OPEN ACCESS

Kashf Journal of Multidisciplinary Research
Vol:01 Issue:09 2024
P-ISSN: 3007-1992 E-ISSN: 3007-200X
https://kjmr.com.pk

MICROORGANISMS: BENEFITS AND EFFECTS

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Article Info

Received: 3rd September, 2024
Review 1: 15th September, 2024
Review 2: 19th September, 2024
Published: 28th September, 2024

Abstract

This paper makes a review on microorganisms benefits and Effects. Microorganisms are minute beings, very ubiquitous in our environment. They have beneficial and negative effects as well. They are responsible for maintaining the cycles of life (such as nitrogen cycle), provide us with a lot of useful things such as enzymes, drugs, etc. However, microorganisms are also harmful on the other hand, due to their role in disease transmission. This review paper discusses about, microorganisms, bacteria, viruses, fungi, benefits of microorganisms, effects of microorganisms, control of microorganisms, and relations. Proper prevention methods are diverse in order to control microorganisms and minimize impending effects.

Keywords: *Bacteria, fungi, virus, culture, vector, infection, death, hygiene.*

Introduction

Recent advances have led to opening up of microbial world, consisting of minute living things dubbed as microorganisms or germs or pathogens. They are ubiquitous in every place, including the air, soil, water, objects and living organisms. Many microbes are described as disease-causing (infectious) and affect biota devastatingly. However, some microorganisms benefit us significantly (such as saprophytic microbes). Over the years, humans have developed ways of utilizing microbes for beneficial purposes (Golec et al., 2007; Wani et al., 2023).

Nevertheless, some microorganisms are unicellular in nature, such as bacteria, and some fungi exist as multicellular organisms. Bacteria exists as simple, without a nucleus. Fungi have a nucleus entity enclosing genetic material, while viruses are the smallest microbes (Kadam & Shalgaonkar, 2022).

Many microorganisms are diverse, due to encouraging factors microorganisms are becoming a thing of concern, more devastating in poor areas of the world (Abbas et al., 2021). The microorganisms have inherent ability to live in difficult conditions, and are supported by determinants in developing countries of the world. Factors such as inadequate immunity, poor prevention, poor vector control, poor pest control, poor health education, contaminated water, poor food hygiene, food insecurity, poor vaccination coverage, personal inequalities (such as poverty level, unemployment, malnutrition), disasters (such as wars, flooding), and human factors encourage effects of microorganisms on humans (Maraz & Khan, 2021). This paper makes a review on microorganisms benefits and effects.

Microorganisms

Microorganisms are minute living beings that can be seen only by microscope aid. Microbes or germs are other names of microorganisms. They are found in water, soil, air, objects, and living organisms. Microbes causing diseases are known as pathogens. Microbes are classified as follows: Bacteria, viruses, fungi, etc (Maraz & Khan, 2021).

Culture

A culture is a specific media for growth of microorganisms. It is a culture that support the growth of microorganisms. The process of culturing living cells or tissues for the growth of microbes is termed as tissue media. A culture media incorporates an agar (jelly-like substance obtained from weed), nutrients (such as beef extract, vegetable juice). Nutrient agar culture may consist of 3g beef extract, 5g peptone, 15g agar, 100 cm^3 water. Mostly, the nutrients required by an organism are provided in their media for growth. Enriched media contains added nutrients for certain purposes, such as blood nutrients agar. Culture media are out in petri dish or test tube dwelling in slant style. A supported microbe in a culture will grow if there are optimum condition, thereby forming colonies. A colony is an association of microbes that differ in size, elevation and shape (top, and side view), texture (rough, smooth), effects on culture, opaque or translucent, pigmentation and color. Culture media may be classified as follows (Abbas et al., 2021; Maraz & Khan, 2021):

Basic media -A type simple media that do not contain special treatment. For instance, nutrient broth, nutrient agar.

Enriched media -This is a type of media that is utilized to grow microorganisms with special

nutritional requirements like *Streptococcus species, Neisseria species*.

Selective media- A type of media that is utilized to inhibit the growth of certain unwanted microorganisms.

