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Study the Effect of Electromagnetic Radiation towards Sustainable Healthy Buildings

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Abstract. In this study, the electromagnetic waves were defined with an explanation of their physical properties and negative biological effects on humans, where the importance of research appears in defining the concept of sustainability, leading to the construction of guiding standards that help designers to reach for sustainable architecture for healthy buildings. Accordingly, the research hypothesizes that sustainable buildings are high-efficiency buildings that reduce negative impacts on the environment and human health, and are designed to be economical in resource consumption. In this study, the sources and negative effects of electromagnetic fields on human health were identified as a problem and some suggestions were presented to solve them and prevent negative electromagnetic radiations from affecting human health by setting standards for protecting buildings from the negative effects of electromagnetic radiation. The main objective of this study is to reach a set of results that enable the achievement of eco-friendly buildings that take into account human needs and health.

Keywords: (EMF), Health Buildings, Sustainable Architecture, Negative (EMF), Ionizing Radiation.

دراسة تأثير الإشعاع الكهرومغناطيسي على المباني الصحية المستدامة

المدرسة / سارة نبيل القبانى
كلية الهندسة | جامعة الأزهر | مصر

المستخلص: في هذه الدراسة تم توضيح مفهوم الموجات الكهرومغناطيسية من خلال شرح خصائصها الفيزيائية وتأثيراتها السلبية بيولوجيا على صحة الإنسان، وتظهر أهمية البحث في تعريف مفهوم الاستدامة مما يؤدي إلى بناء معايير إرشادية تساعد المصممين في الوصول إلى أهداف مستدامة لعمارة المباني الصحية. وفقًا لذلك، يفترض البحث أن المباني المستدامة هي مباني عالية الكفاءة تقلل من الآثار السلبية على البيئة وصحة الإنسان، وهي مصممة لتكون اقتصادية في استهلاك الموارد. في هذه الدراسة تم تحديد المصادر والآثار السلبية للمجالات الكهرومغناطيسية على صحة الإنسان على أنها مشكلة وتم تقديم بعض الاقتراحات لحلها ومنع الإشعاعات الكهرومغناطيسية السلبية من التأثير على صحة الإنسان من خلال وضع معايير لحماية المباني من الآثار السلبية للإشعاع الكهرومغناطيسي. فالهدف الرئيسي من هذه الدراسة هو الوصول إلى مجموعة من النتائج التي تمكن من تحقيق المباني الصديقة للبيئة التي تأخذ في الاعتبار احتياجات الإنسان وصحته.

الكلمات المفتاحية: الاشعاعات الكهرومغناطيسية، المباني الصحية، العمارة المستدامة، الاشعاعات الكهرومغناطيسية السلبية، الإشعاع المؤين.

1- Introduction

Providing a healthy environment for future generations is one of the most important factors that must be concerned with interior, architectural and urban design, and by focusing on sustainable design, a large part of the architecture problems can be overcome, For example, protecting buildings from various negative radiation using modern design methods conscious of the importance of preserving the environment Where the building is part of the environment and not a burden on it, in addition to rationalizing the consumption of resources, including materials, and that the design achieves a significant impact in reducing harmful emissions in buildings, especially residential buildings in which a user spends the greater part of his life, thus preserving his health and the health of society.

Sustainability, according to its principles, provides many environmental treatments to protect the residential building from high electromagnetic fields so that it is a place that achieves comfort for its present and future residents through some guiding standards that the designer can follow, Whether at the level of architecture or interior design, an integrated population that achieves the concept of a sustainable society. A constant electric charge produces an electric field that surrounds the space. An electromagnetic field is produced if the charge is in motion. Electric and magnetic fields are distinguished by their wavelengths and frequencies, and the amount of energy these fields possess changes according to the wavelength and frequency of the field.[1]

