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Design and Fabrication of Blood Purification Device from Bacteria and Viruses

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Annotation: The current work deals with the relationship of wavelengths of visible light with blood and bacteria. We have designed a device that deals with wavelengths such as (red, blue, white, yellow (solar), ultraviolet rays) and their relationship to blood and bacteria. Random blood samples and it was found that it takes a long time in order to obtain reliable results, in addition to that it needs many medical procedures and facilities. We decided to develop the device and add a source of ultraviolet rays, the efficiency of ultraviolet radiation was tested in killing some types of bacteria such as (Staphylococcus aureus, Klebsiella, Proteus mirabilis), which They cause diseases to humans and other living organisms.

Introduction:

Light plays a crucial role in regulating human health and well-being. Exposure to natural light helps regulate our circadian rhythm, which is our body's internal clock that controls our sleep-wake cycle, hormone production, and other physiological processes. Lack of exposure to natural light or exposure to artificial light at the wrong times can disrupt our circadian rhythm and lead to sleep disorders, mood disorders, and other health problems.[1]

Additionally, certain wavelengths of light, such as blue light emitted by electronic devices, can suppress the production of melatonin, a hormone that helps us fall asleep. This can also lead to sleep disturbances and other health issues. On the other hand, exposure to bright light therapy has been shown to be effective in treating seasonal affective disorder (SAD), depression, and other mood disorders. Overall, the relationship between light and human health is complex and multifaceted.[2]

Light is electromagnetic radiation visible to the human eye, and is responsible for the sense of sight. The wavelength of light ranges from 400 nanometers (nm) to 700 nanometers - between infrareds.

(longer wavelengths) and ultraviolet (shorter wavelengths). These numbers do not represent the absolute limits of human vision, but rather the approximate range that most can see.[3]

People do well in most circumstances. The wavelengths of different sources of visible light range from the narrow range (420 to 680) to the widest range (380 to 800) nanometers. Under ideal conditions, humans can see at least infrared rays whose wavelength reaches 1050 nanometers, and children and youth can see what UV is between about 310 to 313 nanometers [4]

Uses of light in the medical field:

There are several uses of light in the medical field, including diagnosis, treatment, and research.

1. Diagnosis: Light is used in medical imaging techniques such as X- rays, CT scans, MRI scans, and ultrasound. These techniques use different types of light to create images of the inside of the body, which can help doctors diagnose diseases and conditions.
2. Treatment: Light is also used in various medical treatments such as phototherapy for skin conditions like psoriasis and eczema, laser therapy for eye conditions like glaucoma and cataracts, and photodynamic therapy for cancer treatment.
3. Research: Light is used in medical research to study the structure and function of cells and tissues. Techniques such as fluorescence microscopy use light to visualize specific molecules within cells.[5]

Fig (1-1) Treatment using blue rays for jaundice

Some of the diseases that are treated with light rays include :

1. Psoriasis: A chronic skin condition characterized by red, scaly patches on the skin. Phototherapy using ultraviolet (UV) light can help reduce inflammation and improve symptoms.[6]
2. Vitiligo: A condition in which patches of skin lose their pigment, resulting in white or light-colored patches. Phototherapy using UVB light can help stimulate repigmentation of the affected areas.
3. Eczema: A common skin condition characterized by dry, itchy, and inflamed skin. Phototherapy using narrowband UVB light can help reduce inflammation and improve symptoms.
4. Jaundice: A condition in which there is an excess of bilirubin in the blood, resulting in yellowing of the skin and eyes. Phototherapy using blue light can help break down bilirubin and reduce its levels in the blood.
5. Seasonal affective disorder (SAD): A type of depression that occurs during the winter months when there is less sunlight. Light therapy using bright white light can help improve mood and alleviate symptoms.
6. Acne: A common skin condition characterized by pimples, blackheads, and whiteheads. Phototherapy using blue or red light can help kill bacteria on the skin and reduce inflammation.
7. Wound healing: Light therapy using red or near-infrared light can help stimulate cell growth and promote healing of wounds.
8. Cancer: Photodynamic therapy (PDT) uses a photosensitizing agent and a specific wavelength of light to destroy cancer cells while minimizing damage to healthy tissue.
9. Sleep disorders: Light therapy using bright white light can help regulate circadian rhythms and improve sleep quality in people with sleep disorders such as insomnia or delayed sleep phase syndrome (DSPS).

Ultraviolet radiation (UV) is a type of electromagnetic radiation that has a wavelength shorter than visible light but longer than X-rays. It is present in sunlight and can also be produced artificially by lamps and lasers. UV radiation can be harmful to living organisms, causing skin damage, eye damage, and even cancer.[7-10]

UV radiation is often treated with protective measures such as sunscreen, sunglasses, and clothing that covers the skin. Sunscreen works by absorbing or reflecting UV rays before they can penetrate the skin. Sunglasses protect the eyes from UV rays that can cause cataracts and other eye problems. Clothing with a tight weave or special coatings can also block UV rays from reaching the skin.