Identification media-The media that is used in order to identify certain bacteria isolated on basically primary cultures is called identification media. It involves addition of certain substances for identification of certain organisms, for example, peptone water sugars, Kligler iron agar.

Transport media- They are utilized to transport microorganisms isolated from one place to the other. They contain chemicals that ensure commensals and others are in a harsh situation, therefore, cannot grow. For instance, Cary-Blair media.

Indicator media - Otherwise known as differential media, include a media containing added dyes or substances to help in differentiating one organism from the other, for instance, MacConkey agar.

Certainly, culture media may also be distinguished as follows:

Solid - A solid media is a solidified form of media such as agar, and gelatin.

Semisolid media- Is manufactured by mixing small agar amount to the liquid media.

Fluid media- They are liquid in nature such as blood culture (Cheesbrough, 1998; Abbas et al., 2021; Kadam & Shalgaonkar, 2022).

Bacteria, Features, and Classification

Bacteria is a group involving large number of unicellular parasites, free-living, saprophytes, of varying size (0.1-10um long). They possessed a simple DNA, RNA, and reproduce through binary fission. Features such as morphology, cultural characteristics, staining, biochemical reactions, antigenic structure, could be used to classify bacteria (Cheesbrough, 1998).

Table 1: Some bacteria caused infections Structure

Bacteria type	Disease (infection)	Route	Effects
Vibrio cholerae	Cholera	Food, water	Vomiting, diarrhea, dehydration
Salmonella typhi	Typhoid	Contaminated Food, water	High fever, bloody diarrhea
Clostridium tetani	Tetanus	Soil, dust, faeces	Death
Treponema pertenue	Yaws	Skin contact, flies	Serious veneral effects
Mycobacterium tuberculosis	Tuberculosis	Air, contaminated milk	Cough, spread and destroy lungs
Corynebacterium diphtheriae	Diphtheria	Air	Tissue damage
Shigella dysenteriae	Bacterial dysentery	Food, water	Abdominal pain, diarrhea

A bacteria structure simply has cytoplasm (involving chromosome, ribosomes, energy, plasmids), cytoplasmic membrane, mesomes, cell wall (with exception), external features (such

as flagella, capsule, pili). A genome consists of DNA coiled in the cytoplasm. Plasmids refers to a self-replicating, single, double stranded circular DNA entities that allow the cell to exchange genetic material among bacterial species. Ribosomes are meant for protein synthesis in the cytoplasm and store energy. Cell wall is a rigidity and protection wall against osmotic damage. Cell wall consists of peptidoglycan. Using cell wall bacteria can be regarded as Gram negative bacteria or Gram positive bacteria. Cytoplasmic membrane (and mesosomes) are semipermeable membranes that monitor movement of nutrients, and excreting products in or out of the cell. Mesosomes are convoluted sites present in the cytoplasm and are responsible for respiratory enzymes and assist reproduction (Abbas et al., 2021; Kadam & Shalgaonkar, 2022).

External parts of bacteria include flagella, capsule, fimbriae. Flagella is found in motile bacteria such as salmonella species; pili are hair like entities in Gram positive bacteria and aid adherence to one another. Capsule is secreted as thick material with the purpose of aiding virulence and identification (Cheesbrough, 1998).

