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Beneficial Effects of Eco-Friendly Microorganisms In Human Life

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ABSTRACT

Microorganisms are treasure and can contribute to environmental safety and sustainable development. Microorganisms can be used effectively in this context due to their astonishing metabolic activity and diverse nutritional requirements and their relationships with plants and animals. Even though microbes have caused many diseases, the main aim of this narrative review is to provide a summary of the different uses of eco-friendly microorganisms, benefits, and the expected results when using them in different applications. Originally, eco-friendly microorganisms are utilized only in organic farming, but at the moment, this is getting wider applications such as in decomposition, food production and dietary needs, sewage treatment, petroleum refining, r-DNA technology, in marine and many more. Microbial biosensors use engineered microorganisms and transducers to detect substances, emitting signals like light or electrical current. In healthcare, they hold promise for early and accurate disease detection by identifying biomarkers associated with conditions such as cancer, enabling faster and more precise diagnoses for improved patient outcomes. The establishment of a sustainable and livable ecosystem for future generations depends on the remediation and restoration of contaminated habitats utilizing efficient and environmentally friendly technology. Microbes in space face unique challenges like altered gravity and cosmic radiation, promoting scientific exploration for their adaptability and potential implication for space missions.

Keywords: Microbes, environment, eco-friendly, agriculture, decomposition, sewage, enzyme production.

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INTRODUCTION

In the biosphere, microbes are ubiquitous and always have an impact on the environment in which they grow. Microorganisms can have helpful, negative or undetectable effects on their surroundings that are not visible to humans. Given that a significant portion of this literature discusses the detrimental effects of microorganisms, or disease-causing agents, Microbes are helpful because of their roles in food production and biotechnological processes, their relationships with plants and animals, and their metabolic activities in the environment.

Although terrestrial plants are obviously primary producers, algae and cyanobacteria account for nearly half of the primary production on the planet. These unicellular organisms which float in the ocean are the "grass of the sea", and they are the source of carbon from which marine life is derived.[1]

Identifying the precise function of every microbe can be challenging. By supplying vital micronutrients like vitamins and other metabolites, the microorganisms connected to the human body play a crucial role in host metabolism. For instance, the production of vital micronutrients, vitamin K, and enzymes by gut microorganisms enables people to digest food and absorb a variety of vital minerals. It is clear that the microorganisms that cause disease have an obvious impact, receive prompt attention, and are discovered sooner than the beneficial ones. These microorganisms produce diseases that must be treated before the infections become lethal. Consequently, identifying them and conducting in-depth research to understand their characteristics, pathogenicity, virulence factors, and susceptibilities to currently available antimicrobial drugs. [2]

The bacteria are identified biochemically, and it will be ascertained whether they are capable of withstanding heavy metals like copper and zinc. Recent years have seen significant advancements in bioremediation techniques, with the ultimate goal being the cost-effective and environmentally friendly restoration of contaminated areas. Various bioremediation approaches have been created and studied by researchers; however, no one bioremediation strategy can be considered a "silver bullet" for restoring damaged habitats due to the nature and/or kind of contaminant. As long as the environment is conducive to their growth and metabolism, autochthonous (indigenous) microorganisms found in contaminated environments hold the key to resolving the majority of the problems related to the biodegradation and bioremediation of polluting substances.

The type of pollution, which might include sewage, plastics, heavy metals, hydrocarbons, dyes, agrochemicals, chlorinated compounds, greenhouse gases, and hydrocarbons, is what determines how the pollutant is removed.[3]

Microbes, microscopic organisms that play pivotal roles in various ecosystems, encompass a diverse array of types. Bacteria, the most abundant microbes, thrive in virtually every environment, from soil to human intestines, contributing to processes like nutrient cycling. Archaea, often found in extreme environments, showcase remarkable resilience. Fungi, including molds and yeasts, participate in decomposition and nutrient recycling.

Bacteria serve numerous essential functions with practical applications across various domains. In agriculture, certain bacteria, like *Rhizobium*, form symbiotic relationships with legume roots, aiding in nitrogen fixation and enhancing soil fertility. In the food industry, *Lactobacillus* bacteria are employed in the fermentation of dairy products, producing yogurt and cheese. Bacteria like *Bacillus thuringiensis* are utilized in biopesticides, providing an eco-friendly method for pest control in agriculture. In wastewater treatment, specific bacteria play a crucial role in breaking down organic matter, contributing to the purification of water. Although bacteria has beneficial effects, bacteria pose the greatest threat among all microorganisms and are accountable for numerous contagious illnesses like tuberculosis, cholera, diphtheria, and more. Viruses, on the other hand, are responsible for specific fatal diseases such as AIDS, influenza, and others.

Fungi have multifaceted roles with significant impact. Mycorrhizal fungi boost plant growth by aiding nutrient absorption, while yeasts are key in fermenting foods like bread and beer. Certain fungi, such as *Penicillium*, have revolutionized medicine with antibiotics. In environmental cleanup, fungi break down pollutants, and in ecosystems, they recycle organic matter through decomposition. Additionally, fungi serve as crucial models in scientific research, shedding light on genetics and cell biology. Overall, fungi's diverse contributions underscore their importance in agriculture, industry, medicine, and environmental sustainability. Fungi can pose various harmful effects on both humans and the environment. Mold growth in buildings can lead to respiratory issues and structural damage. Some fungi produce toxins that contaminate food, causing food poisoning or allergic reactions. Agricultural fungi can devastate crops, leading to economic losses and food shortages. Additionally, fungal infections in humans and animals can result in serious illness or even death if left untreated. Overall, understanding and managing the harmful effects of fungi are essential for maintaining health and safety.