Recently, great concern has arisen among people due to negative (EMF) reports of the health effects caused by magnetic fields. In addition to the presence of ionizing and non-ionizing radiation, which has an impact on buildings. Where changes occur in the structure of reinforced concrete structures under the influence of ionizing radiation. leading to a loss of strength of structures up to 60 %, are described. The influence of non-ionizing radiation is dangerous for reinforced concrete structures with prolonged exposure. This effect is manifested in the fact that in the presence of water in the pores and capillaries, the corrosion rate of metal reinforcement in reinforced concrete increases significantly. In this regard, it is necessary to conduct further research on the influence of the length, frequency, and energy of electromagnetic radiation on the degradation processes of the reinforced concrete structures surrounding us. [2] As a result, many international and national organizations and scientific institutions from universities have studied those waves, classified them, determined their sources, Conducted research on them, and indicated the biological and environmental effects that Infecting them, setting the limits of exposure to it and the highest permissible doses for workers and the public, as well as ways to limit its spread. The largest share of those studies concerned the most dangerous extent to humans and the environment. The human body is always exposed to (EMR) of varying intensity which depends on the location within the building or in the open space. (EMR) are characterized by the frequency, [3] intensity, and direction of magnetic electric fields, and the properties of free space polarization. Thus, the domains can interact within the tissues of the biological body.[4]

The environmental solutions and treatments provided by sustainable architecture can reduce these problems and improve the health of individuals in residential environments in which a person spends most of his life, and thus achieve important economic benefits to society, from sources of radiation, high-pressure lines, land transmission lines, household appliances and electrical appliances such as TV screens, computers, microwaves, wireless communication, etc.,[5] where electromagnetic waves spread in the environment in a wide range of wavelengths and from different sources to serve many purposes of human needs, but some of them are emitted in an undesirable way, which have a harmful effect on health, so solutions must be developed to reduce these health damages.[6]

2- Electromagnetic Radiation (EMR)

2-1 Electromagnetic Radiation (EMR) Definition

In 1820, the scientist Orested noticed that if an electric current passes through a wire, a magnetic effect arises, represented by the deflection of a magnetic needle placed next to the wire. Orested's discovery linked a relationship between the science of electricity and magnetism. The Electromagnetic Spectrum, Electromagnetic Rays, and Electromagnetic Waves all have the same physical meaning. Visible light, Microwaves, X-rays, Gamma rays, television, and Radio Waves are all rays known as Electromagnetic Rays, and they all have the same properties but differ in Wavelength and Frequency as shown in Figure 1. The higher the wavelength, the lower the frequency and vice versa. Electromagnetic fields consist of an electric field and a magnetic field that is perpendicular to each other. These fields are usually described by amount and direction.[7]

(EMRs) consist of oscillating electric and magnetic fields and interact directly with biological systems such as human cells, animals, and plants. To be able to better understand these interactions and to be able to reduce their negative effects on the surrounding environment and building design, it is necessary to know the physical properties of the waves that form the electromagnetic spectrum.

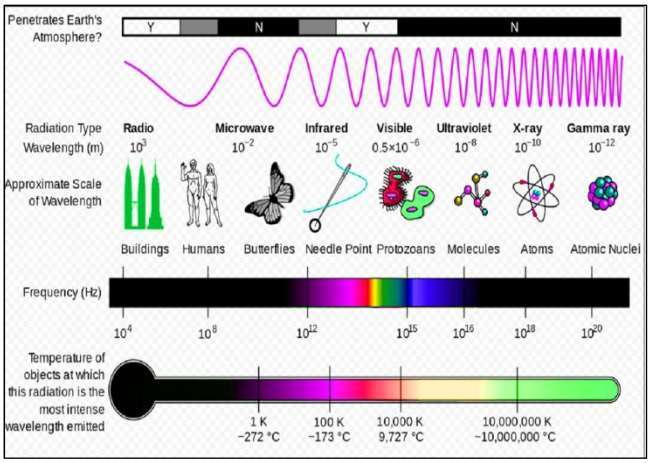

Figure 1: Electromagnetic Radiation Spectrum.8

2-2 Biological Effect and Physical Properties

(EMRs) are waves that travel at a speed of 300,000 kilometers/second and carry energy called photons; these fields consist of two fields that propagate in perpendicular directions, the electric field and the magnetic field. The photon is flown into an orthogonal direction, and electromagnetic waves can be described by wavelength, frequency, or energy. These three factors are related to each other, and each plays a specific role in the effect of the electromagnetic field on the biological system. The frequency of an electromagnetic wave is defined as the number of oscillations that pass through a fixed point per unit of time, the frequency increases as the wave is shorter, for example the average broadcast of AM radio stations operates at a frequency of one million hertz and the wavelength is about 300 meters, Microwave ovens use a frequency of 2.45 gigahertz, and the wavelength here is 12cm.[9]