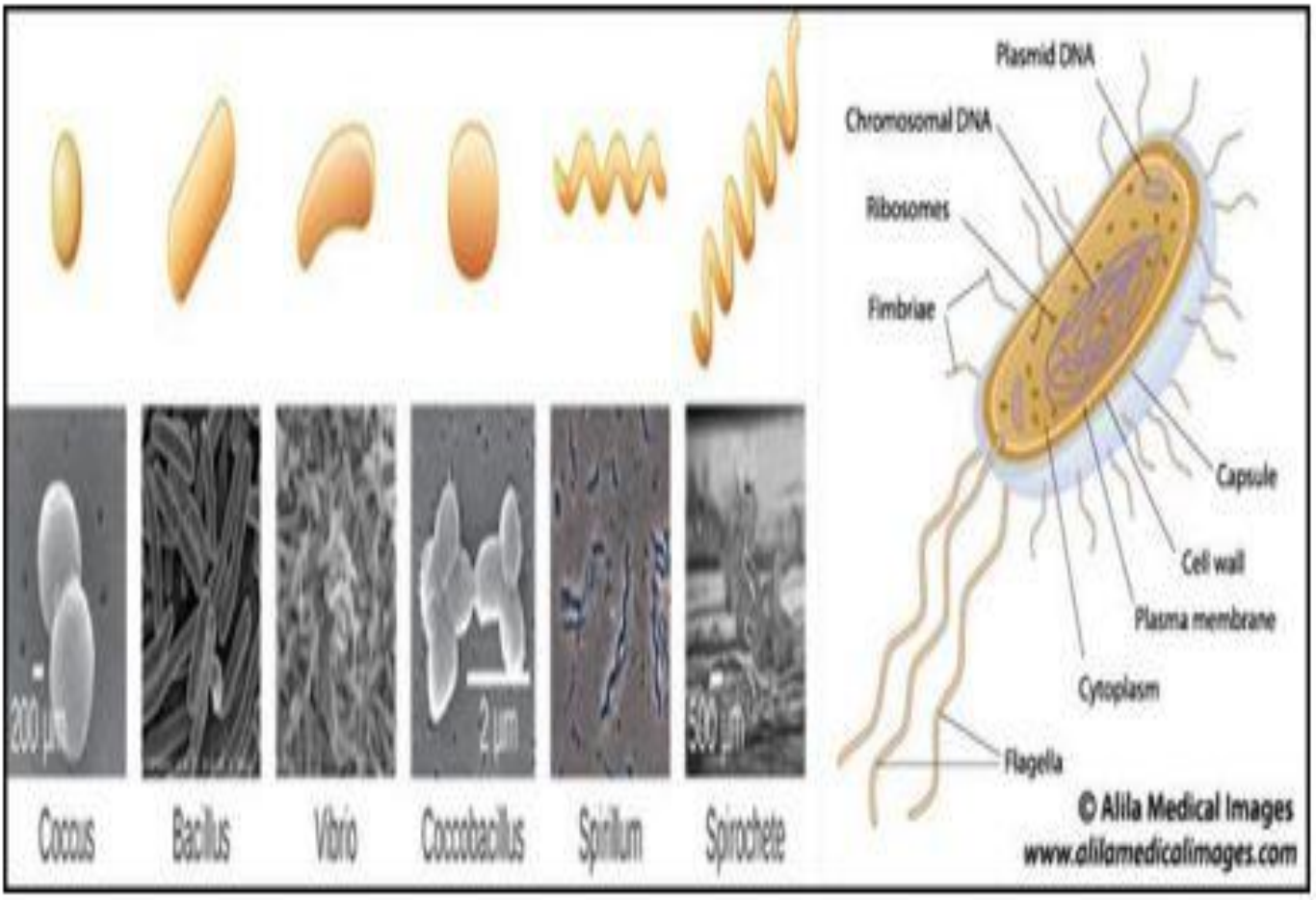

Figure 1: Showing bacteria and some classes; Source: Maraz & Khan (2021).

Bacteria based on morphology

According to morphology bacteria can be classified as:

- Cocci- These bacteria exist as round or oval of about 0.5-1.0um diameter. To multiply they exist as pairs (diplococci), chains (streptococci), and irregular groups (staphylococci).
- Rods are types existing as stick-like entities with tapered, round, squared, or swollen endings. They are about 1-10um in length, 0.3 to 1.0 width.
- Vibrios- They are tiny slightly curved (rods) of about 3 to 4 um in length, 0.5um in width. They are Gram negative type.
- Sprilla- They are small, rigid, regularly coiled, of about 3 to 4 um length.
- Spirochetes - They are coiled, flexible, and motile entities. Spirochetes are further classified as *treponemes*, *leptospires*, and *borreliae*.
- Rickettsia - Classified as bacteria, but are similar to viruses because they only replicate in the living system and enable to live while free.
- Chlamydia - Chlamydia are tiny (about 250 to 500nm) Gram negative bacteria that resemble viruses due to inability to replicate without living cells. They have own enzymes, but need energy to power the machinery (Manga et al., 2020; Kadam & Shalgaonkar, 2022).