Viruses, while primarily known for causing diseases, also find beneficial applications in various fields. In molecular biology and genetics research, viruses serve as vectors for gene delivery and manipulation, facilitating the study of cellular processes. Viral vectors are employed in gene therapy to treat genetic disorders by delivering therapeutic genes into host cells. In agriculture, certain viruses can be harnessed for biocontrol, targeting and controlling pests that damage crops.

Viruses are instrumental in the production of vaccines, where weakened or inactivated forms stimulate the immune system to build resistance against specific diseases. Viruses are notorious for their harmful effects on both humans and other organisms. They cause a myriad of diseases ranging from the common cold to more severe conditions like influenza, HIV/AIDS, and COVID-19. These diseases can lead to significant morbidity and mortality, placing immense strain on healthcare systems and economies worldwide. Moreover, viruses can also impact agricultural productivity by infecting crops and livestock.

Table 1: Useful and harmful effects of microorganisms

Category	Micro organisms	Useful effects	Harmful effects
Bacteria	Lactobacillusreuteri	Used in the treatment of diarrhea, hay fever, eczema	Cough, rashes, tightness in chest, trouble in breathing
	Bifidobactriumbifidii	Helps to digest fiber, prevent infections and produce vitamins and healthy fatty acids.	Weaken immune system and cause infections, stomach bloating or discomfort.
	Eschehrichia coli	Aids digestion and protect us from harmful microbes.	Stomach pain, bloody diarrhoea and kidney failure.
	Streptococcus pneumoniae	Absorb nutrients, fight off bad organisms that might cause diseases, used to produce fermented dairy foods such as yogurt	Cause meningitis, neonatal sepsis, fever, nausea, headache.
	Corynebacterium diphtheriae	Production of amino acids and nucleotides and bioconversion of steroids.	Difficulty in breathing, heart rhythm problems and even death
Fungi	Saccharomyces cerevisiae (yeast)	Production of vitamin B, production of bread	Causes candidiasis
	Penicillium notatum	Used as antibiotic, cheese making	Runny nose, sneezing, coughing, itchy nose, watery eyes
	Agaricusbisporus	Rich source of fiber, protein, reduce the risk of diabetes and cancer	Drowsiness, hallucination, anxiety
	Aspergillus proliferous	Used in fermentation industry.	Produce myotixins
Algae	Claviceps purpurea	Used to treat parkinson's disease and used migrane headache	Produce black spurs in grass
	Green algae(chlorophyta)	Antioxidant in cosmetics, anti-bacterial, anti-viral, anti-cancer.	Causes skin irritation, mild respiratory effects and causes hay fever like symptoms.
	Brown algae(phaeophyta)	Used as a stabilizer in baking and ice-cream industries and used as fertilizer.	Causes inflammation and effects the body's immune system
	Redalgae (rodophyta)	Used to produce agar that is used as a food additive and it is rich in calcium.	Produce toxins that kills fish and make shellfish that is dangerous to eat
	Fucus vesiculosus	Used to treat thyroid disorders, constipation, obesity and aging skin.	Causes iodine allergy and it is not used in surgery
	Spirogyra	Anti-biotic, anti-viral, anti-oxidant, anti-inflammatory and cytotoxic purpose.	Causes diarrhea, nausea, eye and throat infection, breathing difficulties

MICROBES USED IN AGRICULTURE:

Traditional agricultural techniques, such as chemical fertilizers, pesticides, fungicides, and herbicides, enable the protection of crop plants against pathogens and ensure better yield. Chemical compounds present in agricultural chemicals are harmful to the environment and cause soil, atmosphere, and water pollution. These compounds are the reason for the extinction of fish, bees, and plants, and pose a threat to the biodiversity of soil bacterial and fungal communities. Chemical plant protection products negatively affect agricultural soils, i.e., they change soil physical properties, (e.g., texture, permeability, porosity), they disturb the cycle of the elements, such as phosphorus and nitrogen, and they decrease the complexity of soil microbiome. The following are the applications of various microorganisms in the field of agriculture

Table 2: Application of microorganisms in agriculture⁴

Microorganisms	Functions	Applications
Rhizobium species	Nitrogen fixation in legumes	Inoculated into legume seeds
Mycorrhizial fungi	Enhance nutrient absorption	Applied to plant roots
Bacillus subtilis	Plant growth promotion, disease resistance	Soil application and seed treatment
Trichoderma species	Bio control against soil-born pathogen	Soil application and seed treatment
Pseudomonas fluorescens	Plant growth promotion, disease suppression	Soil drench, seed treatment
Azotobacter species	Nitrogen fixation in free living state	Soil application and seed treatment

