* are responsible for the curd formation (convert milk into curd) [22], also reported in his findings that lactobacilli are important in the production of foods that require lactic acid fermentation, notably dairy products like yogurt cheese, fermented vegetables like olives pickles and sauerkraut, fermented meats salami, and sourdough breads. The most commonly genera involved in food fermentations include Lactobacillus, Leuconostoc, Pediococcus and Streptococcus. Another important microorganism involved in food industry is yeast (Saccharomyces spp.) which ferment sugar to ethanol and carbon dioxide during low alcoholic beverages. In food fermentations, yeasts are responsible for converting this carbohydrate into alcohol and carbon dioxide through a process known as alcoholic fermentation and creation of non alcoholic fermented foods like bread, yogurt, cheese, and various condiments [23]. On top that yeasts are used for making many foods: in production of bread, beer and wine fermentation in industrial level, yeasts also used in the production of enzymes and yeast-derived flavor products.

Supporting the above idea [24], pointed out the role of Yeasts *Saccharomyces cerevisiae* in food and feed processing industry and improve the taste, aroma and shelf life of products at very low cost. Similar findings reported by [25], explains microbial contribution to create the product with the necessary properties on a large scale to get desired products, improve sensory quality and safety of the products.

Microbes in Waste Treatment and Environmental Remediation

Agricultural practices, industrial manufacturing, and lifestyle of human beings have raised the accumulation of hazardous compounds into the surrounding. Environmental pollution is the most horrible ecological crisis that man is facing today. The rapid growth of human populations fueled by technological developments in health and agriculture has led to a rapid increase in environmental pollution [26]. Pollution is a global threat to the environment and it becomes a scare word of today's world. Studies conducted by [27], pointed out the development of various industries, and the use of fertilizers and pesticides in modern agriculture has overloaded not only the water resources but also the atmosphere and the soil with pollutants. Although wastes contain nutrients and organic materials that are advantageous for the soil, it also contains pollutants such as heavy metals, organic compounds, and pathogens that may be resulting in destructive effects that endanger human health, threaten natural resources and ecosystems, as well as disrupt the amenity [28]. Similar findings also reported by [29], that rapid introduction of a huge amount of new chemical compounds and technological advancements in addition to other agricultural wastes has resulted in a significantly increased number of environmental pollutants in the environment.

This drastically increasing issues of the environmental concern, urgently need for eco-friendly approaches to solving these multiple issues by the methods of bioremediation, utilizes living microbiomes for cleaning as an eco friendly substitute for sustainable development. Microorganisms play a major role in bioremediation, a process in which hazardous wastes and pollutants are degraded, eliminated, immobilized, or detoxified using a wide range of organisms [30]. Different kinds of microorganisms such as *Bacillus, Pseudomonas, Sphingomonas, Flavobacterium, Nocardia*, *Rhodococcus*, and *Mycobacterium* have the ability to bioremediate different types of environmental pollutants and degrade a variety of complex organic compounds [31] including pesticides, alkane hydrocarbons, and polyaromatics.

Microbial Roles in Agriculture

Agriculture takes advantage of the natural cycles and behaviour of both plants and animals. The unhealthy impacts and high cost of chemical fertilizers are making them unaffordable to use in agriculture [32]. The requirement for chemical fertilizers to support the current demand of nutrients for the production of million tons of foods is still limited. Under this circumstance, exploiting the agro ecosystem services of soil microbial communities appear as a promising approach. From this point of view, currently microbes have played a vital role in the history of farming and agriculture. The microorganisms can act like natural biocontrol agents that help to suppress plant diseases caused by pathogens. Their importance in agriculture also explained by findings [33], who reported that the use of microorganisms in agricultural as plant growth-promoting, (PGP) as nutrient addition, biological control, abiotic stress (e.g., drought, salinity, heavy metals), alleviation to minimize the use of agrichemicals (e.g., fertilizers and pesticides) in agriculture as well as to improve crop performance. The beneficial microbes colonize the rhizosphere of the plant, compete with harmful organisms for resources, produce antimicrobial compounds or induce systemic resistance in plants as a biocontrol. According to the report of [34], sustainable agricultural exercises realized on a global magnitude, and various alternative methods and eco friendly approaches to tackle environmental and economical sustainability issues by exploiting the role of microbial communities for a sustainable and healthy crop production being preserving the biosphere. In support of the above mentioned points [35], also reported that soil microorganisms play an important role in agriculture by improving plant nutrition and health and soil quality. Thus, utilization of successful beneficial microbial services, as a low input in the field of biotechnology which helps sustainable and environment friendly agrotechnological practices.