Bacteria without cell wall

Bacteria without cell wall can be classified as follows:

- Mycoplasmas - A class consisting of naturally stable bacteria without rigid wall, they are tiny and about 0.1 to 2um such as Mycoplasma pneumoniae.
- L-forms- They are mutated bacteria lacking cell wall, mostly made in the laboratory or patients receiving penicillin treatment.
- Protoplasts -They are unstable type lacking cell wall and are mostly made artificially. They are active metabolically, but unable to reproduce.
- Spheroplasts- This class are bacteria made from Gram negative bacteria having damaged wall. Damage can be done using penicillin (Cheesbrough, 1998)..

Reproduction in bacteria

Bacteria reproduce through simple type of binary fission by dividing into two. Bacteria also make gene transfer whereby a fragment from the DNA is transferred between one bacteria to the other (aided by phage). Some make transfer through plasmid, and few of them take-up DNA from the environment.

Cultural Characteristics Classification of bacteria

Bacteria can be dwelling artificially in the laboratory. Aerobes are organisms that need oxygen to grow, anaerobes do not require oxygen to grow, facultative anaerobes can grow in the presence of oxygen conditions, likewise can live in the absence of oxygen. Microaerophiles live when there is reduced level of oxygen (Cheesbrough, 1998).

Normal Microflora

Normal microflora makes the human body their home. In a healthy situation they do not spur disease, therefore, they do not affect a healthy ma. They can be classified as:

Symbionts -They are microbes that incur benefits on the person, such as enteric bacteria of the intestines that help to synthesize vitamin K and parts of B complex.

Commensals- They are organisms found in skin, intestines, vagina, etc that live without causing harm or benefits on the host.

Opportunists- This class involves organisms that if there is an opportunity they can cause infection. Transfer of these organisms from part of the body to the other could lead to infection (E. coli) or in an event of low body immunity (malnutrition, HIV, drug therapy, surgery) infection may arise (Cheesbrough, 1998; Kadam & Shalgaonkar, 2022).

Table 2: Some human microflora

Location in the body	Examples of Microorganisms
Skin	*Streptococcus pyogenes, Candida sp.*
Urinogenital tract	Streptococcus sp., Mycobacterium smegmatis, Candida sp. (female), Trichomonas vaginalis (female only)
Nose and throat	*Hemophilus sp., S. epidermis, S. aureus*
Ear	*S. aureus, S. epidermis*
Eye	*S. epidermis, Corynebacterium sp.*
Mouth	*Candida sp., Corynebacterium sp., Streptococcus sp.*
Intestine	*Lactobacilli, Streptococcus faecalis, E. coli*

Viruses: Features, and Classes

Viruses are different, smaller in size, non-cellular, containing either RNA or DNA, that are unable to replicate without being in the living system.

Structures

Virus or virions are tiny in the sense that they can be viewed by electron microscope not light microscope. Viruses are envisaging a mass or core of nucleic acid (RNA or DNA) and an envelope of protective capsule. A DNA and capsid give the nucleocapsid. Capsid behave antigenically and aid attachment to the host (capsid has capsomeres). Capsid symmetry is utilized to classify viruses. Some viruses are found with an envelope, while others are naked (Cheesbrough, 1998).

Classes

Capsid nature or symmetry classified variety of viruses as:

Icosahedral - A virus with capsomeres structured forming icosahedran arround the nucleic acid. They look spherical.

Helical - Helical viruses have capsomeres in form of spiral of nucleic acid. They look elongated, spherical, or filamentous.

Complex- The capsid symmetry is complex in nature.

Virus infection

Virus nature of their inability to replicate without a living system make them to depend on the hosts. By getting into suitable cell, viruses genome takes over the host cell metabolic tool and instruct the cell to replicate the virus genetic material. The genetic material is used to make virions, DNA viruses mostly replicate in the

nucleus, while RNA viruses replicate in the cytoplasm. After making virions they are dispersed by rupturing the host cell or budding (Cheesbrough, 1998).