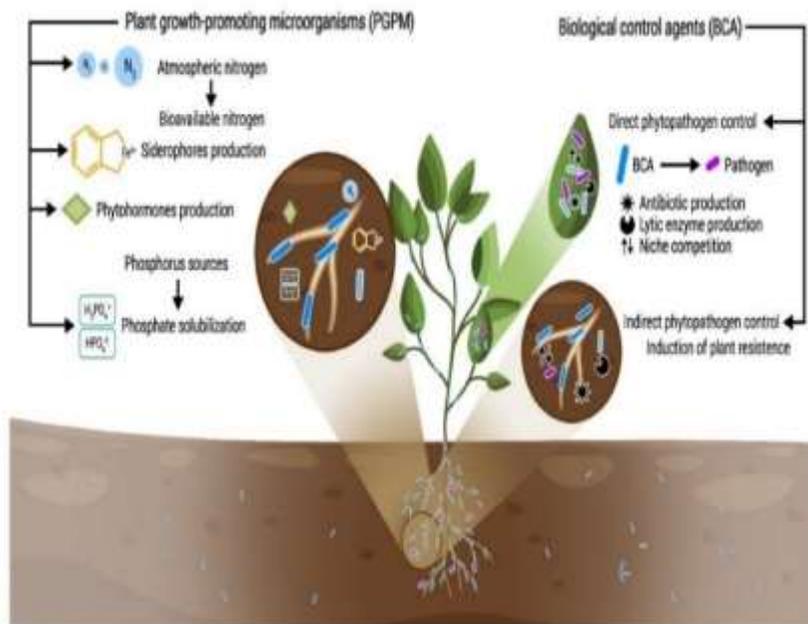


Figure 1: Examples of action mechanisms by beneficial microorganisms in interactions with plants.

Bioinoculants in agriculture

Bioinoculants comprised of living or dormant microbes that are able to promote plant growth and development are called PGPM (plant growth-promoting microorganisms) and have great potential not only for enhancing plant yield but also for remediation of degraded soils. Bioinoculants are cost-effective and environmental-friendly approaches in agriculture. The bio-inoculant formulation is the isolation and identification of a microbe followed by verification of plant growth promotion. An example of a bioinoculant is Rhizobium bacteria, which forms symbiotic relationships with leguminous plants, aiding in nitrogen fixation and promoting plant growth.[5]

Microbial vaccine in agriculture

Microorganisms or their products (toxins) are used by humans to control insects, plant and animal pathogens, weeds, etc. This is called biological control by microbes. This may involve the use of microbial vaccines to control single types or classes of plant diseases. Alternatively, this may involve soil management to promote the combined activity of natural soil and plant associated microbes that contribute to overall control. Biological control, in its narrowest sense, refers to the control of a single pathogen (or pest) by a single antagonist in a single cropping system.

Microbes used in pest control:

Table 3: Application of microorganisms in pest control [6]

Microorganisms	Target pest	Application
Bacillusthuringiensis	Catterpillars, mosquito larvae	Sprayed on crops used in mosquito control
Beauveriabassiana	Bettles, ants, insects	Applied as biopesticides
Metarhizium anisopliae	Termites, beetles and other insects	Applied as biopesticides
Trichoderma species	Soil borne pathogens nematodes	Used as soil treatment to control plant diseases

MICROBES USED IN FOOD:

Most commonly used microorganisms are yeast, bacteria, moulds, or a combination of these. A good example of microorganism usage in food production is the process of fermentation, which results in the production of organic acids, alcohols and esters. These help to either:

1. Preserve the food
2. generate distinctive new food products

Table 4: Microorganisms used in food preparation [7]

Microorganisms	Food components	Fermented food
L. vulgaris	Milk	Yoghurt
Saccharomyces cerevisiae	Milk	Kefir
L. plantarum	Green cabbage	Sauerkraut

Leuconostocmesenteriodes	Cabbage	Kimchi
L. reuteri	Flour, water	Sourdough
Gluconaceacetobacter	Tea, water, sugar	Kombucha
Sccharomycescervisiae	Grapes	Wine
Yeast, Moulds, <i>Streptomyces</i>	Meat	Fermented sausagaes

MICROBES USED IN PREPARATION OF MEDICINE

Various microbes play a crucial role in medicine production. For instance, bacteria like *Escherichia coli* and *Bacillus subtilis*, as well as yeast like *Saccharomyces cerevisiae*, are commonly used in biopharmaceuticals and vaccine production. These microorganisms are employed to produce proteins, enzymes, and other therapeutic substances through genetic engineering and fermentation processes.

Table 5: Microorganisms used in medicine preparation [8]

Microorganisms	Drugs/ medicines	Activity
Penicillium	Penicillin G, V Ampicillin	Antibiotic
<i>Streptomyces nodosus</i>	Ambisome, amphotec	Antifungal
<i>Streptomyces avavermitilis</i>	Ivomec	Anthelmintic
<i>Streptomyces hygroscopicus</i>	Rapamune	Immune suppressant

THE ROLE OF MICROBIAL COMMUNITY IN THE DECOMPOSITION

Dead organic material in forest ecosystems is made up of a variety of leftovers, such as fallen leaves, needles, and coarse and fine deadwood. According to Mason (1977) and Scarascia-Mugnozza (2000), leaf litter can make up 22–81% of the plant litter produced annually other types of litter include twigs, branches, bark, flowers, and occasionally cones. According to estimates, deciduous trees in cold and mild temperate forests produce between three and five tons of leaf litter (henceforth referred to as "litter") per hectare annually. Senescent leaves in deciduous woods begin to fall in the fall, forming the initial layer of litter stratification. The existence of this litter layer on the forest floor serves a number of crucial purposes, including preventing erosion, reducing the amount of rains that might destroy soil aggregates, protecting against changes in the microclimate, and preventing soil compaction (Sayer, 2006). Deadwood is another important kind of forest waste. It is made up of fallen logs, stumps, snags, standing dead trees, and dead roots.

