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A New Approach for Unmanned Aerial Vehicle for Sterilizing Cities from Covid-19 Virus

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ABSTRACT: All the world has been swept by a deadly epidemic called Covid-19 or Corona virus. The spread of this virus has killed thousands of people from different continents of the world alike.It is strange that the fierce invasion of this virus increased in some countries than others, which led scientists of these countries to speculate that the reason for this is the disregard of the citizens of these countries with the virus, or to look at the nature of the cold weather of these countries, which helped the spread of this virus. Also, in view of the absence of any effective drug with a high rate to eliminate this virus, this research works to find another solution in order to eliminate the spread of this virus using unmanned Aerial Vehicles (UAVs) that carry a radioactive source for gamma radiation in order to work on sterilizing cities and eliminating this virus, a due consideration was taken to the proportions and doses chosen to work within the sterilization process, so as not to harm the health of humans or any living organism alike. The challenges of the proposed work was the suitable radiation source that achieve minimum payload with high gamma rays activity enough to inactivate viruses at same time, so in this research cobalt-60 is best choice for it's properties as explained in result section, the main idea of this work is estimate gamma rate at different altitudes from cobalt-60 based on UAV with consideration avoid harmful doses on human. It was noticed from the context of this research that the results of using unmanned Aerial Vehicles in the process of sterilizing using gamma radiation are positive into theoretical results, but it is recommended to conduct practical experiments to compare those theoretical results.

Keywords: Covid-19, UAV, gamma radiation.

Abbreviations: UAV, unmanned Aerial Vehicle;GCS, ground control station; MANET, Mobile ad-hoc network; VANET, Vehicle ad-hoc network; FANET, Flying ad-hoc network; AMU, Atomic Mass Unit.

I. INTRODUCTION

The usage of unmanned Aerial Vehicle becomes more important in our daily life, whether in military or civilian applications, this was indicated from more than one reason, the most important of which is the accuracy, speed, efficiency and safety. It is also indicated that merging other systems to UAVs, such as the use of cloud computing capabilities, as it was indicated in [22] increases the accuracy and capabilities of the UAV systems.And due to the repercussions of the rapid spread of covid-19 and the absence of any effective medicine to eliminate and overcome this virus, it was noticed that all countries around the world are using the same policy in facing this situation, which is the disease prevention policy, by following the quarantine system for the citizens, by making all peoples to stay in theirhomes, this policy led to the emergence of many problems, as an example the economic problems. Also, this policy didn't prevent the spread of the disease, but only reduced the spread of the disease in time. Through this, our work is represented to find another way out, in order to eliminate this virus by using radioactive elements, which was cleared through a lot of researches to be highly effective in eliminating the virus.And from these radioactive element's we intend to use gamma radiation, by using them through the unmanned Aerial Vehicle to sterilize cities and eliminate the virus, considering the use of safe ratios and doses that do not cause harm to humans. The main difference between this proposed work and previous work is that work concolude a movable sterilization system and then sterilization can be done at any place,so the infication rate will be decreased, but other previous work didn't propose this novel approach in sterilization. This paper is organized in ten sections as follow, section two clarify the unmanned Aerial Vehicle and its important role, section three hints about the radiation approach, section four clarify the radiation resources and the unit of measurment, section five shows the effect of the radiation doses, section six discuss the maximum permissible exposure limits, section seven discuss the proposed scenario, section eight calculate the results, section nine concludes the paper and finally a section ten our future work.

II. MATERIALS AND METHODS

A. Unmanned Aerial Vehicles

UAV can be defined as a preprogramed plane without no pilot on the board, and it can be controlled through a GCS by the mean of wireless communication. Although, the spread usage of the UAVs becomes an important role in many aspects such as military and civilian applications, but knowing its components and the scientific paradigms is more significant in order to know what technology you are dealing with. The UAV is a subclass of Adhoc Network, which can be classified into three main categories as shown in Fig. 1, respectively MANET, VANET and FANET, and through this classification, we can recognize that the UAV is a part of FANET, Table 1, shows the main characterization for each category of the Ad-hoc Network, especially FANET [23].