Effects on Host

Infection due to viruses' spur dying of the host cell (cytopathic effects), they may lead to inclusion bodies formation or infusion of infected cells. Some viruses lead to latent infection, some cause tumor synthesis (due to oncogenic behavior).

Transmission of Viruses

Viruses are transmitted through human as host such as in the case of rubella virus, measles, polio viruses, hepatitis, herpes viruses etc. Through humans viruses are transmitted through direct contact such as sex (HIV, hepatitis B); food ingestion (enteroviruses, rota viruses); inhalation of air (such as adenoviruses, rhinovirus); mother to child (such as HIV, hepatitis B); blood transfusion (for instance, HIV, hepatitis C); and by contacting infected objects. Sometimes, viruses are transmitted through others. Others include, arthropods (ticks, flies, mosquitoes), animals (birds, monkeys, rodents). For instance, dengue virus, yellow fever, Rift valley fever virus. This transmission occurs through contact with vegetation, food, objects, human to human transfer, etc (Maraz & Khan, 2021).

Table 3: Some viruses affecting humans

Family or pathogens	Disease	Method of spreading	Remarks
Togavirus (Rubivirus)	Rubella	Air, placenta	Cause congenital malformation
Togavirus (Ross River virus)	Arthritis	Mosquitoes	Fever and other impacts are elicited
Togavirus Chikunya virus	Fever, arthritis	Mosquitoes	Impactful
Rotavirus	Diarrhea	Food, water	Dehydration, death, diarrhea are effects
HIV	HIV(AIDS)	Sex, mother to child, cuts, etc	Emancipation, low immunity, death, etc are some effects
Picornavirus	Poliomyelitis	Food, water, soil	Cause paralysis in children

Fungi: Classification, and Features

Fungi are types of microbes that are parasitic, saprophytic, or sometimes commensals. They can stay in decayed organic matter for aiding recycling (Maraz & Khan, 2021). They are eukaryotic in nature not as bacteria. Cell wall has polysaccharides, chitin, polypeptides, and sterols (that prevent antibiotics from being effective). Most of them behave as obligate aerobes (Raj & Kaur, 2022). Fungi are types as follows:

- Yeast- They are rounded or oval elongated unicellular types that are about 3-15um. The multiplication occurs by asexual reproduction (budding).

- Moulds- Are fungi types existing as multicellular and from branching filamentous features (hyphae). Collection of mass interwoven hyphae is mycelium. Moulds can form conidia and spores (Cheesbrough, 1998).
- Dimorphic fungi - They are able to live as yeasts or as well as moulds (filamentous and pathogenic).
- Nevertheless, fungi can be viewed in for of mycotixicoses. The infection incited through fungi is known as mycoses. Superficial mycoses such as ringworm affect the skin. Subcutaneous mycoses are that of implantation such as chromomycosis, mycetoma, sporotrichosis. Systemic mycoses affect the blood (the whole body in turn) such as histoplasmosis, aspergillosis, as well coccidioidomycosis. This types can spread the whole body and reach the lungs and relations (Braide et al., 2018).
- Sometimes fungi infections are termed as opportunistic such as during the presence of HIV (for instance, Candida species).
- Mycotoxicosis are due to consumption of mycotoxins such as the one made by *Aspergillus favis.*
- Fungal allergies are due to spores such as from Aspergillus (Abbas et al., 2021).

Table 4: Some Examples of fungi and types of infection they caused

Type of infection	Fungi species	Diseases caused
Superficial mycotoxicosis	*Microsporum species*	Dermatophytosis (ring worm, and tinea)
	Malassezia furfur	Pityriasis versicolor
Subcutaneous mycoses	*Phialophora species*	Chromoblastomycosis
	Madurella grisea	Black granule
	Basidiobolus species	Subcutaneous zygomycosis
	Sporithrix schenckii	Sporotrichosis
Systemic mycoses	*Coccidioides immitis*	Coccidioidomycosis
	Histoplasma capsulatum	Histoplasmosis
	Blastomyces dermatitis	Blastomycosis
Opportunist mycoses	*Candida albicans*	Candidiasis
	Aspergillus species	Aspergillosis
	Histoplasma species	Histoplasmosis
	Pneumocystis carinii	Pneumocystis pneumonia

Microorganisms Methods for Overcoming Body's Defense

Microorganisms evolve certain methods in order to pass through the body's immunity and cause diseases (Salisu et al., 2023). Some of the methods are as follows:

Attachment using pili- Microorganisms possessed similar structures that help them attached on host cell surfaces. For example, *E. coli, Shigella species, Salmonella species,* etc.