Dead people would cover the entire planet if microorganisms didn't exist. In order to collect nutrients, bacteria digest dead organisms, animal waste, and plant litter. However, microorganisms recycle nature's garbage in addition to eating it. Chemicals (such carbon, nitrogen, and phosphorus) that are necessary for the development of new plants and animals are released throughout the decomposition process. In other words, substances that were once considered flowers or vegetables will eventually find their way into another living organism.



Figure 2: Unseen bacteria decompose brine fly pupal casings that wash up on the shore of Great Salt Lake.

Snippets (bits and pieces) of sections

- **Modifications in both structure and function**

The breakdown of the cell walls releases the carbon that is present in the litter. Based on their degree of recalcitrance, the components of the cell wall can be categorized into three main categories: According to Fioretto (2005), there are two types of molecules that are soluble in water: i) hemicellulose, cellulose, and pectin; ii) lignin and other aromatic compounds. Small compounds, such as carbohydrates and amino acids, which are readily obtainable and broken down by the rapidly proliferating microbes, make up the first group.

- **Primary decomposition agents.**

Fungi are thought to play a major role in the breakdown of wood and litter, with bacteria playing a supporting role to a lesser degree.

- **Properties of Substrate**

Substratum features that represent the capacity of certain taxa to access and metabolize particular structural chemicals have an impact on microbial communities. Because of this, this type of tree plays a crucial role in determining how the decomposing community is shaped, both for the decomposition of wood and litter. [9]

The World Is Fed by Microbes

A lot of creatures get their sustenance from microorganisms. Microbes are at the bottom of the food chain due to their microscopic size. At Great Salt Lake, for instance, bacteria feed brine flies and brine shrimp, which in turn feed the birds. Great Salt Lake serves as a feeding, resting, and nesting destination for millions of migrating birds that come from hundreds of different species.

Microbes Maintain Our Health

While most bacteria are benign or even beneficial, some can cause illness. Our own cells are outnumbered ten to one by microbes. The healthy bacteria in our mouths stop the growth of fungi. Over 100 different species of microorganisms that support healthy skin can be found on our forearms. Additionally, our digestive tract contains roughly three pounds of beneficial microorganisms that aid in food digestion.

They feed us vital vitamins and break down carbohydrates. And it's not just us who gain from having a relationship with bacteria. Trillions of them are inadvertently hidden within every plant and animal.

The Living Dead: Bacterial Community Structure of a Cadaver at the Onset and End of Bloat Stage of decomposition

When seen as an ecosystem supporting a variety of bacteria, insects, and fungi, many of which are only known to exist and be required in such circumstances, a cadaver is far from dead. Decomposition is a mosaic system in which biotic factors are closely related to one another. Although the process of decomposition is frequently attributed to bacteria, there aren't many published research that list the microbiome of decomposition. A body undergoes multiple stages of decomposition, which are triggered by dehydration and are identifiable by distinct, coarse taphonomic alterations. Wetness and flesh discoloration, along with the beginning and end of bacterially-induced bloat, are indicative of the early stages of decomposition. Intrinsic bacteria start to break down the intestines from the inside out during early deterioration, eventually consuming the surrounding tissues. Additionally, the cadaver's dead cells' enzymes start to degrade the tissues.

Additionally, the cadaver's dead cells' enzymes start to degrade the tissues (a process known as autolysis). Anaerobic respiration is a process that bacteria go through during putrefaction, producing gases as byproducts as methane, hydrogen sulfide, cadaverine, and putrescine. As a result of the gas accumulation, pressure is created, which causes the carcass to swell and finally forces fluids out. The transition from early to late decomposition is signified by this purging action, which might not be consistent.[10]

Microbes in sewage treatment:

Sewage treatment by microbes involves the use of microorganisms to break down and remove organic pollutants in wastewater. The process typically occurs in wastewater treatment plants and follows these key steps:

1. **Primary Treatment:** In this phase, large debris and solids are physically removed from the wastewater through processes like screening and sedimentation. This helps reduce the overall organic load before microbial treatment.
2. **Secondary Treatment:** Microbial treatment primarily occurs in the secondary treatment stage. This involves the use of aerobic (oxygen-dependent) or anaerobic (without oxygen) microbes to break down organic matter. The two common types of secondary treatment are:

Activated Sludge Process: Wastewater is mixed with microorganisms in aeration tanks. The microbes consume organic pollutants, and the resulting mixture (activated sludge) is settled and separated.

Trickling Filter Process: Wastewater is trickled over a bed of rocks or plastic media where microbial biofilms develop. These biofilms contain bacteria and other microorganisms that digest organic substances.

Tertiary Treatment (Optional): Tertiary treatment may follow secondary treatment to further polish the water. This can involve additional filtration, chemical treatment, or advanced biological processes to remove remaining contaminants.

The microbes involved in sewage treatment play a crucial role in breaking down complex organic compounds into simpler, more stable substances. Key microbial activities include:

Aerobic Bacteria: Consume organic matter in the presence of oxygen, producing carbon dioxide and water.

Anaerobic Bacteria: Function in the absence of oxygen, breaking down organic compounds and producing gases such as methane.

Overall, microbial sewage treatment is an environmentally friendly and cost-effective method for purifying wastewater before its release into natural water bodies or reuse in certain applications.