One book source that discusses UV radiation and its effects on the body is "Radiation Protection in Medical Radiography" by Mary Alice Statkiewicz Sherer et al. This textbook provides an overview of different types of radiation, including UV radiation, and discusses how to protect oneself from exposure .[11]

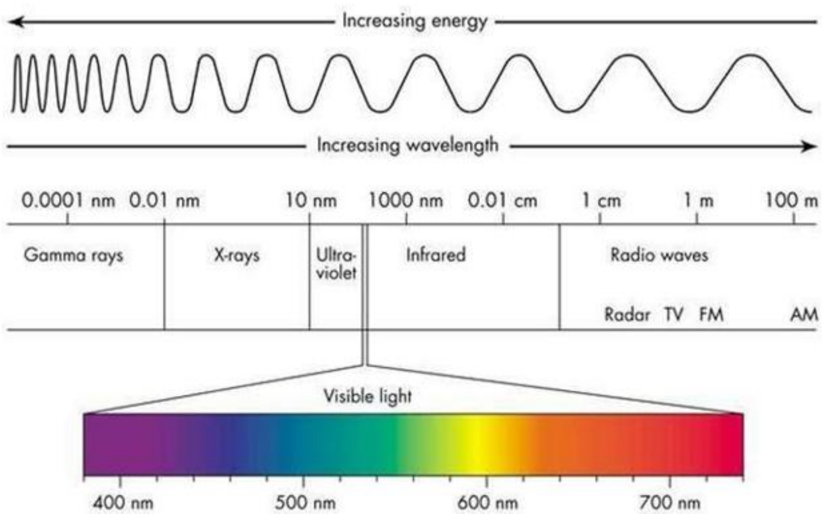


Fig (1-2) A diagram showing the electromagnetic spectrum, with UV radiation located between visible light and X-rays.

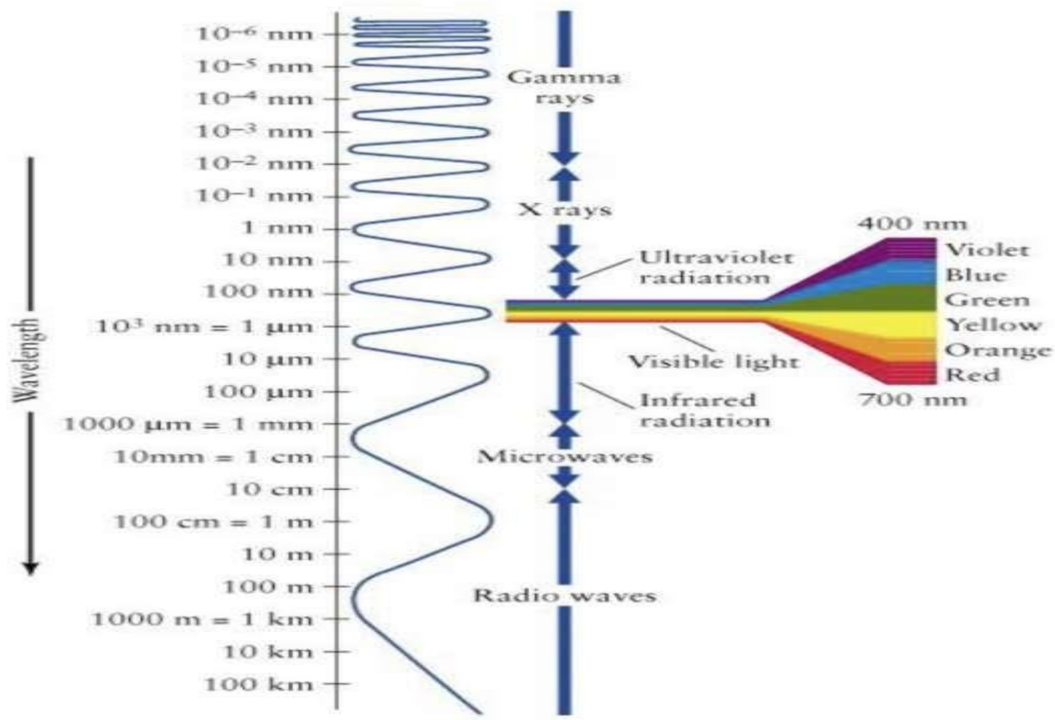


Fig (1-3) optical spectrum

Ultraviolet rays and sterilization:

Ultraviolet rays are used for sterilization by damaging the DNA of microorganisms, which prevents them from reproducing and causing infections. This process is called germicidal irradiation and is commonly used in hospitals, laboratories, and water treatment plants.

According to the book "Principles of Environmental Science and Technology" by Ahindra Nag, ultraviolet radiation with a wavelength of 254 nanometers is most effective for sterilization. This wavelength is absorbed by the DNA of microorganisms, causing damage to their genetic material. As a result, they are unable to replicate and are killed off.[12]

Another book, "Handbook of Disinfectants and Antiseptics" by Joseph M. Ascenzi, explains that ultraviolet sterilization is particularly useful for disinfecting surfaces and air in enclosed spaces. UV lamps can be installed in HVAC systems or air purifiers to kill airborne pathogens as they pass through.

Overall, ultraviolet rays are a powerful tool for sterilization due to their ability to damage the DNA of microorganisms. This technology has been used for decades to prevent the spread of infections in various settings.

Ultraviolet (UV) rays have been used in the field of sterilization in medicine for many years. UV radiation is a type of electromagnetic radiation that has a wavelength shorter than visible light but longer than X-rays. It is known to be effective in killing microorganisms, including bacteria, viruses, and fungi.