Enzymes - They have some enzymes that specifically breakdown host structure for easy invasion. For instance, *Clostridium perfringens*

have a hyaluronidase that breaks connective tissues of host cells (Choudhari, 2023).

Beta lactamases- Beta lactamases are specialized in destroying penicillin, for example, *Neisseria gonorrhea, Staphylococcus aureus*

Destruction of antibodies - Some microbes make antigens that neutralize antibodies made by host, for instance, *Pseudomonas aeruginosa* destroy an antibody using it protease.

Exotoxin synthesis - Gram positive and some certain Gram negative microbes release potent exotoxin injuring cells. For example, *Clostridium botulinum, Clostridium perfringens, Shigella dysenteriae,* and *Vibrio cholerae.*

Interference with phagocytosis - Host cells depend on phagocytosis as a major instrument to ingest invading microbes. However, the capsule of the parasite aid in shielding the microbes against opsonization, and as well phagocytosis. For instance, *Klebsiella pneumoniae, Neisseria meningitidis, Streptococcus pyogenes.*

Endotoxin release - Some microbes establish themselves by releasing endotoxins chemicals leading to toxaemia, chills, shock, rigor, etc (Nayak et al., 2020).

Microorganisms in our Environment

Microorganisms are parts and parcel of the environment humans are inhabiting. They are found in the air, water, food, soil, etc (Cheesbrough, 1998). The following are places where microbes are mostly in contact with human environment:

Air- Microorganisms move around in the air in droplets, dust, and as spores spread by human or microbial actions. Viruses such as common cold virus, measles, polio virus, influenza virus, pox virus are possibly contacted in the air. Bacteria such as *Bacillus anthracis*, pneumonia, *staphylococci, mycobacterium tuberculosis* are present in the air.

Water medium. In the water medium, microbes find a befitting habitat due to presence of nutrients. Bacteria such as *azobacter, Bacillus, Vibrio, Spirochetes, Sarcina, Thiobacillus, Coccus, etc are present*. Fungi such as mould, mildew are present in water medium (Sarkingobir et al., 2023; Salisu et al., 2024).

Human body- In the human body there are normal microflora that dwell from childhood to adulthood, while also there are other microbes that get into the human body such as *Entamoeba histolyca, Spirochetes, Clostridium tetani,* and several others.

Through the food-Microorganisms tend to utilize food materials as an ideal habitat due to presence of nutrients. Sometimes the agents of contamination may be flies, animals, rats, cockroaches, contaminated utensils, and unhygienic preparations (Kadam & Shalgaonkar, 2022; Sarkigobir et al., 2022; Sarkingobir et al., 2023).

Control of Microorganisms

Microorganisms are all around us. It is very difficult to entirely get rid of them, albeit conceited efficient efforts can be utilized to drastically minimize microbial effects, in order to salvage humans from impeding hazards (Cheesbrough, 1998). The following are enumerated attempts to control microorganisms and their effects.

Vector control - Vectors carry pathogenic microbes around; therefore, they are supposed to be dealt with to control specific diseases transmission. Vectors such as flies, fleas, mosquitoes, cockroaches, etc can be control

through use of chemicals such as insecticides, pesticides, rodenticides to kill the vectors. Environmental sanitation methods such as cutting of grasses and weeds in the surrounding, draining of drainage, and cleaning of environments from waste materials aid to control vectors (Nayak et al., 2020).

Use of high temperature -Mostly, microbes affecting humans require 37^{o}C as optimum; therefore, escalating the temperature during food cooking, boiling of foods, boiling of contaminated objects for 30 minutes at 160oC using oven or autoclave control microbial growth.

