

Mutagenic effect of Ultra Violet (UV-C) on living organisms

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Abstract:

The increase in environmental pollution and the observed changes in the climate and the high depletion in the ozone layer was attract the attention of scientists to study the solar radiation, especially UV-C because of its arrival in recent years to the surface of the earth and its devastating effect on living organisms such as humans, animals and plants. UV-C was the major reason of skin mutations in humans, destruction of the immune system and the effect on physiological processes in animals and plants, and it may be a source of mutations inherited in plants through their impact on photosynthesis processes, the formation of proteins and the destruction of genetic material (DNA). This reflects on the morphological shape of the organism and causes a decrease in the productivity of some crops. The most important of these mutations that form in eukaryotic organisms such as humans, plants and animals, which were monitored in this review as a mutagenic effect of UV-C rays on living organisms: predominantly cyclobutane pyrimidine dimers (CPDs) and pyrimidine (6-4) pyrimidinone products [(6-4) PPs] on the genome.

The aim of this review is to investigate the risks and damaging effects of UV-C radiation especially the mutagenic effect on human and other organisms, in addition to studying the mechanism of mutations on the genome of the organisms and the effect on its phenotypic characteristics. UV light especially UV-C radiation has strong genotoxic effect which induced mutations, so this radiation came from sun ray which is the major natural source, despite the important benefits of sunlight, but it is a source of harmful rays, UV radiation causes what is known as photolesion in DNA by formation thymine dimers which is same in all organisms.

Key words: *UV-C radiation, mutagenic effect, living organisms, pollution, DNA.*

Introduction:

Environmental pollution, such as air pollution in many countries of the world, is due to modern life, and many third-world countries, such as Iraq, is due to wars and the emission of gases from car exhaust is one of the main factors that greatly affect the raising of air temperatures and cause global warming, and thus directly affect on solar radiation, there is a positive relationship between the increase in temperature and the intensity of ultraviolet radiation, (Al-Shammari, 2015) that led to a decrease in the ozone layer and therefore the amount of ultraviolet radiation (UV-C) reaching the earth's surface was

increased (Urban et al., 2016). Which represent the dangerous part of solar light on living cells (Douki et al., 2000), where direct exposure to UV-C leads to cell damage and is considered a lethal factor (Paul and Gwynn, 2003). The research papers indicated a high UV-index in some cities of Iraq and other countries, which ranges between (7-8) which concedes high range, which has a mutagenic effect, especially when the hours of exposure to radiation are increased, (UV-index: It is an international standard index used to describe the level of ultraviolet radiation on the Earth's surface and ranges between 5-11). (Al-Jarrah and Al-Qazwini, 2009).

UV-C considered one of an important type of mutagens because it is easily absorbed by genetic material of living cells, we can define the mutation: is a change in a DNA sequence which leads to damage in DNA gene causing change the mRNA transcribed from that gene which carry an altered message (Marx,

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2016). it was noted that there is a close relationship between skin cancer(malignant melanoma) and direct exposure to ultraviolet rays in humans(Saucedo et al.,2019). In plants, UV-C plays a major role in changing the course of metabolic processes such as photosynthesis (shetta and Ibrahim, 2009).

Carotenoids, protein and proline content in desert plants (Salama et al., 2010) Also, the exposure of the aquatic plant (juncus effusus) to periods of UV-C rays caused physiological and structural changes in the vegetative system, and that increasing the exposure period led to a reduction in plant growth and biomass, an increase in antioxidant enzymes, and a reduction in chlorophyll content and chloroplast volume (Najeeb et al, 2011). UV-C also caused morphological and genetic changes in tomato fruits, and the lowest germination rate was recorded in tomato seeds when exposed to a period of 10 minutes of radiation exposure periods of more than 60 minutes not only affect the physiological characteristics, but also affect the internal anatomy of the plant and the pigments that are reduced as a result of chlorophyll oxidation (photo oxidation).(Abdulkareem et al., 2015).