One of the most common uses of UV rays in sterilization is in the disinfection of surfaces and equipment. This process involves exposing the surface or equipment to UV radiation for a certain amount of time, which kills any microorganisms present on the surface.

According to "Medical Microbiology" by Samuel Baron, UV radiation has been used for many years as a method of sterilization in hospitals and other healthcare settings. The book states that UV radiation can be used to disinfect surfaces, air, and water, and is particularly effective against airborne pathogens .[13]

Another source that discusses the use of UV rays in sterilization is "Principles and Practice of Disinfection, Preservation and Sterilization" by Adam P. Fraise et al. The book explains that UV radiation can be used to disinfect medical instruments such as endoscopes and surgical instruments. It also notes that UV radiation can be used to disinfect water supplies in healthcare facilities. [14-16] Some types of bacteria that kill ultraviolet rays Staphylococcus aureus is a gram-positive bacterium that is commonly found on the skin and in the nasal passages of humans. It is a facultative anaerobe, meaning it can survive in both aerobic and anaerobic environments. S. aureus can cause a range of diseases, from minor skin infections such as boils and impetigo to more serious infections such as pneumonia, sepsis, and endocarditis. Ultraviolet (UV) radiation has been shown to be effective in killing S. aureus. UV radiation damages the DNA of bacteria, preventing them from reproducing and causing infection. Specifically, UV-C radiation (wavelengths between 200- 280 nm) has been found to be most effective in killing S. aureus. One source that discusses the use of UV radiation to kill S. aureus is "Handbook of Ultraviolet and Visible Absorption Spectra of Organic Compounds" by Jerry Workman Jr. and Art Springsteen (2006). The book explains how UV radiation can be used for disinfection purposes and provides information on the effectiveness of different wavelengths for killing various microorganisms, including S. aureus.[17]

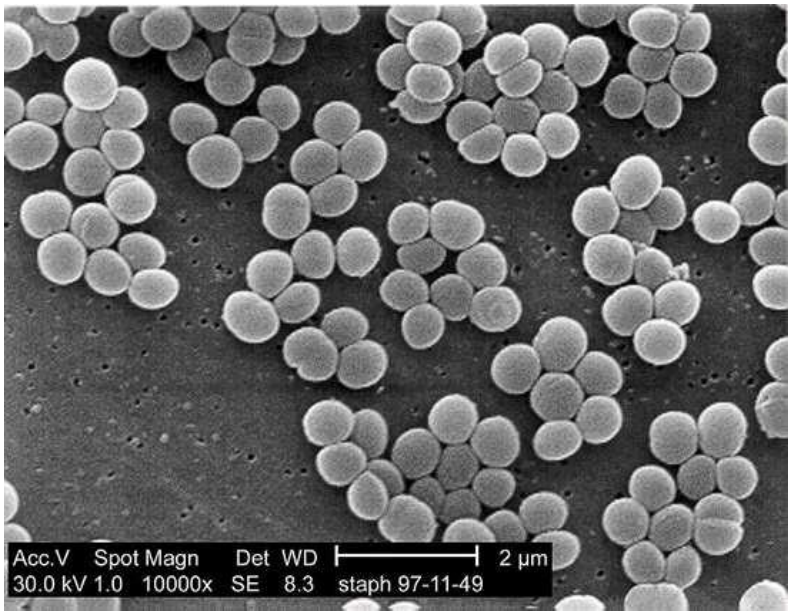


Fig (1-4) Staphylococcus aureus

Proteus mirabilis

Is a Gram-negative bacterium that is commonly found in soil, water, and the intestinal tracts of animals and humans. It is a motile bacterium that can move through the use of flagella.

Proteus mirabilis can cause a variety of infections in humans, including urinary tract infections (UTIs), wound infections, and pneumonia. It is also known to cause sepsis in immunocompromised individuals.

Ultraviolet (UV) radiation has been shown to be effective in killing Proteus mirabilis. UV radiation damages the DNA of bacteria, leading to cell death. This method of disinfection is commonly used in water treatment plants and hospitals. [18]