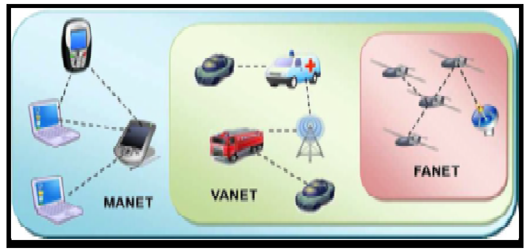

Fig. 1. The Classification of Ad-hoc Network [23].

Table 1: Ad-hoc Network Characterization [23].

Point of Comparison	MANET	VANET	FANET
Node mobility	Low	High	Very high
Mobility model	Random	Regular	Regular for Predetermined paths, But special mobility models for Autonomous multi-UAV systems
Node density	Low	High	Very low
Topology change	Slow	Fast	Fast
Radio propagation model	Close to ground, LoS is not available For all cases	Close to ground, LoS is not available For all cases	High above the ground, LoS is available for most of the Cases.
Power consumption And network lifetime	Energy efficient Protocols	Not needed	Energy efficiency for mini UAVs, But not needed for small UAVs
Computational Power	Limited	High	High
Localization	GPS	GPS, AGPS, DGPS	GPS, AGPS, DGPS, IMU

In [20], the main problem facing the UAVs, which was considered as the routing problem due to the dynamic change into the network topology was solved by equipping Cloud Computing to the system to work as a single system, this system was examined in [21] and gave a high performance to the UAV systems.

B. Radiation Approach

In this section a deep perspective consideration will be considered upon the atomic structure and the radiation methodology as follows:

(i) **Atomic structure:** The great scientist Bohr proposed a model [1], to define the atomic construction. This model consists of a central nucleus composed of neutrons and protons encircled by several orbital electrons equal to the number of protons as shown in Fig. 2, where the charge of Proton is positive, and the neutrons have no charge. Each has a mass of about 1 AMU, but on the opposite side, an electron has a negative charge and a mass of 0.00055 AMU [1]. The total number of protons indicates the atomic number (Z), where any element may have several isotopes. The isotope of any element is composed of atoms, which are included the equal number of protons as all other isotopes of that element, however, every isotope has a various number of neutrons than other isotopes of that element [2]. Some of the isotopes are stable, although others are unstable. Unstable isotopes commonly loose energy by undergoing a nuclear process named (decay) through one of the numerous radioactive processes. Elements are arranged in the periodic table ascending to Z. Radioisotopes are organized by A and Z in the chart of the nuclides as shown in Fig. 3.

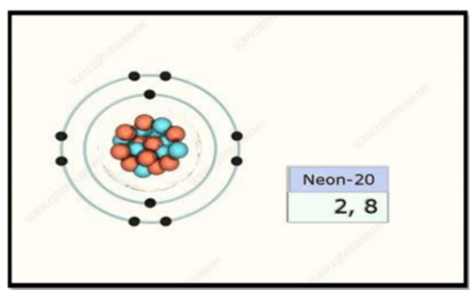

Fig. 2. The Neon atom [3].

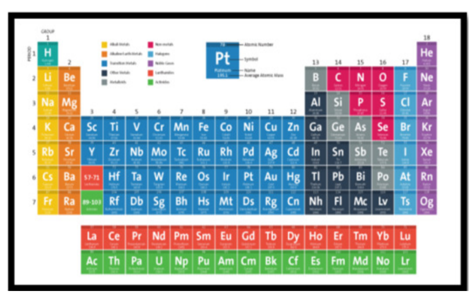

Fig. 3. The periodic table [4].

(ii) **Radiation:** Radiation is energy transferred through space in the form of electromagnetic waves or energetic particles. Electromagnetic as radiation, light or radio waves, have no mass or charge. Fig. 4, is a diagram of the electromagnetic spectrum, showing various properties across the range of frequencies and wavelengths [5].