The aim of this review is to investigate the risks and damaging effects of UV-C radiation especially the mutagenic effect on human and other organisms, in addition to studying the mechanism of mutations on the genome of the organisms and the effect on its phenotypic characteristics. UV light especially UV-C radiation has strong genotoxic effect which induced mutations, so this radiation came from sun ray which is the major natural source, despite the important benefits of sunlight for human health by natural synthesis of vitamin D, but it is a source of harmful rays, UV radiation causes what is known as photolesion in DNA by formation thymine dimers which is same in all organisms.

Types of radiation

Several research papers indicate that ultraviolet radiation are divided based on wavelengths : UVA (315-400nm)it constitutes 95% of UV radiation, which are long-wavelength rays that penetrate the ozone layer, exposure to it for a long time leads to skin cancer, and high doses of it cause the formation of free radicals and thus cause DNA damage, UVB(280-315nm)it constitutes 5% of UV radiation, It is called burning radiation because it is formation photoproducts that damage the DNA(Luigi et al.,2016)(Byrne et al.,2015). UVC(200-280 nm)it is called short-wave, completely absorbed by the ozone layer, it is characterized by its high ability to kill microorganisms, so it is used for sterilization purposes, it is also characterized by its high mutagenic ability(Hideg et al .,2013).

The mechanism and Damaging effects of UVC radiation on living organisms:

Many researchers have confirmed that UV-C has an inhibitory and harmful effect on living material such as lipids, proteins and enzymes. UV-C absorption leads to the formation of double bonds between the double carbon atoms in nucleic acids this causes a change and damage in the DNA structure (Rosolem et al.,2012).The inevitable result of UV-C absorption is the

formation of thymine dimers or cytosine dimers, which causes undesirable effects such as increased mutations, inhibition of replication, transcription and finally cell death (Banas, 2020). The mechanism of mutation by direct absorption of UV radiation by DNA causing pyrimidine photoproducts (6-4), or UV radiation causes what is known as photolesion in DNA by formation thymine dimers, which can occur in prokaryotes, yeast, mammalian cells and plant (Castell et al.,2010 ;Yaday et al.,2019) the increased of thymine dimers and the decreased of removal of these dimers is the main reason of decreased mutations rates and developing of skin cancer (Al Mahroos, 2002).

On the other hand the direct absorption of UV radiation by living cells affects on their different functions because the damage forming due to the production of reactive oxygen species (ROS). The absorption of UV radiation by amino acid produce free thiol groups which form new disulfate bridges(Banas 2020), moreover (ROS) causes many amino acid modifications such as nitrosylation, glutathionylation and carbonylation. which effect on protein functions(Beck et al., 2014).

The mutagenic effect of UV-C rays on living organisms:

1- Effect of UV-C rays on human

Xeroderma pigmentosum (XP): it's a genetic disease defined as a decreased ability to repair DNA damage which caused by ultraviolet UV radiation, and its disorder of DNA repair as a result of sun sensitivity, there is a strong link between sun exposure, DNA damage and skin cancer, clinical researches confirmed that nearly 10,000 fold increase in xeroderma pigmentosum around the world. Ultraviolet rays can be summed up with the term "complete carcinogen" because it is mutagen and tumor initiator and promoter, so the excessive exposure to UV light lead to profound health risk (D'Orazio, et al.2013) Many research papers explain the factors that increase the incidence of skin cancer: Light-skinned people (caucasians) are more frequent to burning skin because they are always UV-sensitive due to easy penetration of UV radiation the epidermis and damage melanocytes and keratinocytes so this individuals have high risk of skin cancer more than dark skin and the people who work outdoor are more exposed to the sun (Digiovanna, 2012) (D'Orazio, et al.2013), (XP) is caused by mutations in genes which responsible for repairing damaged DNA, when UV rays damage genes that control cell growth and cell division, cell either die or grow too fast and in an uncontrolled way that lead to the development of cancerous tumors(Rabie, 2021).