All these factors generate quantitative changes between autotrophic and heterotrophic bacteria. Tetrasphaera, Rhodoferrax, Rhodobacter, Candidatus Microthrix, and Hyphomicrobium are the bacteria. The way that bacteria obtain oxygen separates them into other groups. Three main types of bacteria aerobic, facultative, and anaerobic are utilized in wastewater treatment to treat the waste that enters the treatment plant.

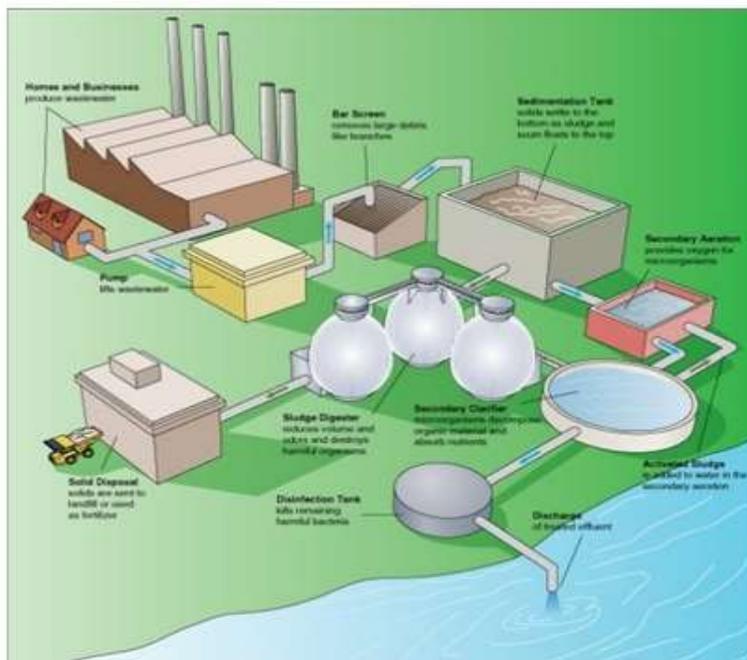


Figure 3: Microbes in sewage treatment

The majority of our wastewater is managed by large-scale operations using an approach known as activated sludge. This method, which was developed just over a century ago, consists of the following fundamental steps: filtration, activation (aeration), clarity (settling), and disinfection. Sludge is a very rich medium that is full of organic materials that microorganisms find tasty but humans find repulsive. The term "activated sludge," which can apply to both the substance and the waste management procedure, is used to describe this sludge after microorganisms have broken it down. Sludge is an extremely rich medium, full of organic elements that are disgusting to humans but delicious to microbes. Once the material has been broken down by microorganisms, it is referred to as "activated sludge," a phrase that can be used to refer to both the substance and the waste management process. Then Aeration process by the use of aerobic bacteria in the sludge to proliferate and expand, they must break down the organic material surrounding them. This process is known as nitrification, and it converts ammonia into nitrate and nitrite. Then clarification and disinfection process occurs activated sludge settles at the bottom and is sent off for additional processing once the water has clarified to the facility's satisfaction. After clarification is disinfected with ultraviolet (UV) rays or chemicals, such as chlorine is used. Finally, any pathogenic organisms left are effectively eliminated by this phase. [11]

MICROBES IN PETROLEUM REFINING

A new bioengineering approach called microbial enhanced oil recovery (MEOR) combines oil recovery techniques from petroleum engineering with the features of microbes. MEOR stimulates microbial activity, enabling the release of metabolic products from the microorganisms, including

biomass, biosurfactants, biopolymers, biogases, bioacids, and biosolvents the development of MEOR as a competitive substitute for chemically enhanced oil recovery (CEOR), which is mostly viewed as an expensive and environmentally unsound technique [12]

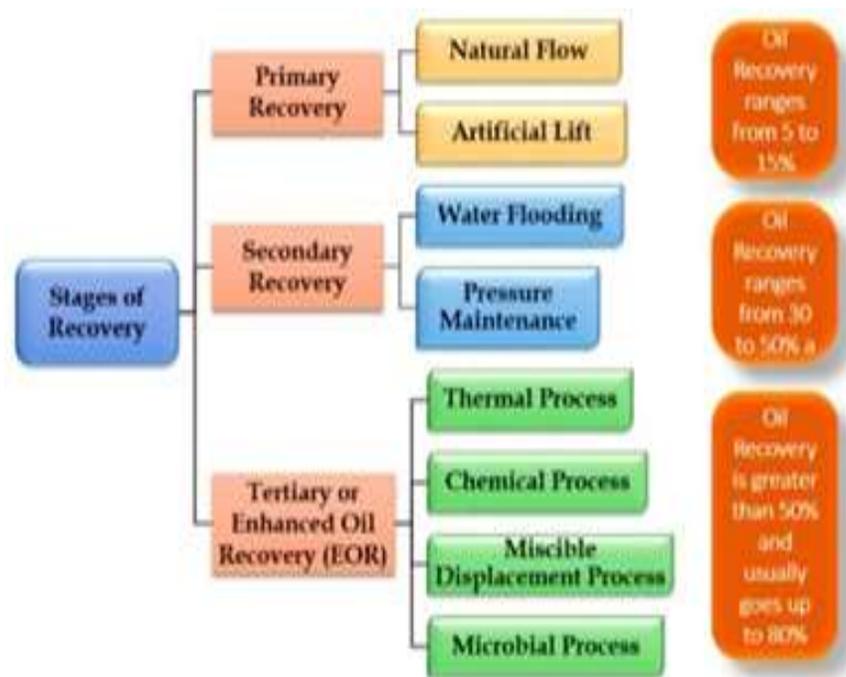


Figure 4: Schematics on the classification of the oil recovery phases.