As shown in Figure 1, the electromagnetic spectrum begins with long-wavelength and low-frequency radio waves, then the microwave region, the infrared region, the visible region, the ultraviolet region, the X-ray region, and then the gamma-ray region, this sequence is depending on the increasing frequency of these waves. Each region of the electromagnetic spectrum has characteristics that distinguish them from each other, and accordingly, different applications of these rays resulted. The effect of electromagnetic waves on biological systems is determined on the one hand by the strength of the fields and on the other hand by the energy of the photon. Therefore, some international organizations have taken upon themselves to calculate the values of the specific absorption rate and the power density that are allowed to be exposed, and which should not be exceeded,[10] such as The Australian Radiation Protection and Nuclear Safety Agency Standard (ARPANSA, 2002),[11] National Council on Radiation Protection and Measurement (NCRP, 1986),[12] the Institute of Electrical and Electronics Engineers (IEEE, 2001),[13] the International Commission on Non-ionizing Radiation1986), Protection (ICNIRP, 1998),[14] etc. Table 1 shows the higher SAR values that should not be exceeded.

Table 1. The Higher SAR Values Should Not be Exceeded.

ORGANIZATION	FCC	IEEE	IEEE	ICNIRP
Year of Update	**2001**	**2004**	**2005**	**1998**
SAR Value Measured on Human Head and Torso (watts/kg)	**1.6**	**1.6**	**2**	**2**
Mass of Living Tissue Used for Examination (gm)	**1**	**1**	**10**	**10**
Radiation Exposure Eime (minutes)	**30**	**30**	**6**	**6**

2-3 Electromagnetic Waves Types

Electromagnetic waves are classified according to their frequency and energy into "Ionizing Radiation" and "Non-Ionizing Radiation":

2-31 Ionizing Radiation.[15]

Ionizing radiation contains sufficient energy to ionize atoms. This usually implies that it can take electrons from atoms, while other forms of radiation can produce nuclear processes involving protons and

neutrons. Ionizing radiation is found in the higher-energy region of the ultraviolet spectrum, whereas non-ionizing radiation is found in the lower-energy zone, See Figure 2.

Ionizing Radiation Types: High-energy ultraviolet light, X-rays, Gamma rays, Alpha particles, Beta particles, Neutrons, High-energy protons, charged atomic nuclei from, cosmic rays and the Sun, Positrons and other antimatter, Background radiation.

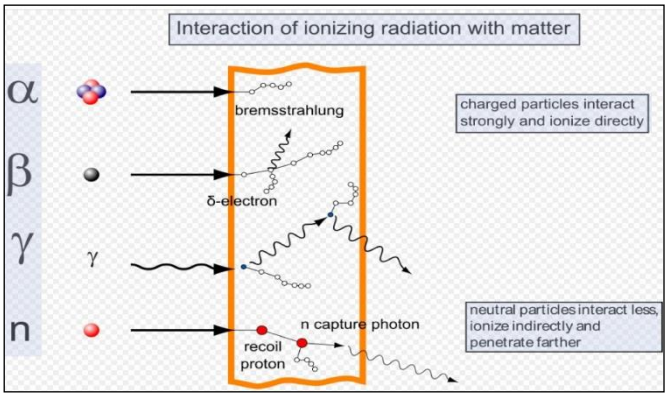

Figure 2: Radiation Interaction: Gamma Rays are represented by Wavy Lines, Charged Particles and Neutrons by Straight Lines, The Small Circles Show Where Ionization Occurs.[16]

2-3-2 Non-Ionizing Radiation.[17]

Non-ionizing radiation is radiation that does not have enough energy to ionize atoms or molecules. It does, however, contain enough energy for excitation, which causes electrons to move to higher energy states, See Figure 3.

Non-Ionizing Radiation Types: Near-ultraviolet light, Visible light, Infrared radiation, Microwaves, Radio waves, Very low frequency (VLF) radiation, Extremely low frequency (ELF) radiation, Thermal radiation, Black-body radiation.