2-Effect of UV-C rays on plants

UV-C rays are considered the most harmful wavelengths of genetic material and the most absorbed by the DNA (genetic material), and therefore the most mutagenic (Hadi, 2012) cause a lot of changes at the level of the genetic material DNA, and thus this is reflected in the morphological shape of the plant. the most famous of these changes that have been studied in the Arabidopsis thaliana plant is cyclobutane pyrimidine dimers (CPDs), which constitutes 75% of the damage caused when exposed to UV-C rays, and there are other types such as pyrimidine(6-4) pyrimidinone products [(6-4) PPs] in the genome.

They also noted that mitochondria and chloroplasts produce (ROS) and thus (AtMC8) mutation is formed, which is induced in response to active oxygen species, which works with the gene caused by cell death (AtMC8), which makes plants vulnerable to cell death (Nawkar et al., 2013).

They also found in the Arabidopsis thaliana plant that (HY1) hypersensitivity to UV-C rays formed in the same plant is associated with a decrease in the synthesis of carotenoids and flavonoids as well as the rest of the defenses and antioxidants. Flavonoids are considered antioxidant molecules that may act as free radical scavengers by resisting free radicals and removing them before damaging plant cells (Xie et al., 2012). The irradiation of dandelion plants and purple coneflower, which are medicinal plants, high nutritional and therapeutic value, with UV-C rays for periods (10,30,60,120min) It caused physiological and structural changes in buds of common dandelion and purple coneflower the source stated that ultraviolet radiation increases the rate of genetic mutation in plants due to its strong oxidizing role. It has negative effects on flowering, transpiration and photosynthesis (Catronuov et al., 2017). Also, treatment with ultraviolet rays of yellow corn seeds for periods (0,30,60,120min) led to a decrease in germination of seeds exposed to different periods and a significant decrease in all studied traits such as root length, shoot length, seedling fresh weight and other traits, with an increase in the formation of mutant plants as a result of exposure to radiation and stimulating the growth of root hairs with a high density, and the seeds exposed to UV-C rays were resistant to fungal infection (Hammok, 2019). As a result of exposure to UV-C rays, the plants defenses will activate to counter free radicals, and these defenses are known as (sun screens) and include two types, physical such as trichomes and chemical such as pigments: anthocyanins, beta-carotene, phenols, glycosides, and hydroxycyanic acid, and activation of special receptors such as UVR8 protein (Binkert, et al., 2016; Rai and Agrawal, 2017; Arroof and urban 2020; Vanhaelewyn, et al., 2020). In a recent study, the

sup F system was developed to detect mutations in the DNA of Arabidons Irradiation of transgenic plants with UV (500-1000) j/m² led to a significant increase in mutation frequencies From 26-45, the transitions from G:C to A:T increased by 43% to 67%, and a high percentage of transitions from A:T to A:T occurred by 56% of the basic alternatives. It is a distinctive feature of the mutations obtained from plants exposed to UV-C (Nakamura, 2021).

3- effect of UV-C rays on animals:

The effect of UV-C rays is not limited to plants and humans, but includes animals as well. Animals receive solar radiation and this radiation causes them skin lesions, optic tumors, caloric stress or even death, with substantial consequent financial losses in the industry (Aionso, et al., 2015). Animals that are exposed to the sun for a long time and that are white in color or have little hair are more vulnerable to the risks of skin diseases caused by radiation And the main cause of these diseases is the destruction of DNA by UV, and the mutations are of the type cyclobutane pyrimidine dimers (CPD), pyrimidine (6,4) and pyrimidin one (6,4 PP), which cause negative effects such as inhibition of replication and transcription, which cause negative effects and inhibit replication and translation and affect the life cycle of the cell and cause death to it. (Tafurt and Marin, 2014). There are many diseases including cataracts disease in rabbits' eyes due to the formation of cross-linking protein and a change in cellular DNA (Frank, et al., 2011). UV also causes epidermoid carcinoma, which occurs in cows, and melanomas in dogs, which occurs in the mouth, lips, skin and fingers area. (Maricela, et al., 2019).

Methods of collect the references:

We collected the references from :Google scholar , Research gate , Scopus , ScieceDirect (Elsevier) , Conference and Book.

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