The field pilot of microbial enhanced oil recovery (MEOR) in a high-temperature petroleum reservoir represents a practical initiative to test the efficacy of microbial treatments in improving oil recovery under challenging conditions. The microbial treatments are expected to employ various mechanisms to enhance oil recovery. This may include the modification of interfacial tension, wettability, or the production of gases and biomass that influence the reservoir's characteristics and aid in oil displacement. Environmental and Economic Implication will Assessing the environmental impact and cost-effectiveness of MEOR in high-temperature reservoirs is crucial. Successful outcomes could present MEOR as a sustainable and economically viable option for enhancing oil recovery in challenging thermal environments. The field pilot of microbial enhanced oil recovery in a high-temperature petroleum reservoir is an applied study aimed at demonstrating the practicality and benefits of using microorganisms to improve oil production in extreme thermal conditions. [13]

MICROBES AND DISEASES

Only a tiny percentage of bacteria, for example, are dangerous enough to infect humans when they enter our bodies as hosts. Infectious illnesses like the flu and measles are brought on by microbes. Additionally, there is compelling evidence linking bacteria to a number of chronic non-infectious

disorders, including certain types of cancer and coronary heart disease. Various microorganisms can cause a variety of diseases. Pathogens are microorganisms that cause illness. Microbes need to get inside of our bodies in order to infect us. The entrance point is referred to as the doorway of entry.

Table 6: Microbes and diseases [14]

Infectious disease	Microbe that causes the disease	Type of microbe
Cold	Rhinovirus	Virus
Chickenpox	Varicella zoster	Virus
German measles	Rubella	virus
Whooping cough	Bordatella pertussis	Bacterium
Bubonic plague	Yersinia pestis	Bacterium
Tuberculosis	Mycobacterium tuberculosis	Bacterium
Malaria	Plasmodium falciparum	Protozoan
Ringworm	Trichophyton rubrum	Fungus

Table 7: Microorganisms used in disease treatment [15]

Microorganism	Uses in disease treatment
Bifidobacterium species	induces apoptosis and inhibits invasiveness of non-small cell lung cancer cell
Lactobacillus species	Prevent infection
Arbuscular mycorrhizal fungi	Control soil-borne pathogens
Streptococcus salivaries	Upper respiratory and oral infection

MICROBES IN MARINE

In recent decades, lead compounds that have been determined to have several pharmacological applications have come from marine sources. It is interesting to note that marine microorganisms continue to be the most important and unknown source of numerous bioactive compounds. Microorganisms occupy an endurance range that stretches from the shallow water of the shoreline to the vast seaward regions that cover 70% of the biosphere. Certain marine species may be able to produce unique secondary metabolites since the marine system differs from the terrestrial environment in terms of temperature, pressure, and sun light.

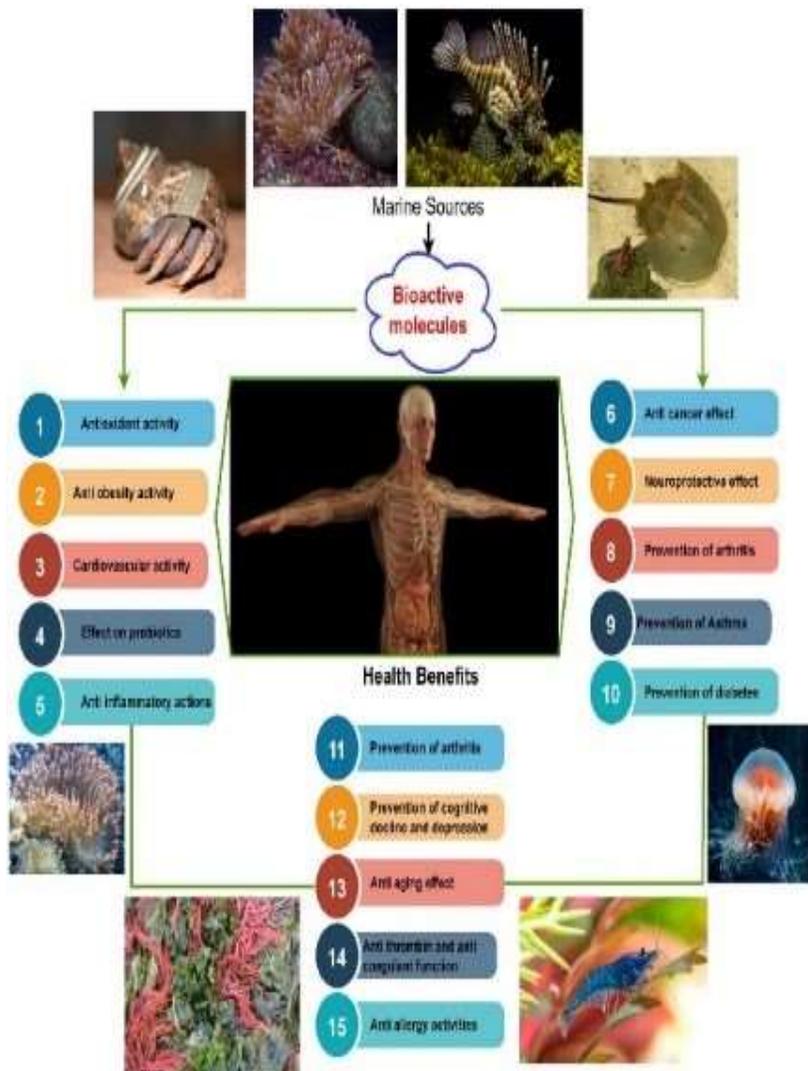


Figure 5: Diagrammatic representation showing health benefits from marine microbes