Studies conducted by [36], in similar way reported the role of soil microbiome in plant growth development and soil fertility for sustainable agriculture through facilitating nutrient cycling, organic matter decomposition, ecosystem functioning and resistance to biotic and abiotic stress. In line with these findings [37], sustainable agriculture, composed of groups of microbiomes used for nutrient acquisition through rhizosphere or endophytic through symbiotic interaction mechanisms and plant protection through the use of biopesticide and bio fungicide. The microbiome can also be used as a biocontrol agent by the plant associated microbiota [38] through the production of siderophores, volatile compounds, enzymes, and antibiotics and phytohormones. According to [39], in agriculture, the plant microbiome inhibiting effect through the growth and activity of pathogens with competition for nutrients and microenvironments, parasitism and antibiosis by doing so they confer the plants' immune system protecting the plant from pathogens belonging to the different genera.

In agriculture [40], reported that biotechnology and microbiology together offer improvement of crop quality, crop productivity, and sustainability of existing systems to produce more and better quality agricultural products through genetically modified organisms (GMO) and transgenic crops. Microbes also provides in sustainable agriculture in various ways, like as biofertilizers, biopesticides, bioherbicides, bioinsecticide and reduces the dependence on agrochemicals in sustainable agriculture by the management of biotic and abiotic stresses.

Beneficial Effects of Microbes in Human Health

The microbes that normally live-in associations with humans on the various surfaces of the body (called the normal flora). Microbial communities play a pivotal role in shaping various aspects of human health. The human microbiome comprises bacteria, archaea, viruses, and eukaryotes which reside within and outside our bodies. These organisms impact human physiology, both in health and in disease, contributing to the enhancement or impairment of metabolic and immune functions and colonize various sites on and in the human body, where they adapt to specific features of each niche. According to [41], human micro biome is also composed of a collection of dynamic microbial communities that inhabit various anatomical locations in the body such as the skin, the mucosa, gastrointestinal tract, respiratory tract, urogenital tract, and the mammary glands.

These micro ecosystems, contributed a direct consequence to the mutualism between the host and its microbiota, and also fundamental for the maintenance of the homeostasis of a healthy individual [42]. Besides, commensal provide the host with essential nutrients, metabolize indigestible compounds, defend against colonization of opportunistic pathogens and contribute to the development of the intestinal architecture as well as stimulate the immune system among others. Similar findings of [43], and reported that the host provides bacteria with nutrients and a stable environment, both host and indigenous and adapted to each other in a particular case of microevolution to maintain the benefits that this mutualism confers. In line with this [44], explained the beneficial effects of various human microbes which exert within the human body. He also explained their preventive mechanisms not to be colonized by pathogens and competing for attachment sites and for essential nutrients; antagonize competitors and foreign bacteria through the production of substances, ranging from relatively nonspecific fatty acids and peroxides to highly specific bacteriocins [45], also reported their contribution in carbohydrate fermentation and absorption, enabling the host to utilize some normally in digestible carbohydrates [46]; synthesize and excrete vitamins like Vitamin K, Vitamin B12 and B vitamins excess of their own needs, which can be absorbed as nutrients by their host [47], provide a continuous and dynamic effect on the host's gut and systemic immune systems and stimulate the development of certain tissues [48].

Studies conducted by [49], confirmed the role of human microflora such as *Lactobacillus* such as *Lact obacillus acidophilus* and *Bifidobacterium*, in protectin g their hosts from infections by preventing colonization of potentially harmful pathogenic microbs. Thus, there r ole and contribution fully appreciated and nowadays get consideration for their metabolically important compou nds they provide within the host [50].

Microbial Role in Biotechnological Application

Microbiology makes an important contribution to biotechnology, an area of science that applies microbial genetics to biological processes for the production of useful substances. Microorganisms play a central role in recombinant DNA technology and genetic engineering. Important tools of biotechnology are microbial cells, microbial genes and microbial enzymes. The genetic information for many biological products and biological processes can be introduced into microbes in order to genetically engineer them to produce a substance or conduct a process. The genes can come from any biological source: human, animal, plant or microbial. This opens the possibility for microbial production of foods, fuels, enzymes, hormones, diagnostic agents, medicines, antibiotics, vaccines, antibodies, natural insecticides and fertilizers, and all sorts of substances useful in our civilization and society. Also, the microbial genes that encode for these substances, most of which are unknown, are a tremendous resource of information for application in medicine, pharmacy, agriculture, food science and biotechnology.