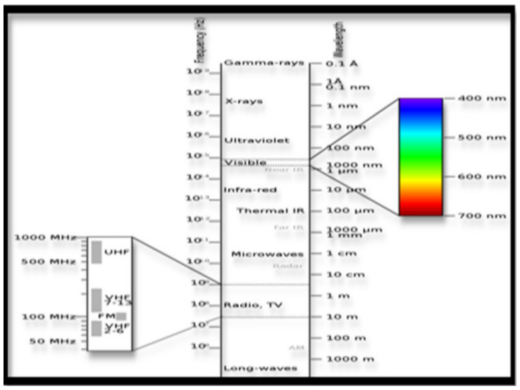

Fig. 4. Diagram of the electromagnetic spectrum [5].

(iii) **Classification of Radiation:**Radiation is arranged into two main categories, non-ionizing and ionizing [6] as shown in Fig. 5, the ionization depending on the capacity to ionize matter and the ionization potential of atoms.

Whereas, the Ionizing radiation can be classified into:

Directly ionizing radiation (charged particles): like electrons, protons, alpha (α) particles and heavy ions. This type deposits energy in the medium through straight Coulomb interactions between the directlyionizing charged particle and orbital electrons of atoms in the medium [7].

Indirectly ionizing radiation (neutral particles): photons (X- rays and gamma (γ) rays), neutrons [7].

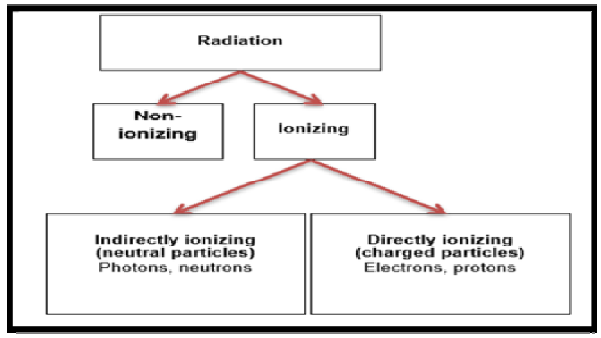

Fig. 5. Classification of Radiation.

C. Radiation Resources and the Units of Measurement

(i) **Radiation resources:** There are several resources for radiation, some are natural, and others are artificial, Table 2, represent those resources with the main properties for each, respectively, the half-time, types of disintegrations, applications and the origin of each element [8, 9].

Table 2:The Radiation resources properties [8,9].

Chemical Elements	Half-Life Time	Origin	Application	Types of disintegration		
				Alpha	Beta	Gamma
Tritium	12.3 years	Artificial	Thermonuclear fusion Biological tagging		✚	✚
Carbon-14	5,730 years	Natural	Dating		✚	
Potassium-40	1.3 billion years	Natural			✚	✚
Cobalt-60	5.27 years	Artificial	Radiotherapy Industrial irradiation Gamma radiography		✚	✚
Strontium-90	28.8 years	Artificial	Thickness gauges		✚	
Iodine-123	13.2 hours	Artificial	Nuclear medicine		✚	✚
Iodine-131	8.05 days	Artificial	Nuclear medicine (therapy)		✚	✚
Cesium-137	30.2 years	Artificial	Brachytherapy		✚	✚
Radon-222	3.82 days	Natural	—	✚		
Thorium-232	14 billion years	Natural	Mineral dating	✚		✚
Uranium-235	704 million years	Natural	Nuclear deterrent Fuel	✚		✚
Plutonium-239	24,100 years	Artificial	Nuclear deterrent Fuel	✚	✚	✚

(ii) **Types of Disintegrations:** The disintegrations are, Alpha (α) particles, B and Gamma (γ) rays [10], Table 3, s specifications for each. Disintegrations Types [10].

And according to the purpose of this research, which is eliminated and overcoming the spread of COVID-19, and from the properties of Gamma (γ) rays, which is illustrated in Table 3, Gamma (γ) rays were selected for this purpose.

(iii) **Units of Measurement for Radioactivity:** There are two terms for measuring radioactivity, respectively Quantity and Intensity, the quantity of the radioactive substance donation, is generally measured in terms of activity rather than mass, where the activity is a determination for the number of the radioactive disintegrations, the degenerations or the transformations for a quantity of matter undergoes in a given time, and it is recognized by two main units which are the Curie (Ci) or the Becquerel (Bq) (Ci=3.7 $\times 10^{10}$ Bq) [10,11].