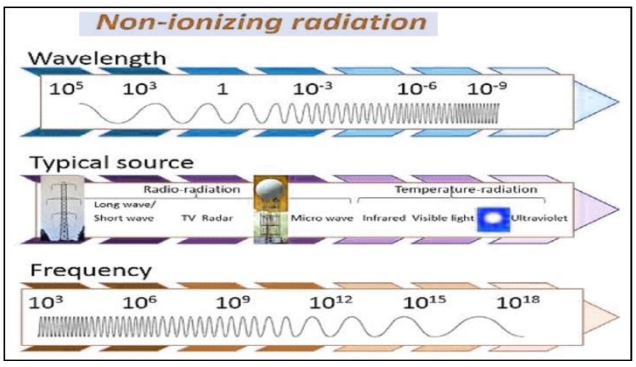

Figure 3: Non-Ionising Radiation is Divided into Two Main Areas- Optical Radiation and Electromagnetic Fields. [18]

3- Protection from Negative (EMR)

Engineers, architects, designers, and planners have a unique opportunity to create a healthier living, learning, and working environment by reducing the use of wireless technologies as they produce negative levels of (EMR).[19] Although it is better and less costly to include radiation-free solutions during

the initial design and construction stages,[20] there is numerous potential for improvement in existing buildings. Figure 4 shows a Flowchart of instant Processing (EMF).

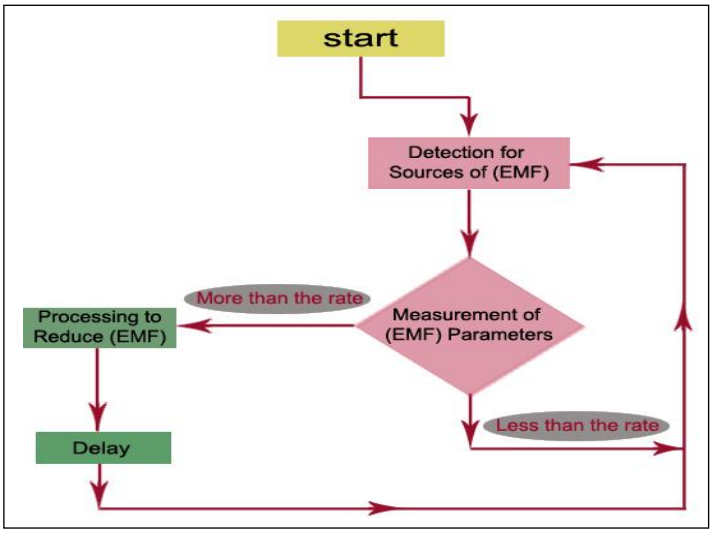

Figure 4: Flowchart of Instant Processing of (EMF) Rates.

3-1 Detection for Sources of (EMF)[21]

Electromagnetic radiation (EMR) is spreading more in our quiet living space. It surrounds us everywhere. There are three main sources of electromagnetic radiation that are used in remote sensing:

- Solar radiation, in other words, is natural radiation that originates from the sun.
- Terrestrial radiation, in other words, is natural radiation emitted by the Earth's surface.
- Artificial radiation originating from a remote sensing system.

Relative to the last source for many years, radio and television were the main sources of (EMR), but recently we have become more and more surrounded by technology and striving to make life more comfortable. At the same time, we are adding new sources of (EMR): mobile phones, base station antennas of cellular operators, Wi-Fi routers, access points, Bluetooth adapters, microwave ovens (microwave ovens), computers, phones, TVs, etc.

3-2 Measurement of (EMF) Parameters

Protection processor measures levels of (EMR) in the low frequency (LF: 5 Hz - 400 kHz) and high frequency (HF: 30 MHz - 39 GHz) band, and measures electrical (V/m) and magnetic (A/m) components for the (EMF), measure the power flux density (μW/cm2).[22] (EMF) can be measured from sources in the high-frequency band and sources in the low-frequency band.

The measurement is a stage to clarify the frequency if it is less than the rate or greater than the rate, and in this case, it is necessary to move to the next stage, which is the Processing.