Use of antiseptics and disinfectants - Antiseptics are substances meant to kill or habit microbial growth, for instance 70 % alcohol, boric acid. Disinfectants are more potent substances that aid in inhibiting microbial growth (such as carbolic acid).

Antibiotics are chemicals meant to kill bacteria, for instance, penicillin, quinolones, lincosamides, metronidazole, tetracycline, etc.

Dehydrations- This involves removal of water from a medium so that microbial growth is prevented. Dehydration could be drying using sunlight or heat.

Food hygiene - It is important to say that, food must be made, stored, and prepared hygienically. Control of diseases in foods starts from field, through the market, and up to the mouth. Therefore, farm sanitation, market sanitation, restaurant sanitation, should be ensured to supply the public with uncontaminated (pure) food (Cheesbrough, 1998).

Personal cleanliness - Practicing good personal hygiene habits scuttle chain of disease transmission.

Maintaining good health- Consumption of balanced diet enhances the body's ability to fight diseases of all types. Immunization involves a healthy technique to elicit body's immunity against specific infections. Likewise, to maintain good health provision of healthcare is paramount approach (Cena et al., 2021).

Water, sanitation, and hygiene (WASH)- Provision of clean water is essential for health. About 80 percent of diseases occurring in developing countries is due to water problems, and sanitation issues. Use of methods such as boiling, filtration, chlorination, coagulation, etc to treat water before consumption is strongly significant in prevention of water related problems (Cheesbrough, 1998). Thus, providing clean, enough water, sanitation and hygiene are essential disease prevention tips. Prevention of open defecation practice by providing the public with improved sanitation (latrine) facilities is a great tool to reduce infectious and non-infectious disease prevalence. Waste management is part of WASH indices, waste mismanagement encourages infections prevalence as well (Abbas et al., 2021; Kadam & Shalgaonkar, 2022).

Benefits of Microorganisms

Microorganisms are performing several essential benefits in human life and endeavors, some of which are as follows:

Biodegradation of pollutants- Contemporary world is being challenged by pollution. Pollution is a great public health threat around the world, thus, search for solutions is essential. Studies have reiterated that microbes have special enzymes machineries that are able to degrade pollutants such as oil, plastics, persistent organic pollutants, etc (Raj & Kaur, 2022).

Agriculture - Microbes are used to clean polluted soils for farming, and the essentiality of nitrogen

fixing microbes in nitrogen assimilation is highly noted. Several essential nutrients elements needed by plants are recycled in the environment with the aid of microbial actions, for instance microbes degrading biomass to release carbon dioxide, methane, etc (Cheesbrough, 1998; Schulz et al., 2013).

Genetic engineering - Microorganisms are subjects of genetic engineering used to produce several industrially useful products and public consumed goods. Due to this, food industries, pharmaceutical companies, chemicals industries, etc utilized microbial products at large scale (Maraz & Khan, 2021).

Musa and Muhammad (2024) opined that "….bacteriophage to serve as an alternative to antibiotics. Antibiotics are meant to kill or inhibit bacteria threatening humans or related biota. Bacteria are able to affect humans or biota due to ability to incite infections. The discovery of antibiotics has been considerably of important to modern medicine until recently when resistance is developing due to evolution and other prevailing forces (such as misuse, abuse, massive use, etc). Therefore, seeking alternative against infectious bacteria is imperative. Phages are viruses that kill bacteria. They are supposed candidates to kill bacteria and combat resistance to antibiotics. The phages are able to specifically invade bacteria, hijacked the host replicating machine, instruct the phage DNA replication, elicit lysis to release upcoming phages. This kills the hosting bacteria. The phages are specific, numerous, and effective. Their use should be enhanced for mankind benefits"