The mass of radioactive substances is the main source of activity, however, the greater the mass of radioactive material, the more atoms are present to undergo radioactive decay [10,11].

Whereas, it is not constantly powerful to define the potential danger of a radioactive material in terms of its activity, resulting in using the intensity term for its coverage purpose, the term of intensity is as the radiant energy, that is emitted by a source per unit time per unit solid angle in a given direction, under a specific condition of radioactive elements, Table 4, shows the three main quantities for measuring the intensity.

Table 3: DisintegrationsTypes [10].

Property\disintegration	Alpha(α) particles	Beta(β) particles	Gamma(γ) rays
Nature	Positively charged particle	Negatively charged particle	No charge. It is wave like light
Effect of electric and magnetic field	Deflected by electric and magnetic field	Deflected by electric and magnetic field	No deflection by electric or magnetic field
Ionization	Strongest ionization	Less than α particles	Little or no ionization
Penetration	Least penetration power (stopped by a sheet of paper)	More than α particles. It can penetrate through clothes, skin and a sheet of paper (stopped by a sheet of aluminum)	Powerful penetrating. It can penetrate the human body and may be harmful for organs (stopped by many centimeters of lead or concrete)
Charge value	+2 charge value	-1 charge value	No charge
Travelling	Travel 2-4 centimeters	Travel 2-3 meters	Travel up to 500 meters

Table 4: The quantities for radiation intensity [10,11].

Quantity	Unit of measurement	Definition of unit	Amount
Exposure	-Roentgen(R) Coulombs/kg	Amount of charge produced in 1 kg of air by x- or gamma rays	-1 R = 2.58×10^{-4} Cb/kg
Absorbed Dose	-rad -Gray (Gy)	The amount of energy absorbed in 1 gram of matter from radiation.	-1 rad = 100 ergs/gram -1 Gy = 100 rad
Dose Equivalent	- rem - Sievert (Sv)	Absorbed dose modified by the ability of the radiation to cause biological damage.	-rem = rad x Quality Factor -1 Sv = 100 rem

D. The Effect of the Radiation Doses on the human and the virus

It was stated in [12,13] that, the external Radiation doses quantities are affected by three terms, respectively, time, distance and Shielding. These terms will be discussed as follows:

(i) **The Time:** The amount of radiation dose absorbed by an individual depends on how long the individual stays in the radiation field, the next relation defines this process [12]:

$$\text{Dose(mrem)} = \text{DoseRate(mrem/HR)} \times \text{Time(hr)} \quad (1)$$

Whereas, to restrict a human dose, the time spent in the area must be limited, in which the period of time that a human can stay in an area without exceeding a designated the dose limit is defined as the stay time, and it is determined from the equation (2) [12].

$$\text{StayTime} = \frac{\text{Limit (mrem)}}{\text{Rate Dose}\left(\frac{\text{mrem}}{\text{hr}}\right)} \quad (2)$$

Table 5 shows some of the proposed dose rate values and the stay time values in minutes, at the maxallowable limit for humans is 100 mrem, and at a fixed distance from the radiation source.

Table 5: Dose Rate and Stay Time at limit 100mrem.

DoseRate(mrem/ hr)	1500	1400	1300	1200	1100	1000
Stay Time (minute)	4.0	4.29	4.62	5.0	5.45	6.0

From the values obtained in Table 5, Fig. 6 illustrates that by decreasing the dose rate, the stay time increased and vice versa, this results in managing the effect of radiation dose on humanity and limit the harmful effects.

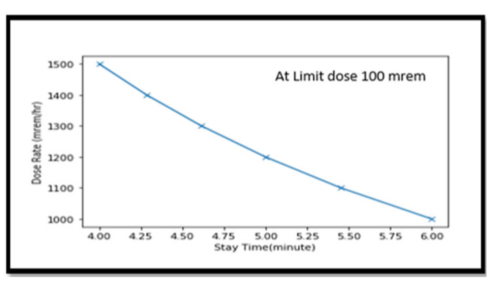

Fig. 6. Dose Rate and Stay Time at limit 100 mrem.

