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Microbial contribution towards human welfare

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Microorganism is a broad term which includes bacteria, protozoa, fungi, viruses, some algae, viroid and prions. An environment without microbes is next to being incomplete. The earth is home to a trillion species of microorganisms with human bodies hosting a huge number of them. Microbes are minute particles invisible to the naked eye which can be very beneficial to the environment and on the other hand, may pose as a serious threat. Microorganisms may require a host for its survival or may replicate outside of any host. The size of microorganism varies from 10 nm to 1 milimeter.

Antimicrobial property is exhibited by Ribosomally synthesized and Post translationally modified Proteins (RiPP). RiPP such as lasso peptides, plantazolicin, lanthipeptides, thiopeptides, sactipeptides etc. have the potential in drug discovery programme to deal with antibiotic resistant problems (Mitchell *et al.,* 2018). Microbial natural products known to have provided scaffold for various drug discovery. It has already been proven from the genome sequencing of microbes that the microbes with large genome have the capacity to produce a large number of secondary metabolites. Actinomycetes have the capacity to produce as many as 30-50 secondary metabolites and have antifungal, antiviral and antibacterial activity (Krzensniak *et al.,* 2018). In bacteria viruses and bacteriophages can infect and replicate which may have both beneficial and detrimental effects. Treatments like phage therapy are used to treat bacterial disease but has problem of transmission of antibiotic resistance. The problem of antibiotic resistance can be overcome by combining phages with antibiotics to increase their efficacy on antibiotic resistant bacteria (Barcelo, 2018). Combining of techniques like diffusion chambers and iChip (Isolation Chip) technology is helpful in growing bacteria which depends on other surrounding bacteria for their growth and production of secondary metabolites like antibiotics (Deng *et al.,* 2018). There are trillions of microbes present in our gastrointestinal tract and many of them are known to have a role in critical aspects of host physiology. Various novel antimicrobials can be obtained from the GI tract and can be used as an alternative to antibiotics and thus help to address the problem of antimicrobial resistance. Study of microbiome of a person with Parkinson's disease is helpful in understanding the etiology of disease and may provide a more efficient way to treat the disease (Sampson, 2019). Staph infection caused by *Staphylococus aureus* can be efficiently controlled by *S. lugdunensis* and its antimicrobial product, Lugdunin (Zipperer *et al.,* 2016).

Microbes have a great role in the wastewater treatment. Microorganisms are mixed with wastewater in activated sludge where they come in contact with biodegradable material in wastewater and consume them as food. A slimy sticky layer is delevoped by the microorganisms over the cell wall and helps them to clump together leading to formation of sludge. This sludge can be separated from the liquid phase easily. Some microorganism commonly used for wastewater treatment includes *Tetrasphaera*, *Trichococcus*, *Rhodoferax*, *Rhodobacter*, *Hydromicrobium*, Ascomycetes (Mcllory *et al.,* 2015). Biogenic Nanoparticles (BNPs) fabricated using microbes are efficient in wastewater treatment as they have unique properties like high specific surface area, desired morphology, catalytic reactivity for biodegradation and biosorption of treatment of toxic and emerging pollutants (T&EPs) (Ali *et al.,* 2018).

Microorganisms are useful in production of food like bread, yogurt, cheese, beer, wine and other fermented foods. Yeast specially *Saccharomyces cerevisiae* are used in making bread, to brew beer and

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to make wine. Lactic acid bacteria are used to make cheese, yogurt, pickles, sauce etc. The gastrointestinal microorganisms have a crucial role in the human health. A total of about 160 species of microorganism are found in the gut of an individual (Stojanovic & Vos, 2014). It is estimated that about 3 million genes i.e. 150 times larger than that of human genome is present in gut microbiota (Zhang *et al.,* 2010). The colonic microbiota has proteolytic power to convert dietary protein into shorter peptides, amino acids and derivatives, short fatty acids, gases like NH_3, CO_2, H_2, H_2S (Macfarlane *et al.,* 1986). Gut microbita can also synthesize various vitamins, mainly Vitamin K and B group vitamins like folates, cobalamin, nicotinic acid, biotin, pyridoxine, thiamine, riboflavin and panthotenic acid (Hill, 1997). Polyphenols obtained from fruits and vegetables are metabolized by colonic microbiota and can affect their bioactivity (Russell *et al.,* 2008, Duda *et al.,* 2015). A proper dietary approach to modulate the composition and metabolic function of the microbial community that are present in the gastrointestinal tract is helpful in improving health and to prevent and treat disease. Microbes are useful in digesting complex carbohydrates and plant polysaccharides into short chain fatty acids like acetate, propionate and butyrate. Bacteria like *Bifidobacterium, Bacteroides, Faecalibacterium, Lactobacillus* and *Roseburia* can ferment oligofructose in vitro (Holscher, 2018). Peoples of higher altitude from western Himalayan region use a traditionally leavened what based bread called Kambir and used to eat routinely. This food has inhibitory effect on growth of enteropathogens and can be used as a medicinal food for human welfare (Hor *et al.,* 2019). Certain probiotics can be administered in an adequate amount as functional food ingredients for the benefit of the host health. The most frequently used microbial probiotics in human nutrition includes *Lactobacillus* spp., *Bifidobacterium*, *Enterococcus* spp., *Saccharomyces cerevisiae* (Syngai *et al.,* 2016).