Table 8: The following is the table of drugs derived from marine microorganisms and their uses

Drugs	Derived from	Uses
Eribulin (halaven)	Marine sponge	Metastatic breast cancer
Aplidin (Plitidepsin)	Marine tunicate	Investigated for anti-cancer properties
Salinosporamide A	Marine bacterium	Studies for its potential anti-cancer agent
Bryostatin	Marine bacterium	Alzheimer’s disease

As a matter of fact, the ecology of marine natural products reveals that a large number of these chemicals are weapons that have developed into extremely strong physiological process inhibitors in predators, rival marine organisms, and prey. Natural products have been a useful source for treating a variety of illnesses since the dawn of humans. Over half of all pharmaceuticals available for clinical use globally are derived from natural sources. Because of the negative effects of

synthetic medications, the process of finding new drugs from natural sources is currently underway. [16]

Bioactive substances derived from marine microorganisms have antibacterial properties. There are few treatment options available for conditions like Alzheimer's, rheumatoid arthritis (RA) and other typer arthritis, type 1 diabetes, heart diseases, irritable bowl syndrome, allergies, asthma, cancer and many more. Additionally taking too much of some medications can have serious negative effects on a patient's health.

MICROBES IN SPACE

Microorganisms, including viruses, bacteria, fungal spores, and lichens, exhibit varied responses to space conditions such as microgravity, galactic cosmic radiation, solar UV radiation, and space vacuum. While they often thrive in space, displaying enhanced growth and resistance to inhibitory levels of antibiotics, the underlying mechanisms remain unclear. Experiments refuted the hypothesis of microgravity interacting with radiation-induced DNA repair processes. Extraterrestrial solar UV radiation emerged as the most detrimental space factor, affecting all organisms except lichens. Lichens maintained viability in outer space, challenging the upper biosphere boundary. The study supports the concept of lithopanspermia, suggesting the potential interplanetary transfer of microorganisms within meteorites, especially if shielded from solar UV. [17]

Microbes offer significant potential for diverse applications in space exploration, contributing to biological life support systems (BLSS), in situ resource utilization, and astronaut therapeutics. Their versatility spans health-related functions, renewable resource utilization, or a combination of both. However, the challenges of heightened pathogenicity and biofilm formation during spaceflight pose potential threats to astronaut health and spacecraft integrity. Effective mitigation strategies are crucial to address these hazards, ensuring the safe and beneficial. [18]

Table 9: Microorganisms and their products used in real space environment-[19]

Microorganisms	Products in real space environment
Streptomyces coeli color A3	Changes in secondary metabolite production and morphology; production of bioactive (antibacterial) substances.
Streptomyces fradiae	Increased production of the antibiotic tylosin
Streptomyces plicatus	Increased actinomycin D production after 17 days in space
Streptomyces avermitillis	Increase of avermectin production after 40h in space (Shenzhou VII-mission)
Streptomyces plicatus	Increased actinomycin D production onboard the ISS
Humicolafuscoatra WC5157	Increased production of monorden on board the space shuttle mission STS-77

Nocardiamediterranei var. kanglensis 1747-64	Increased production of immunosuppressant kanglemycin C after 6 days of space exposure (Shenzhou III)
Salmonella	Development of new vaccines against diarrhoea-causing salmonella strains aboard the ISS

MICROORGANISMS IN ANTIBIOTIC PRODUCTION:

The term antibiotic, which means "fight against health," is often used methods by various investigators. antibiotics as molecular low weight-bearing compounds produced by microorganisms that inhibit the growth of other creatures in the vicinity of the low-lying area. Similarly, Thomas how and his colleagues refer to antibiotics as distinct chemicals low-molecular compounds of cells produced by other micro-organisms to inhibit the growth and binding metabolic activity of other microorganisms. Therefore, Okafor described antibiotics as ingredients produced by any living species (microbes, algae, plants, or animals) that contained the ability to inhibit the growth of another species, in a low-lying area. In a broader sense, chemotherapeutic antibiotics prevent the growth of species such as bacteria, fungi, viruses, and protozoa. Antibiotics comprise a broad group of chemicals it is combined with the various cellular targets in fighting infectious diseases. Some antibiotics are different of applications are therefore widely produced volumes, e.g. penicillins, and some only give applications and therefore only produced at small quantities prices, e.g. vancomycin.