(ii) **Distance:** The amount of radiation dose absorbed by an individual depends on how close the person is to the source of radiation [12, 13], in this novel approach it is very important to compute the effects of radiation at several distances, it is indicated that the sources of x- and gamma radiation intensity at different distances are controlled by the inverse square law, which states that in the intensity of the radiation (I), there is a decrease in the balance with the inverse of the distance, results from the source (d) squared [12].

$$I\,\alpha\left(\frac{1}{d^2}\right) \quad (3)$$

And equation (3) can be written in the form of

$$I=K\left(\frac{1}{d^2}\right) \quad (4)$$

Where, K is a constant of unknown value, and to calculate two different intensities I_1, I_2, with two different distances d1 and d2, we will apply the equation number (4) as follows:

$$I_1=\left(\frac{K}{d_1^2}\right) \quad (5)$$

$$I_2=\left(\frac{K}{d_2^2}\right) \quad (6)$$

So, the relation between I_1 and I_2, could be written in the form of:

$$\frac{I_1}{I_2}=\frac{d_2^2}{d_1^2} \quad (7)$$

From equation (7), we can manage different intensities operating at different distances asshown in Table 6.

Table 6: Relation between source distance and intensity.

Source distance (feet)	1	2	3	4	5	6
The intensity (mR/hr)	500	4.29	4.62	5.0	5.45	6.0

Table 6 shows that the intensity is decreased by the mean of increasing the distance from the radiation source.

(iii) **Shielding:** The mean of decreasing the time or increasing the distance can't be a desirable choice, then shielding material to reduce the external radiation intensity is an acceptable choice, and the rules which manage this process is given in equation (8), as follows [12]:

$$I = I_0 \times e^{-\mu x} \quad (8)$$

Where, I is the intensity outside of a shield of thickness χ , I_0 is the unshielded intensity, μ is the linear attenuation coefficient of the shielding material and x is the thickness of shielding material [12].

(iv) **Maximum Permissible Exposure Limits:** Sterilization is exposure by which viruses and microorganisms are inactivated or killed. Gamma radiation intensity and dose have some limitations for individuals to avoid hazard effects.

Dose Limits For Individuals: The total effective dose equivalent to the individual must not exceed 100 mrem (1 mSv) in a year, and it is very important that the dose in the unrestricted area must not exceed 2 mrem (0.02 mSv) per hour [12].

Gamma Dose For Decreasing Microorganisms: To decrease the probability of bacterial, fungal or viral disease transmission, Gamma irradiation allows for the targeted reduction of microbial and viruses, often without drastic alterations of tissue properties. Nevertheless, radiation will cause some physical and chemical transformations in the graft, a compromise is required to ensure high enough radiation for microbial deactivation but low enough radiation to maintain the properties of the allograft [12, 14].

Whereas, a dose of 25 kGy of radiation was long regarded as the standard for tissue treatment and has been shown sufficiently to inactivate many bacteria, fungi, and enveloped and non-enveloped RNA and DNA viruses [12, 14].

However, tissue banks often modify their dosage from the reference 25 kGy and use dosesbetween 15 - 35 kGy to match the bio burden of the sample, achieve the desired safe and maintain tissue integrity [12, 14].

E. The Proposed Scenario

The proposed scenario depends upon the previous sections, by assuming a UAV with high payload in order to load the radiating elements, and to operate at different altitude as shown in Fig. 7, in order to sterilize an infected area.

The scenario implemented is to sterilize the infected area, while assuming some individuals in this area under sterilization, and we are going to test the operation specifications for the UAV system , that enable to control and inactivate the virus, and at the same time limit the hazardous effects for the human.