Role of Microorganisms in Climate Change

Global warming and accompanying climate change are one of the serious problems in the world due to its global effect and increase in the concentration of greenhouse gases that have been the major cause of this problem. Warming of the climate system is occurring at unexpected rates in increasing anthropogenic greenhouse gas concentrations which is responsible for most of global warming according to the International Panel on Climate Change [51, 52].

According to [53], Climate change adversely impacts water quality, food security, and global economies and it becomes the biggest health threat facing humanity which resulted from humans' actions such as burning of fossil fuels, deforestation, and rapid population growth have clearly contributed to climate change. These actions have increased concentrations of greenhouse gases, which, in turn, have increased the Earth's temperature and altered the climate globally [54].

Microorganisms play a major role in proper functioning of the atmospheric ecosystem through cycling of nutrients and other biogeochemical cycles and significantly responsible for the production and consumption of greenhouse gases such as CO_2, CH_4, NO and N_20 [55]. Since they are the most abundant and diverse organisms on earth, microbes contribute to the planet's climate because of their large numbers [56], which and drivers of global geochemical cycling, critical symbionts of global crops, and important producers and consumers of greenhouse gases.

Microbes also plays an essential role in all eco system processes, such that microbial abundance and ac tivity determines the sustainable productivity of agricult ural lands, ecosystem resilience against nutrient mining, degradation of sil and water resources, and GHG emiss ions [57]. Supporting this idea [58], also explained conc entrations of these gases continue to rise, however, soil microbes may have various feedback responses that acc elerate or slow down global warming and contributes a l ot to climate change.

According to [59], soil microbiome can also stock up excess CO_2 in the atmosphere into stable and nongaseous forms through biotic and abiotic processes. As the excess CO_2 entered the soil through plant and photosynthetic microbes, soil microbiome can be manipulated in situ through addition of pyrolyzed carbon which increases the activity of soil microbes to sequester carbon in a relatively stable state. It also increases organic matter retention by reducing microbial mineralization and plant root exudates [60], thus it promotes plant growth and reduce CO_2 release. Similar findings reported on [61], that microbial processes have a central role in the global fluxes of the key bio genic greenhouse gases (carbon dioxide, methane and nitrous oxide) and are likely to respond rapidly to climate change. Microorganisms regulate terrestrial greenhouse gas flux. This involves consideration of the complex interactions that occur between microorganisms and other biotic and abiotic factors. In line with these [62], reported their potential to mitigate climate change by reducing greenhouse gas emissions through managing terrestrial microbial processes and their role is widely accepted that microorganisms have played a key part in determining the atmospheric concentrations of greenhouse gases.

Microbial Role as Biofuel Production

Increase in global energy demand, rise in crude oil prices, depletion of resources and environmental challenges have resulted in the need of biofuels which are a renewable, sustainable, efficient, cost effective and eco friendly source of energy with the potential to replace conventional petroleum based fuels. The production of economically feasible and eco friendly renewable energy fuels is the world's highest demand that indicates the potential to simultaneously replace the conventional fuels and reduce the environmental concern [63], the production of biodiesel is limited by insufficient raw materials, low economic benefits, long life cycles, and the impact on the price of agricultural products, arable land resources, and food security.

Biofuel production using lignocellulosic biomass has now been promoted and the process is made cost effective by the use of microorganisms to produce important biofuel production like biodiesel, bioethanol, biogas, etc from various substrates [64]. According to the report of [65], this could be achieved through conversion of lignocelluloses into ethanol by bacteria and fungi; alternatively, through CO_2 conversion into biomass by microalgae; or through the use of methane generated from landfill in to biofuels production. He also reported that the use of versatile microorganisms in generating renewable energy fuels from the biomass and biological wastes using microbial community gets greatest concern for biofuel production because of the metabolic diversity of different microorganisms that enables the production of biofuels from various substrates of which Cyanobacteria and microalgae also possess the potential to photosynthetically reduce the atmospheric CO_2 into biofuels, and methanotrophs can use methane to produce methanol [66].

Microbes from various habitats naturally produce a broad array of bioactive compounds that are used as fuels, drugs, and other important chemicals [67]. Similar research findings indicated by [68], that microbes also excelled production of biofuel through the biosynthesis of different enzymes which convert diverse feed stocks lignocellulosic biomass to biofuels through depolymerization of polysaccharides catalyzed by the action of specific microbial enzymes. Compared with traditional biodiesel feedstocks, microbial lipids derived from oleaginous microorganisms have been considered excellent alternative feedstocks for biodiesel production. Findings of [69], also reported supporting idea, to be sustainable and cost-effective feedstocks, it is important to seek low cost materials of nutrients to cultivate these oleaginous microorganisms.

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