3-3 Processing to Reduce (EMF)

When the measured values exceed the limit values or have high values, the source of (EMF) must be eliminated due to its harmful effect on human health. If this is not possible, it is necessary to take measures to prevent and protect from it is a negative effect, and the most important solutions to reduce

radiation exposure is to reduce the period of exposure to radiation, keep distances from the negative radiation source and finally use shielding solutions see Figure 5

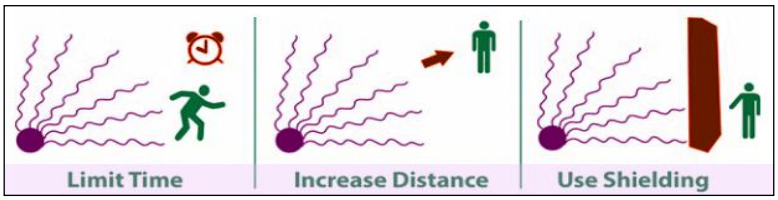

Figure 5: Solutions to Reduce (EMF) Exposure.[23]

3-3-1 Effective Implementation of Shielding Projects

The shielding of (EMR) propagating in space is based on the interactions with the materials. The major interaction at the interface of multiple propagation mediums is reflection. When the (EMRs) make contact with the materials, they are reflected if there is a significant difference between the materials' impedance and the free space.,[24] Therefore, the characteristics of the materials selected for buildings must be taken into account during the initial design stages,[25] for example, Ionizing radiation particles (e.g., alpha, beta) or high-energy photons (gamma rays, X-rays) can travel different distances and interact with the atoms of absorbing materials in their paths, causing ionization or excitation of the atoms. As shown in Figure 6, while alpha and beta particles are not very penetrating through other materials, gamma and X-rays are quite penetrating, as are neutrons.[26]

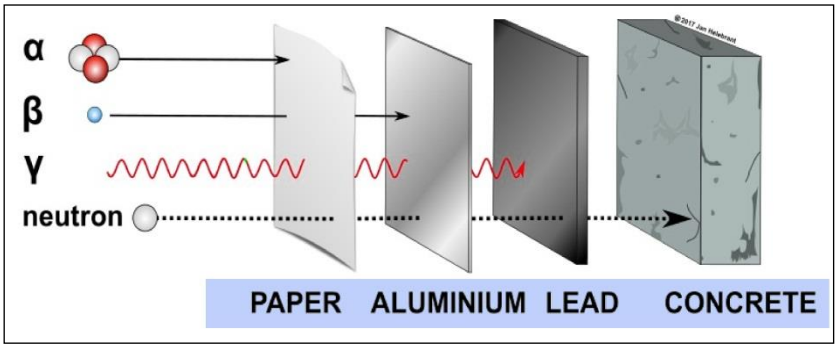

Figure 6: The Penetrating Power of Different Materials from Types of Ionizing Radiation, Ranging from the Least Penetrating Alpha Particles to the most Penetrating Neutrons.

3-2-2 Constructions and Materials of (EMR) Shielding[27]

Electromagnetic shielding is the practice of reducing the (EMF) in space and reducing the negative effect on human healthy by shielding the field, with barriers made of conductive or magnetic materials. Shielding is usually applied to buildings to isolate them from the environment through which the negative (EMF) passes. There are several methods of shielding, the most important of which are the following:

- Protective coating.
- Protective films for openings and windows.
- Special grounding for electromagnetic field shielding.
- Special protection curtains.
- Own shielding networks.
- Metallic foil.

4- Buildings Protection Standards from Negative (EMR)

There are standards for building protection from negative electromagnetic radiation related to the principle of studying the location of the surrounding environment and the efficiency of resource consumption, some of the important engineering parameters include:

4-1 Building Shape

The constructivism mass of the building design must be taken in a way that ensures obtaining the least surface of walls and external surfaces exposed to radiation in negative radiation areas. To get less radiation exposure and reduce the increase in other treatments used to protect from it,[28] and to reach that, the relationship between the external walls and the volume of the space must be studied as an internal environment for the health of users.

4-2 Exterior Envelope Design

The building envelope can be defined as the part separating the internal and external environment, whether it is ceilings or walls. It protects the building and its users and organizes the internal environment.[29]It also represents the main axis for all the processes of radiation exchange and transmission, as it is an insulator of the internal environment from the external.

4-3 Openings Design

The openings are defined as the empty parts inside the external walls, and one of their most important functions is the entry of natural light and ventilation. They are also used for plastic and aesthetic purposes, but they may be the main source of heat penetration into the building. Materials that can be easily shaped are often used in finishing the openings. Glass is preferred because of its high transmittance to light or sunlight or for vision purposes. [30]

The openings for the buildings must provide appropriate lighting and natural ventilation, as well as sound insulation and prevent heat leakage or increase, as well as radiations, and it is natural that the lower the percentage of glass in the facade, the better in terms of reducing radiation reflection. [31](Olagy) did a study that proved that the amount of radiation that penetrates glass is thirty times greater than the amount that penetrates through an opaque object.[32]Therefore, determining the size, location, and orientation of the openings during the design process plays a key role in the process of protection from negative radiation, and it is clear that glass treatments are developing at present to resist the rapid absorption of radiation.