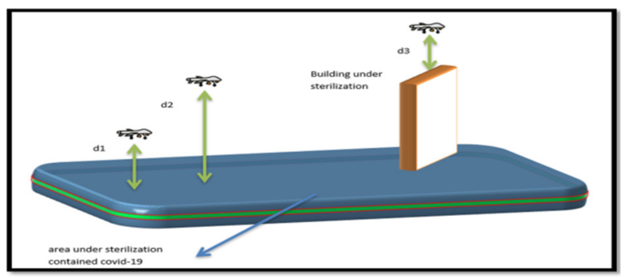

Fig. 7. Sterilization based on gamma rays and UAVs.

As shown in Fig. 7, the UAV altitude of the infected area is represented as (d), the exposure rate is (I) for every (d), which is according to the variation in distance (d) and exposure rate (I) that led to the absorbed dose changes at every surface.

III. RESULTS AND DISCUSSION

In order to choose the radiation resource, we use cobalt-60, The main advantage of cobalt-60, is the high intensity gamma-ray emitter with a relatively long half-life, 5.27 years, compared to other gamma ray sources of similar intensity, and it is used in sterilization of medical equipment [14].

The specifications of Cobalt-60 are listed in [15] , we found that,the gamma exposure rate (I) at 1 cm from 1 mCi is 12838 mR/hr, hence to estimate the (I) at 1 cm from 1Ci multiplying by 10^3,then (I) equals 12838 $\times 10^3$ mR/hr, which equal 3566.11 mR/sec, by increasing the quantity of Ci by factor 10^n .Then the exposure rate will increase by the same factor 10^n, for n=2 that mean ,the new quantity is 10 Ci and (I) will become 3566.11$\times 10^2$mR/sec , etc.

To estimate the weight of one Ci, in [16], we found that the weight of one Ci equals 0.91$\times 10^{-3}$ grams, according to this fact,we can estimate any quantity of n Ci by multiplying by factor n.

To estimate absorbed Dose, from [17, 18] one R deposits 0.00877 Gy, to estimate the dose Equivalent, from [18,19] one R deposits about 0.96 rem.

The results in next tables are based on the previous rules, Table 7 shows presents the parameters required to inactivate the viruses, by employing 10^{n} Ci (0.91 gram), the parameters estimated are the altitudes in (meter-foot), the exposure rate(I) in mR/sec at different altitudes, we use the relation (7) to estimate the (I) at each altitude, then, Dose Equivalent (De) in mrem/sec, absorbed Dose (Ad) in Gy/sec are estimated, and the total time (T) required to inactivate the viruses according to this relation which is used in next tables.

T=inactivation dose/absorbed Dose =25000Gy/Ad (9)

Table 8 shows the parameters required to inactivate the viruses, by employing 10^{6}Ci (0.91×10^{3}gram=0.91 kg), the parameters estimated as same as in Table 7.

Table 9 shows the parameters required to inactivate the viruses, by employing 10^{8}Ci (0.91×10^{5}gram=91 kg), the parameters estimated as same as in Table 7.

Table7: Parameters required to inactivate the viruses by using 10^{3}Ci (0.91gram)

Altitude(m-foot)	I (mR/sec)	De (mrem/sec)	Ad (Gy/sec)	T(sec-minute-hour)
0.01=0.0328084	3566111.111111111	3423466.666666	31274.79	0.79936=0.0133=0.00022
1=3.28084	356.61111111111114	342.346666666	3.12747	7993.86=133.23 =2.22
10= 32.8084	3.566111111111111	3.42346666	0.031274	799386.07=13323.1=222.05
25=82.021	0.5705777777777777	0.54775466	0.0050039	4996103.03=83268.38=1387.8
50=164.042	0.14264444444444443	0.136938	0.0012509	19985610.3=333093.5=5551.55
75=246.063	0.06339753086419753	0.0608616	0.0005559	44972117.287=749535.288=12492.25
100=328.084	0.03566111111111111	0.03423466	0.00031274	79938607.14=1332310.11=22205.16
150=492.126	0.01584938271604938	0.015215	0.00013899	179869055.327=2997817.5=49963.62
200=656.168	0.008915277777777777	0.00855866	0.00007819	319733981.32=5328899.688=88814.99

Table 8: Parameters required to inactivate the viruses by using 10^{6} Ci.