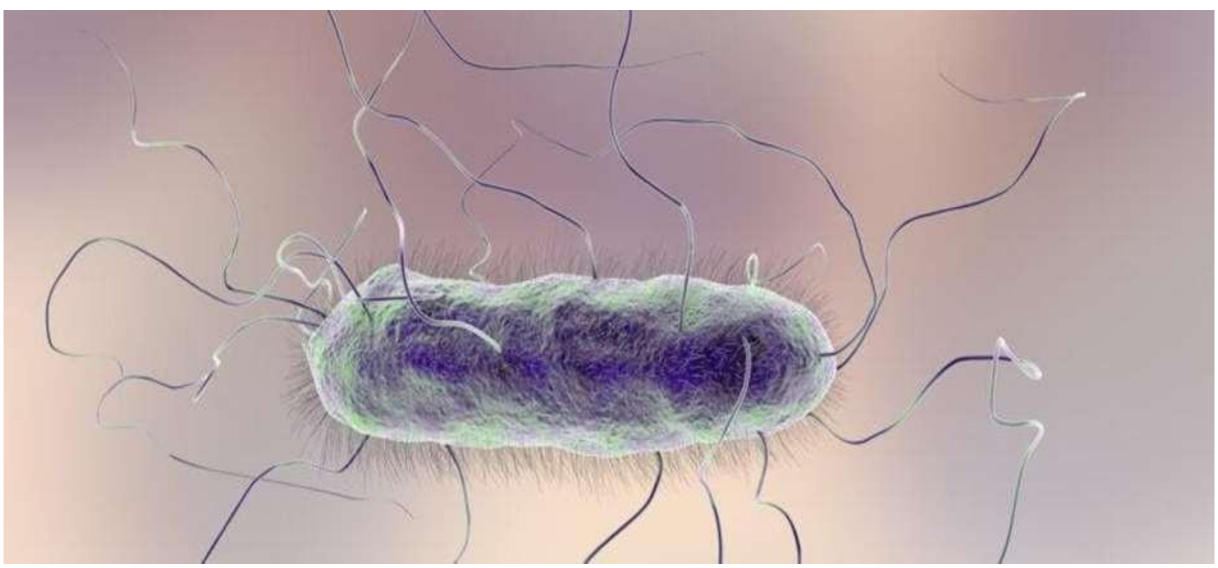


Fig (1-5) Proteus mirabilis

Klebsiella bacteria

are a type of gram-negative bacteria that are commonly found in the environment, including soil and water. They can also be found in the human body, particularly in the digestive tract.

Klebsiella bacteria can cause a range of diseases, including pneumonia, urinary tract infections, and bloodstream infections. These infections can be particularly dangerous for people with weakened immune systems or underlying health conditions.

Ultraviolet (UV) rays can be used to kill Klebsiella bacteria by damaging their DNA and preventing them from reproducing. This process is known as UV disinfection and is commonly used in water treatment facilities to kill harmful bacteria and viruses.

According to the book "Handbook of Water and Wastewater Microbiology" by Duncan Mara and Nigel Horan, UV disinfection is an effective method for killing Klebsiella bacteria in water. However, the effectiveness of UV disinfection can be affected by factors such as water quality, temperature, and UV dose.

Overall, while Klebsiella bacteria can cause serious infections, they can be effectively killed using UV disinfection methods. [19]

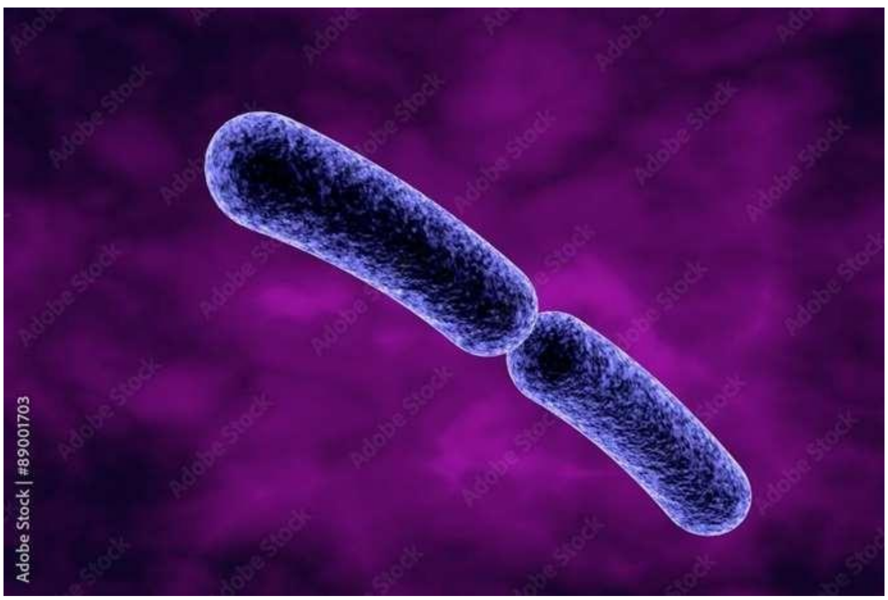


Fig (1-6) Klebsiella

Because the bacteria on which we conducted the examination are multi-drug, therefore ultraviolet rays must be used to kill them.

Multi-drug resistance bacteria

are strains of bacteria that have developed resistance to multiple antibiotics, making them difficult or impossible to treat with standard antibiotic therapies. These bacteria have acquired genetic mutations or acquired resistance genes that allow them to survive exposure to multiple antibiotics, including those that are commonly used to treat bacterial infections. This can lead to serious and potentially life-threatening infections that are difficult to control and treat. Multi- drug resistance is a growing concern in healthcare settings and the community, as it limits treatment options and increases the risk of complications and mortality.

Bacteria that resist treatment with more than one antibiotic are called multidrug- resistant organisms (MDROs for short). Multidrug-resistant organisms are found mainly in hospitals and long-term care facilities. They often affect people who are older or very ill and can cause bad infections. [20]

Problem Statement:

Antibiotics are used to treat viral and bacterial diseases, which contain side effects These common side effects include sedation, impaired motor function, dizziness, dry mouth and throat, blurred vision, urinary retention and constipation And others that appear in the long run and are more dangerous, Based on this We tried to test the effectiveness of ultraviolet rays and lights of different wavelengths in treating viral diseases without or with fewer side effects.