Table 10: Application of microorganisms in antibiotic preparations[20]

Microorganism	Antibiotic	Spectrum of activity
Penniciliumchrysogenum	Penicillin	Gram-positive bacteria
Streptomyces rimosus	Tetracyclin	Broad spectrum
Streptomyces griseus	Streptomycin	Gram-negative bacteria
Cephalosporiumacremonium	Cephalosporin	Broad spectrum
Bacillus subtilis	Bacitracin	Gram-positive bacteria

ROLE OF MICROBES IN ENZYME PRODUCTION

Enzymes are biocatalysts produced by living cells to bring about specific biochemical reactions generally forming parts of the metabolic processes of the cells. Enzymes are highly specific in their action on substrates and often many different enzymes are required to bring about, by concerted action, the sequence of metabolic reactions performed by the living cell. All enzymes which have been purified are protein in nature, and may or may not possess a nonprotein prosthetic group.

Table 11: Application of microorganisms in enzyme production[21]

Microorganisms	Enzymes produces	Applications
Rhizopusniveus	Amyloglucosidase	Hydrolysis of starch
Aspergillusniger	Cellulose	Production of alcohol
Bacillus amyloliquefaciens	Glucoamylase	Hydrolysis of starch
Arthrovacter sp.	Glucose isomerase	Manufacturing of high fructose syrup
Saccharomyces cervisiae	Invertase	Inversion of sucrose
Streptomyces fradiae	Keratinase	Removal of hair from hides
Escherichia coli	Penicillin acylase	Production of 6-aminopenicillanic acid
Bacillus subtilis	Protease	A beer stabilizer
Aspergillus oryzae	Protease	As a meat tenderiser

ROLE OF MICROBES IN SENSORS AND DIAGNOSTICS:

Microbial biosensors are ingenious devices that integrate living microorganisms with transducers to detect specific substances. These microorganisms are engineered to respond to a target molecule by emitting a measurable signal, such as light or electrical current. By utilizing the natural recognition capabilities of microbes, biosensors can identify a wide range of analytes, including toxins, heavy metals, and even disease-causing pathogens. Microbial sensors are particularly promising in healthcare diagnostics. They offer the potential for early and accurate disease detection, paving the way for personalized medicine. For instance, biosensors can identify specific biomarkers associated with conditions like cancer or infectious diseases. This enables faster and more precise diagnosis, leading to timely interventions and improved patient outcomes.

Microbial sensors also play a vital role in environmental monitoring. They can be deployed to assess the quality of air, water, and soil by detecting pollutants and contaminants. In aquatic environments, microbial sensors are used to identify harmful algal blooms, ensuring the safety of drinking water sources and aquatic ecosystems. This real-time monitoring capacity is essential for preventing environmental disasters and safeguarding public health. Microbial sensors offer several advantages over traditional methods. Their rapid response times and sensitivity make them ideal for on-site testing and monitoring. Moreover, their ability to be integrated into portable devices empowers healthcare professionals, researchers, and field workers to access valuable information quickly. However, challenges such as maintaining microbial viability, standardizing detection protocols, and ensuring sensor reliability remain areas of active research and development.

How is Bacterial Biosensors Used?

Perhaps a better question is: What can't bacterial biosensors be used for? The list of applications for these tiny tools is continuously growing. In general, however, their applications can be split into 2 categories: environmental and biomedical.

Environmental Applications

On the environmental front, whole-cell biosensors provide insight on nutrient levels and organic compounds in soils, which can inform methods for managing crop growth. They can also signal the presence and levels of potentially problematic compounds. For example, Ajo-Franklin's group, along with collaborators at Rice, developed a biosensor that can detect thiosulfate, a chemical commonly used in water treatment that in excess amounts can trigger microbial freshwater blooms. Notably, most biosensors rely on transcription of a reporter gene to produce a signal, which takes time (up to 30 minutes) and lots of cellular energy. In an effort to optimize the process, the Rice team took a post-translational approach, creating a synthetic electron transport chain in *Escherichia coli*. Electrons from thiosulfate move through this synthetic chain and ping up against an electrode, generating an electrical current in 1 minute or less. With this technology, "we have the chance to rapidly respond to an unintended release [of an environmental toxin] so that we could mitigate the ecological impact," Ajo-Franklin said.

Biomedical Applications

In addition to nutrients and toxic compounds, bacterial biosensors can be designed to respond to, well, other bacteria. Microbes secrete all sorts of metabolites, many of which could serve as target analytes. For instance, microbial biosensors that detect quorum sensing molecules secreted by bacterial pathogens can signal the presence of disease-causing microbes in water, or in human samples to help diagnose infections.

Indeed, bacterial biosensors may provide useful intel into the health of human patients. A recent study described a biosensor made from the environmental bacterium, *Acinetobacter baylyi*, that can detect DNA from cancer cells *in vitro* and in a mouse model. This study provides a basis for the application of microbial biosensors in cancer detection and diagnosis. Scientists have also created ingestible biosensors that can detect bleeding or inflammatory biomarkers in the gut to monitor intestinal health; the signals from these internal microbial devices can be transmitted to external devices, like cell-phones, thus illustrating how biosensors can be paired with existing digital technologies to facilitate data collection and analysis.[22]

CONCLUSION:

Microorganisms, including bacteria, fungi, and viruses, play crucial roles in various ecosystems, industries, and human health. They contribute significantly to soil fertility, and plant health in agriculture. In medicine, microorganisms are utilized in the production of antibiotics, vaccines, and other pharmaceuticals. Additionally, they aid in sewage treatment, biosensors and diagnostics.

Overall, understanding and harnessing the beneficial effects of microorganisms can lead to advancements in agriculture, medicine, biotechnology, and environmental sustainability.

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