4-4 Exterior Colors

Electromagnetic radiation is transmitted from a hot mass to a less heated mass through a vacuum or any transparent field such as air or glass,[33]as for the emissivity of a mass, it is the ratio of the radiation emitted by it to the radiation emitted by a black body at the same temperature. Since the absorbance of many materials for long waves differs from their absorbance for short waves, we find a difference in the absorbance of objects from their emissivity. Buildings painted white, for example, have absorbance ranging from (10-30%) while their emissivity ranges between (80-90%),[34]while for example, this big

difference in absorption does not appear in the glossy aluminum envelope that is used in building packaging. Table 2 absorption and emissivity coefficients of some materials and paint colors.

Table 2. Absorption and Emissivity Coefficients of Some Materials and Paint Colors.[35]

Material or Finish	Absorption Factor	Emission Factor
Aluminum Foil polished	0.05	0.05
Galvanized Steel, bright	0.25	0.25
Aluminum paint	0.5	0.5
Whitewash. New	0.20 – 0.15	0.9
White. Dirty	0.35 – 0.3	0.9
White paint	0.3 –0.2	0.9
Gray, green, brown, light colors	0.5 – 0.4	0.9
Gray, green, brown	0.8 – 0.7	0.9
Ordinary black paint	0.9 – 0.85	0.9
Cream brick. tile or plaster	0.5 – 0.3	0.95 – 0.85
Yellow or buff stone or plaster	0.7 – 0.5	0.95 – 0.85
Redbrick stone or title	0.8 – 0.65	0.95 – 0.85
Concrete title	0.65 – 0.45	0.95 – 0.85
Bitumen (black)	0.9 – 0.8	0.95 – 0.85
Glass	Transparent	0.95 – 0.85

4.5. Selection of Materials Used in Structure

Materials and Finishes in Sustainable Interior Design

Sustainable buildings must take into account reducing the use of non-renewable resources in construction and at the same time design and construction in a way that makes the entire building or some of its elements at the end of its life a source and resources for other buildings, So that we use eco-friendly buildings materials with low production capacity that do not contribute to an increase in the internal pollution of the building. There is also what is known as the radiation-related properties of materials that greatly affect the building's performance to make the required balance, which ultimately leads to preserving the environment from negative radiation that reduces the use of mechanical methods that help people reach comfort in the building,[25] concerning the materials used in the interior design, find many studies that have proven that most users in closed environments complain of symptoms that include a sense of physical stress, fatigue, headache and symptoms of depression caused by harmful emissions of some materials used in the manufacture of furniture or cladding and finishes, so all precautions must be taken to ensure not to leak any toxic negative radiation that spreads in the atmosphere of the internal environment of the building through building materials and materials used in finishes, furniture or construction systems of the building.[36]

5- Results and Discussion

The results of the research found the importance of reducing or avoiding the usage of pro (EMF) devices and Remain out of the (EMF) zone; keeping high-load appliances away from areas where we

spend a lot of time in addition to Using shielding processing as the last solution, shielding techniques can be used to reduce the level of fields. Shielding elf fields necessitates redirecting the fields around the location considered magnetically sensitive. Work to find local standards through which care is taken to evaluate sustainable residential buildings for the areas of radiation exposure to them also Attention to the idea of sustainable design compatible with the environment, as it has become a necessity necessitated by the requirements of the times and circumstances to solve the problems of the residential environment related to the exposure of buildings and users to a negative effect (EMR) and to achieve comfort for users.

6- Conclusion

In conclusion, the residential environment in our society cannot be considered sustainable unless the concepts of sustainability are adopted as a basis for modern residential design theories for users, by promoting social interaction and achieving a healthy environment free of radiation pollution while providing an economic dimension through the use of eco-friendly materials at low cost, all these ways are achieved by embracing the idea of co-creative design that adopts the principles of human design in which the human health being is the primary goal.

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