Objective:

Designing a device that explains or shows us the extent of the effect and effectiveness of wavelengths of visible light and ultraviolet radiation on both blood and its components and some types of bacteria that cause diseases to humans and other living organisms.

Fig (2-1) The first part before adding ultraviolet rays

Components of the device:

- ➢ First part is a movable mechanical support that moves from several angles

The first beakers is to put the diluted blood in it before it enters the device) (500ml

, 20•C)

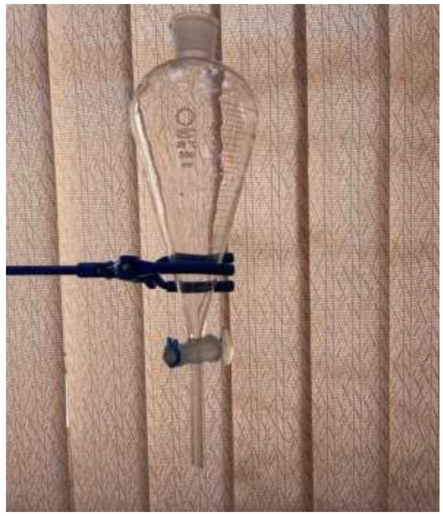


Fig (2-3) The second beaker is to receive blood after it leaves the device and expose it to different wavelengths) (250)

Fig (2-4)

X- ray tube or frequencies

Fig (2-5)

- Three buttons (to turn on the light and give us the desired wavelength)

Fig (2-6)

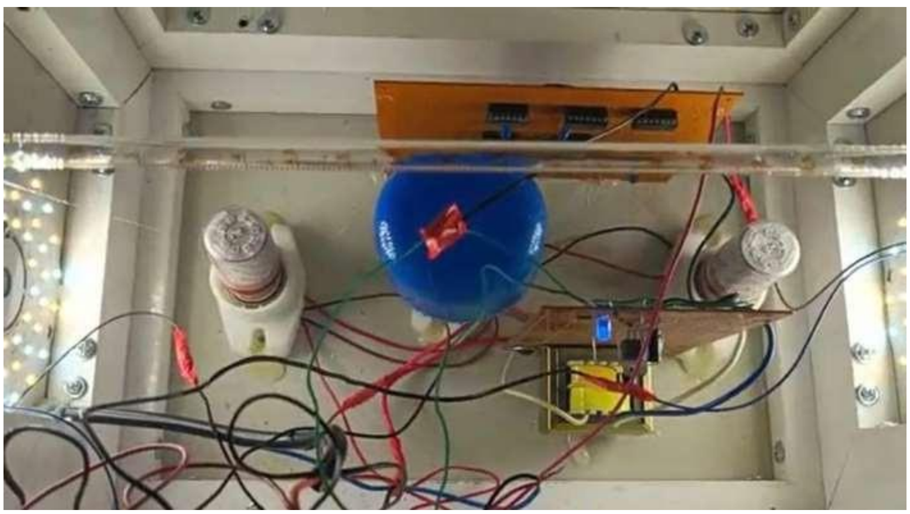


Fig (2-7)

- Power supply

Fig (2-8)

Electromagnetic radiation tester

An electromagnetic radiation tester is a device used to measure the level of electromagnetic radiation in a given area or from a specific source. Electromagnetic radiation is energy that is propagated through space or matter in the form of electromagnetic waves. This can include radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

Electromagnetic radiation testers typically use a sensor or detector that can detect the specific type of electromagnetic radiation being measured. For example, a tester designed to measure radio frequency radiation may use a radio frequency meter or a spectrum analyzer to detect the level of radiation in the area. Similarly, a tester designed to measure X-rays or gamma rays may use a Geiger counter or other specialized detector.[21]

Some electromagnetic radiation testers are designed to be portable and can be used to test the radiation levels in different locations. Others may be designed for use in specific environments, such as medical facilities, laboratories, or industrial settings.

It is important to note that while electromagnetic radiation can have harmful effects on human health, the levels of radiation that most people are exposed to on a daily basis are generally considered to be safe. However, in certain situations, such as in the presence of high levels of radiation from a specific source, it may be necessary to use an electromagnetic radiation tester to ensure that the radiation levels are within safe limits.[21,22]

Part two after adding ultraviolet rays.

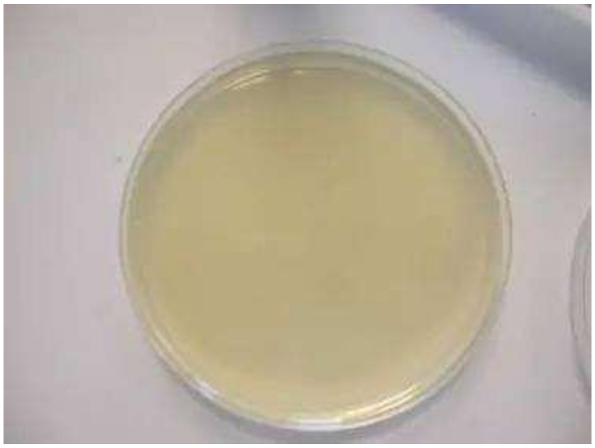


Fig (2-9)

Nutrient Agar is a basic culture medium used to subculture organisms for maintenance purposes or to check the purity of subcultures from isolation plates prior to biochemical or serological tests. In semi-solid form, as agar slopes or agar butts, the medium is used to maintain control organisms1