Microbial decomposition of organic matter leads to the production of biogas. Methane forming archea (mathanogens) and acetic acid forming bacteria (acetagens) are commonly used for biogas production. A soil bacterium, *Corynebacterium glutamicum* is extensively used in industrial biotechnology for the production of amino acids L-glutamate and L-lysine at a level of 6 million tons per year. Fermentation of *C. glutamicum* leads to production of many proteogenic amino acids like L-lysine, L-isoleucine, L-methionine, gama aminobutyric acid, Ectoine, pipecolic acid etc. L-lysine is mainly applied as a feed additive to pigs and poultry. L-isoleucine and L-methionine serves as a major supplement special diets and infusions. Gama aminobutyric acid can serve as building blocks for pharmaceuticals, foods and biodegradable plastics. Pipecolic acid can be used as a precursor of peptide antibiotics or immunosuppressant. Ectoine is regularly used in cosmetics industry (Becker et al., 2018).

Microorganisms like *Bacillus subtilis*, *Pseudomonas* sp., *Arthrobacter* sp.have been known to produce surfactine which is a lipopeptide (Arima et al 1968; Cameotra and Makkar 2004). It is been extensively used for the production of cosmetics, pharmaceuticals as well as food products. The lipopeptides so produced are also used in manufacturing anti-wrinkle cosmetics (Guglielmo and Montanari 2003; Montanari and Guglielmo 2008). The properties like deterging and emulsifying activity are exploited in the production of cleansing cosmetics (Mukherjee 2007; Gallot and Douy1986; Lang and Philp 1998; Meena and Kanwar 2015; Bçckmuhl 2012). These lipopeptides developed from the microorganisms have found its use in the whitening cosmetics for the delivery of amelanocyte-stimulating hormones (Ogawa et al. 1999).

Microbial electrosynthesis (MES) is a bio-electrochemical approach that has an impact on current method of chemical synthesis. Electrical current is used as electron source by elctro autotrophic microbes and reduces carbon dioxide to multi carbon organics.

It leads to the production of renewable energy that is stored in the covalent bonds of organic compounds synthesized from greenhouse gases. Fungi of genus *Rhodosporidium* is extensively used for the production of microbial lipids. Microbial lipids are alternative feedstock for production of biodiesel and are advantageous over planting oil crops such as less need of land use, short life cycle and adaptability to various renewable resources (Xu & Liu. 2017). *Methylobacterium extorquens* can produce various metabolic intermediates for the production of chemicals like crotonyl-CoA. Crotonyl CoA is a precursor for butadiene synthesis. Butadiene is a chemical used for the manufacture of automobile tires, latex, engineering plastics and synthetic resins (Yang et al., 2018).

Microbes great have role in soil fertility. Soil microbiota helps in maintaining nutrient balance carbon sink and soil health. Microalgae and cyanobacteria are abundantly found in soil. They play major role in maintaining soil health and fertility necessary for growth of plants. Microalgae releases phytohormones, allelochemicals and enzymes that play vital role in enhancing plant growth and detoxifying chemical agents

(Abhinandan et al., 2019). Many microorganisms can solubilize/mineralize insoluble soil phosphates and make them available to plants and thus help in improving the growth of huge variety of crops. Phosphate Solubulizing microorganisms includes *Pseudomonas spp., Bacillus circulans, Azotobactor, Enterobactor, Paenibacillus, Rhizobium, Rhodococcus, Salmonella, Serratia* etc. Inoculation of Phosphate Solubilizing microorganisms (PSM) is a promising strategy to world food production without causing any harm to the environment (Altori *et al.,* 2017). Plant-microbial interaction is beneficial for the plants as it helps them to produce a rich and different repertoire of metabolites that helps them to combat various biotic and abiotic stresses (Korenblum & Aharoni, 2019).

Microbes also have a role in controlling various pests. It can be used as biocontrol agent for the control of pests. *Mortierell globalpina* is a nematophagus microbe that helps in the control of a detrimental pest, root-knot nematode, *Meloidogyne spp* (Dilegge *et al.,* 2019). *Bacillus subtilis* is a plant growth promoting rhizobacterium (PGPR) which forms spores and can survive in soil for a considerably longer period of time. It enhances plant growth and also exhibit biocontrol mechanism to suppress various diseases caused by pathogens to the plant. The PGPR helps the plant to survive efficiently by producing various secondary metabolites, hormones, antioxidants to combat with the pathogen and also promotes plant growth and provide systemic resistance (Hashem *et al.,* 2019). *Pantoea dispersa* is a bacterium that is used as a biocontrol agent for the control of black rot in potato caused by a fungus, *Ceratocytis fimbriata (*Jiang *et al.,* 2019). Various fungal and bacterial phytopathogens can be controlled by *Streptomyces spp.* They also produce various antibiotics and volatile organic compounds and hence can be used an efficient biocontrol agent (Vurukonda & Stefani, 2018).

It is seen that microorganisms are a boon to the mankind, although it has some hazardous effects on human health along with the environment as a whole. With the advancement in technology today, microorganisms are exploited fully as per the needs of human beings so as to get the maximum benefits from them and causing minimal damage to the environment. It is the prime responsibility of every individual to keep a check on the destruction caused to the nature in order to fulfill our needs.

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