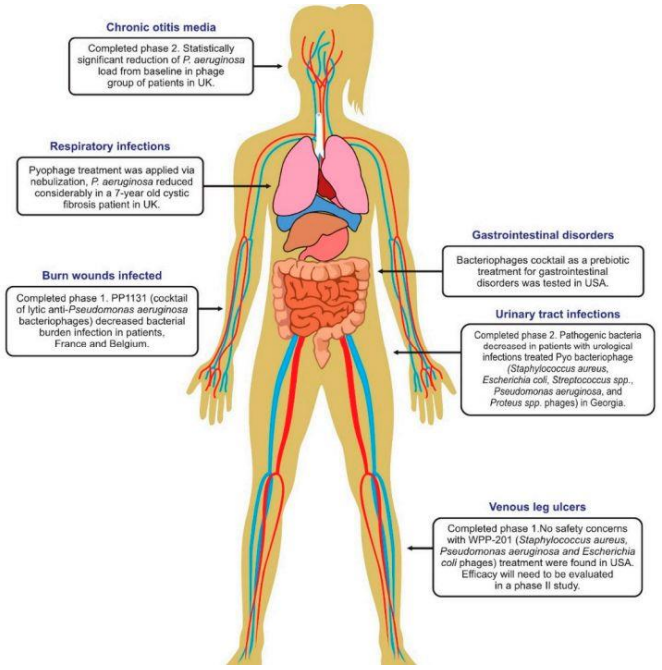

Figure 2: Phages to be soon unveiled; Source: Romero-Calle et al., (2019)

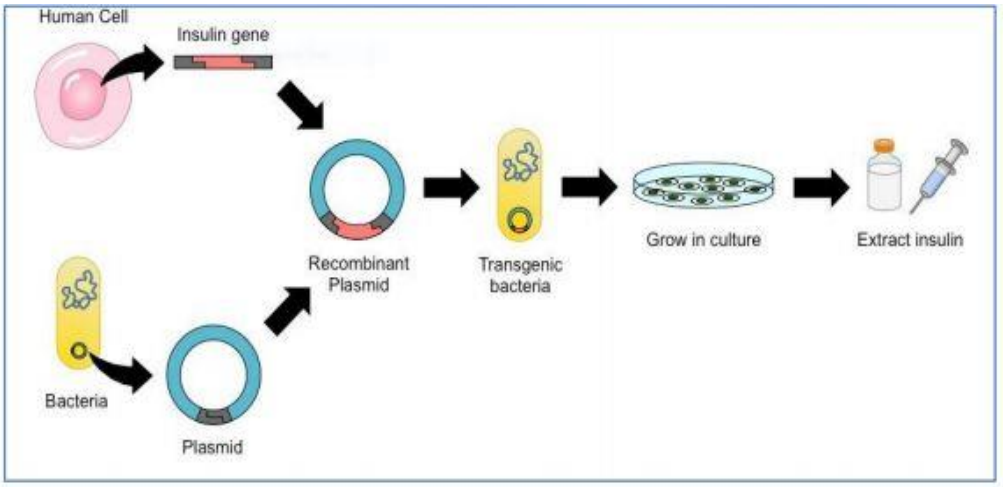

Figure 3:Synthesis of insulin using microorganism; Source: Maraz & Khan (2021).

Table 5: Some beneficial applications of microorganisms

Products	Microorganism	Use in industrial application
Citric acid	*A. niger*	Food additive
Cellulose	*Acetobacter xylinum*	Fibers, filters, plastics
Penicillin	*Penicillium notanum*	Antibiotic
Streptomycin	*Streptomyces griseus*	Antibiotic
Amylase	*Bacillus*	In detergents
Vinegar	*Acetobacter*	Alcohol
Bread	*Saccharomyces cerevisiae*	Bread
Yoghurt	*Lactic acid bacteria*	Food
Proteases	*Aspergillus, Bacillus*	Meat tenderization
Soy sauce	*Aspergillus oryzae*	Foods
Pectinase	*Aspergillus*	Preservation of fruits
Phage	Viruses	Pharmaceutical industry

Conclusion

Microorganisms are essential part of human environment. They are everywhere, and indeed beneficial in some respects brought by recent advancements in science and technology. Nevertheless, microorganisms are also causing a lot of problems due to their role as disease causing agents that affect public health severely. Preventive measures should be followed to control microorganisms.

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