Fig (2-10)

UV radiation

UV radiation is electromagnetic radiation just like visible light, radar signals and radio broadcast signals (see Figure 1). Electromagnetic radiation is transmitted in the form of waves. The waves can be described by their wavelength or frequency and their amplitude (the strength or intensity of the wave). Wavelength is the length of one complete wave cycle. For radiation in the UV region of the spectrum, wavelengths are measured in nanometers (nm), where 1 nm = one millionth of a millimetre.[23]

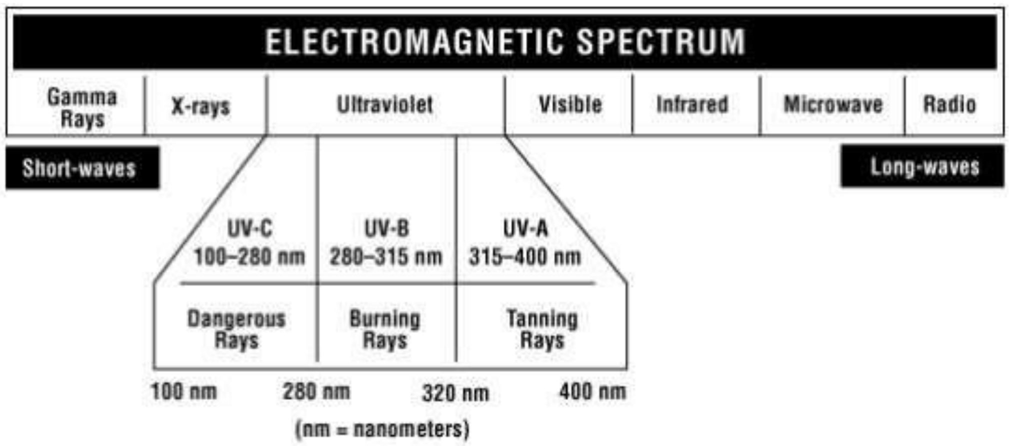


Figure 1 - Electromagnetic spectrum

Fig (2-11)

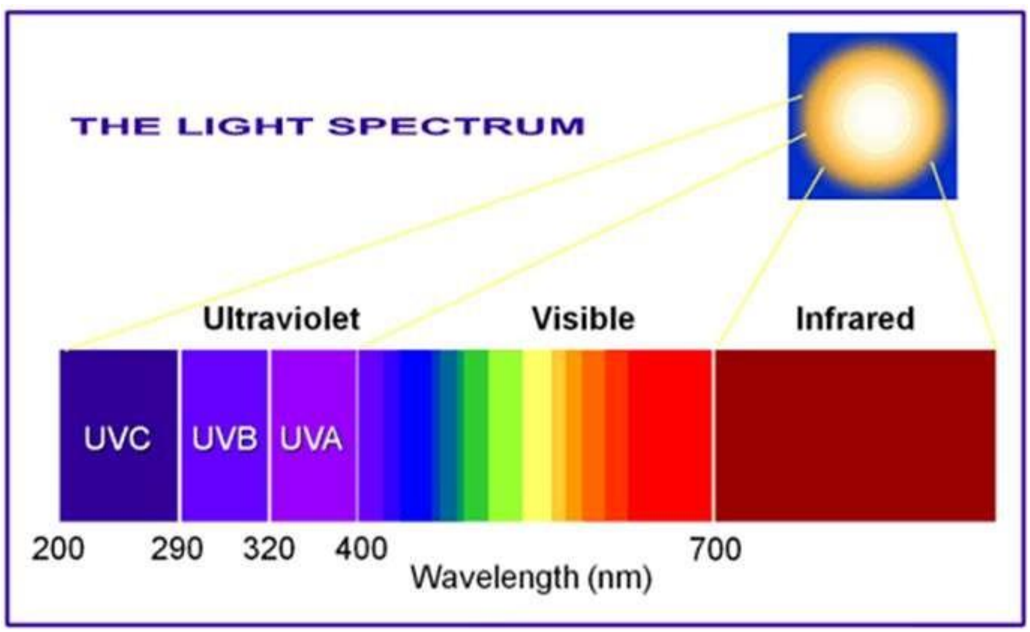


Fig (2-12)

Different wavelengths of electromagnetic radiation cause different types of effects on people.[24]

For example, gamma rays are used in cancer therapy to kill cancerous cells and infrared light can be used to keep you warm.

UV radiation has shorter wavelengths (higher frequencies) compared to visible light but has longer wavelengths (lower frequencies) compared to X-rays.

Used of UV:

Ultraviolet (UV) radiation is generally used for the disinfection of water in aquaculture and wastewater facilities because it does not produce any known toxic residuals or byproducts that may pose a risk to people or fish UV radiation. [34] used to improve air quality within buildings. Although intense UV radiation can be harmful to operators if used improperly, UV radiation is widely used in industrial processes and in medical and dental practices for a variety of purposes, such as killing bacteria, creating fluorescent effects, curing inks and resins, phototherapy and suntanning. Hospitals use UV sterilization to disinfect surgical equipment in patient roomsThe UV spectrum is commonly subdivided into three sections: **UVA** (wavelengths of 400 nm to 315 nm), **UVB** (315 nm to 280 nm), and **UVC** (280 nm to 200 nm). UVC radiation denatures the DNA of microorganisms, which have a high absorbance of the UV spectrum at 254 nm. [25]. Studies have shown that UVC at 254 nm is effective against all foodborne pathogens, natural microbiota, molds, and yeasts. Because microorganisms come with different sizes and shapes that affect their UV absorption, the required time for killing each species varies.