Altitude(m-foot)	I (mR/sec)	De (mrem/sec)	Ad (Gy/sec)	T(sec-minute-hour)
0.01=0.0328084	3566111111.111111	3423466666.666	31274794.44	0.00079936=0.000013322=0.00000022
1=3.28084	356611.11111111113	342346.666666	3127.47	7.994=0.133 =0.00222
10= 32.8084	3566.111111111111	3423.46666	31.274	799.38=13.323=0.222
25=82.021	570.5777777777778	547.75466	5.004	4996.003=83.2667=1.387
50=164.042	142.64444444444444	136.938	1.250	20000=333.33=5.551
75=246.063	63.39753086419753	60.8616	0.556	44964.0287=749.4=12.49
100=328.084	35.66111111111111	34.234	0.3127	79948.83=1332.48=22.2
150=492.126	15.849382716049382	15.215	0.139	179856.115=2997.6019=49.96
200=656.168	8.915277777777778	8.5588	0.07818	319774.878=5329.581=88.826

Table 9: Parameters required to inactivate the viruses by using 10^{8} Ci.

Altitude(m-foot)	I (mR/sec)	De (mrem/sec)	Ad (Gy/sec)	T(sec-minute-hour)
0.01=0.0328084	356611111111.1111	342346666666.66	312309444.44	0.00008004=0.0000013324=0.000000022
1=3.28084	35661111.111111113	34234666.66666	312747.94	0.07994=0.00133 =0.0000222
10= 32.8084	356611.1111111111	342346.6666666	31274.479	0.79937=0.01332=0.000222
25=82.021	57057.77777777778	54775.46666	500.39	49.96103=0.832667=0.01387
50=164.042	14264.444444444444	13693.866666	125.099	199.841=3.33069=0.05551
75=246.063	6339.753086419753	60806.16288	55.599	449.64837=7.494=0.1249
100=328.084	3566.111111111111	3423.4666	31.274	799.386=13.323=0.222
150=492.126	1584.9382716049382	1521.540	13.89	1799.85=29.997=0.499
200=656.168	891.5277777777778	855.866666	7.818	3197.748=53.29581=0.88826

IV. CONCLUSION

From Table 7,8,9,we observe that by increasing the quantity of Ci, the parameters (I), (De) and (Ad) are increasing but the total is decreasing.

To use the UAV in sterilizing Cities from Covid-19 Virus, it is recommended to carry the less weight and at the same time the total time in Sterilizing must be at minimum as much as possible, so we recommend to use the parameters in Table 8.

From Table 8, we can observe that, the range from 0.01 meters to 50 meters can achieve sterilizing,by using UAV easily for high altitude building, the UAV can make sterilizing in building at different altitudes at the minimum time required according to parameters in Table 8.

Another suggestion we can use the same parameters in Table 8 by using smart cars in Sterilizing streets,and robotics in rough areas such as Football pitches seats.

From Table 8, we can observe that to limit the hazardous effects on human, the area under sterilization must be evacuated , the short time in sterilization will short the total time of evacuation.

This work is compared to other related work, the main advantage in this work is the method of reducing Covid-19 in wide areas at different altitudes in short time as explained in previous sections. Barcelo (2020) the authorpresented a survey of modern findings and solutions for a much understanding o fthe environmental and health problems associated with COVID-19, the Paper provides precautions and recommandations that can be considered a huge data bout Covid19 which is very helpful for scientists of different disciplines, social media and citizens in general [20]. King *et al.,* (2020) the authors presented recommandations for workers healthy in specified area, these recommandations based on Lessons From Taiwan's Severe Acute Respiratory Syndrome Response, they recommended routine daily environmental cleaningand disinfection in the clean and transition zones. To avoid the increased danger of health care worker infection, cleaning, and disinfectionin the hot zone is limited, and only required in the case of visible contamination with bodily fluids [21].

V. FUTURE SCOPE

In the future work, we may study another radioactive element in sterilization. Also, we can focus on developing the robotics and smart vehicles in the sterilization process.

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