UV sterilization also known as UV disinfection or ultraviolet germicidal irradiation (UVGI) works by breaking down certain chemical bonds and scrambling the structure of DNA, RNA and proteins, causing a microorganism to be unable to multiply. When a microorganism is unable to multiply, it is considered dead since it cannot reproduce within a host and is no longer infectious.[26,27]

EFFECT OF ULTRAVIOLET RADIATION ON MICROORGANISMS

Viruses are composed of nucleic acid which can be double-stranded deoxyribonucleic acid(DNA) or ribonucleic acid (RNA) and single-stranded DNA or RNA (Kowalkski, 2009). Single-stranded viruses exhibit high susceptibility to UV since they lack the genetic information redundancy present in the second strand, enabling double-stranded viruses to repair the UV damages (Tseng and Li, 2005). Non-enveloped viruses are mostly highly resistant to UV than enveloped viruses as the envelope's proteins and lipids are susceptible to other viral parts (Pinon and Vialette, 2018). Factors like the presence of a repair mechanism, physical size, surface hydrophilicity and weight of molecules determines the susceptibility of virus to UV radiation (Raeiszadeh and Adeli, 2020).[28]

UVC has very destructive impacts on bacteria, as previously indicated, because their UVC photons are substantially absorbed by intercellular components (proteins, DNA and RNA) (Bolton and Cotton, 2011). The absorbed UVC photons presents severe damage to the genomic system of microbes (nucleic acid and proteins), prohibiting it from living and reproducing, since the adenine-thymine bond is broken and a pyrimidine dimer, covalent linkage is generated between two adenines(Raeiszadeh and Adeli, 2020). Increased environmental UV dose would probably result in a higher rate of viral mutation (Norval, 2006). UV's fatal effect on viral nucleic acid (RNA or DNA) is dependent on where it affects in the viral genome (Norval et al., 1994). A vast number of mutations reduce virulence of viruses, while some mutations may lead to more virulent strains, because majority viral genes serve specialised purpose.[29]

For example, as a result of UV radiation, a unique receptor-binding protein can be produced, enabling the virus to infiltrate a particular cell type different from the one it infects before being exposed to UV light.(Raeiszadeh and Adeli, 2020). Virus strains that are UV resistant can also emerge due to evolving a thicker capsid structure to prevent UVC from damaging the nucleic acid (Norval et al., 1994).[30]

UV's effects on viruses differ between a laboratory- controlled system and a real- world system.

Is the use of ultraviolet radiation safe for the rest of the components of the body?

Yes, The appropriate wavelength to kill bacteria without harming other body cells is around 200-280 nanometers, which is in the ultraviolet-C (UV-C) range. This wavelength is absorbed by the DNA and RNA of bacteria, causing damage that leads to their destruction. However, it is important to note that UV-C radiation can also be harmful to human cells, so it must be used with caution and proper protective measures.[31]

The wavelength of ultraviolet radiation used is in the range of 200-260 nm

This chapter encompass the practical work at two stages:

- **The work before converting**
- **The work after converting**

The work before converting:

working inside the hospital with the use of random blood samples, not on appointment.

The work after converting:

adding a source of ultraviolet radiation and killing some types of bacteria that cause diseases to humans and other organisms

A/Part One includes measuring blood samples in the hospital(Without UV).

1- The device was taken to perform the practical part inside Ibn Al-Quff Hospital.

2- At the beginning of the examination, Whele Blood samples were taken from people, not by appointment.

Fig (2-13) Blood Sample

3- We calculated the components of the blood using the **Complet Blood Count.**

Fig (2-14

Fig (2-16)

4- Using Device:

a- The device is equipped to receive samples.

b- Before conducting the examination, the blood samples were diluted with a special liquid for dilution so that the blood flows easily inside the device.

d- Place the sample inside the device:

Fig (2-18)

e- Turn on the device and the process is started:

Fig (2-19)

f- Highlighted sample exit:

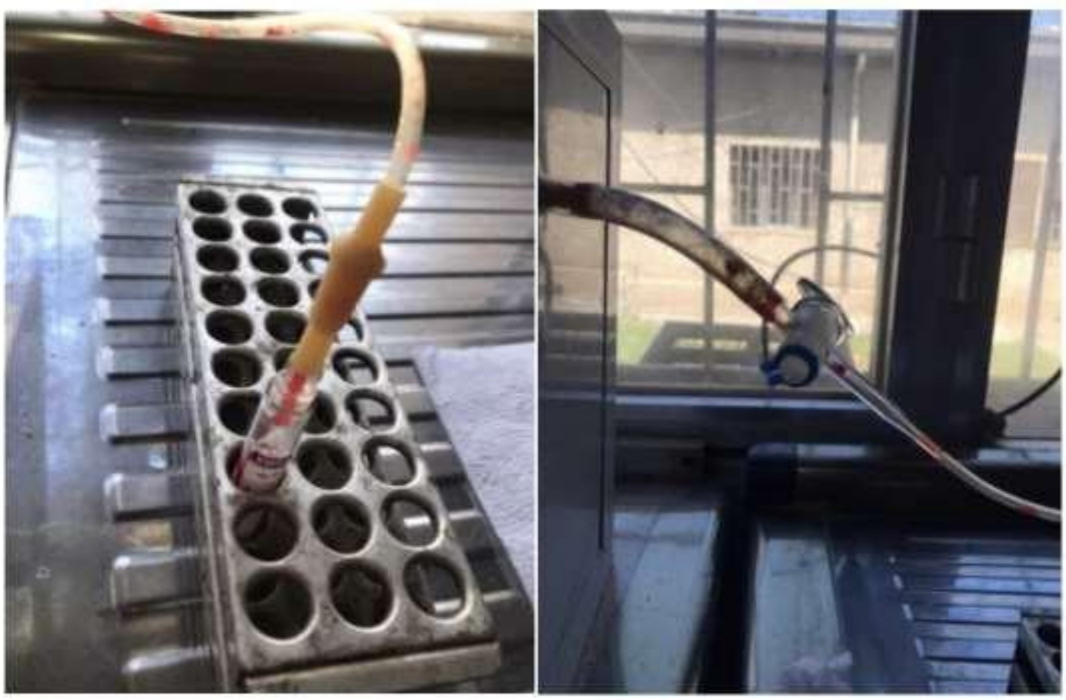


Fig (2-20)

B/Part Tow involves killing bacteria by ultraviolet radiation .

1- The device was modified and ultraviolet rays were used to kill some types of bacteria that cause diseases to humans, animals, etc.

Fig (2-22)

2- Various types of bacteria were cultured in a suitable medium.

3- Placing the bacteria inside the device:

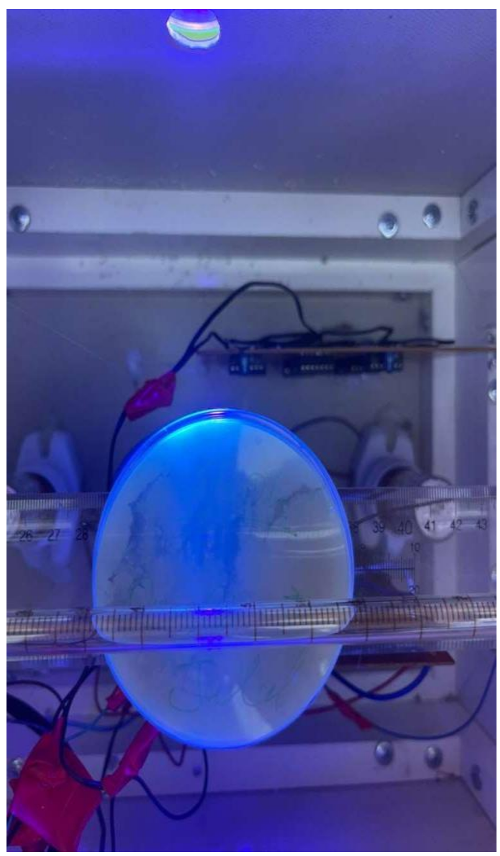
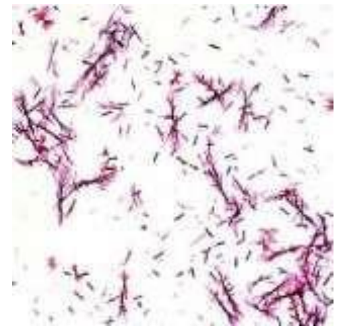


Fig (2-23)

Table (2-2)

Name of bacteria			
Proteus mirabilis			
Staphylococcus aureus			
klebsiella pneumoniae			

Results

The first part without ultraviolet radiation:

1- non-recruitment samples of blood from randomly assigned patients were examined.

2- We note that the device needs a long period of time, which may take about six months to obtain acceptable and clear results.

3- The strict and numerous medical procedures required to examine samples are very long and intensive.

So, we decided to develop the device for a device that uses ultraviolet rays against bacteria.

The second part with ultraviolet rays:

1- The bacteria used in the experiment were killed and destroyed by ultraviolet radiation.
2- Using an appropriate wavelength of radiation so that it is safe for cells and the rest of the body's components, as the wavelength is 200-260 nm.
3- The user time is about 5-10 minutes.

Conclusion

From previous experimental work and results, we can conclude the following:

1- The relationship and effect of wavelengths of the visible spectrum on human life and health.
2- Certain frequencies can be employed and modeled to obtain useful technologies in the health field.
3- The relationship of wavelengths with blood and its components.
4- Using a suitable wavelength of ultraviolet radiation as an aid to get rid of some types of bacteria that cause diseases to the organism.
5- The ease and safety provided by the use of such technology (use of wavelengths).

Recommendations for future work:

1. The test takes a very long time (about six months) to obtain clear and explicit results.
2. The need for prolonged and intensive medical procedures to perform this type of examination.
3. Using appropriate samples, whether blood or bacteria.
4. It needs an intensive study of wavelengths.
5. It requires several blood samples and tests on different patients.

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