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Impacts of Radiation

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Abstract: ***At present environmental degradation is matter of concern and has received the top priority in current topics in political agenda across the globe. Apart from all other biodegradable and non biodegradable factor, today's most emerging threat to the environment is the nuclear radiations and electromagnetic radiations. Nuclear fissions in nuclear activities such as testing of atomic bombs, uses of nuclear weapons in wars, Nuclear accident and Nuclear power plants have created threats and hazards for human being due to its radioactive emissions of energy and harmful high energetic particles. Most of the part of radiated energy is thermal energy which could disturb the heat budget of the environment and can be shown using mathematical model based on relativistic mass energy relation. Calculation reveals the emitted particles and rays are high energetic and ionizing particles such as*** α, β ***and*** γ ***ray that leads to various biological effects on human body. Moreover, radioactivity is a long term process and radioactive emission continues for years and years and it imposes a big challenge to the disposal of the nuclear wastes . Besides it, thermal radiations from nuclear activity may pollute the aquatic ecosystem. The threat posing to human being due to nuclear activity in future is Nuclear winter which may adversely affect the animal kingdom and human being. Cold Nuclear fusion could be a partial solution to Nuclear fission. In addition to Nuclear hazards, the most recent pollution owing to the call of modernization is the threats from different sources of electromagnetic radiations which too have its adverse effects on our physical and mental health.***

Keywords: Nuclear fission, radioactive disintegration, Power plant Heat budget , nuclear fusion, electromagnetic

1. Introduction

Modern ecologist points out that environmental pollution is the negative change in the quality of any component of the environment so that it is no longer suitable for intended use. The emission of any undesirable nuclear radiation in the form of heat and particulates have also been identified as a source of environmental pollutant as nuclear radiation adversely affects human health, other living organism and aquatic ecosystem .The nuclear wastes are created by all aspects of nuclear technology including test of nuclear weapon , nuclear accident, atomic explosion(fission), nuclear power plant, industrial and research applications[1-3]. From 1957(the start of nuclear power generation) to 1983 it is estimated that 17millions pounds of wastes were generated and the disposal of which is still a big concern as the radioactive wastes remain active for thousand to million of years[4].It is reported a single nuclear power plant produces 1,000 cubic meters of low level wastes and larger nuclear power plant can discharge 30 metric ton spent fuel per year [4]. Apart from theses wastes, thermal radiations due to nuclear fission in atomic explosions, power plants, nuclear accident and all other nuclear technological activities have yielded a large amount radiations. On the hand electromagnetic radiation especially radio frequency radiation is also believed to be pollutant as far as the health quality of humans are concerned although research is being carried on in full swing.

2. Materials and Method

The paper is intended to review the quantitative strength of nuclear hazards that it could be as a result of nuclear radiations which can be done to some extent using Einstein relativistic mass-energy equivalence relation and exponential law of radioactivity i.e $\Delta E = \Delta mc^2 and\ N = N_0 e^{-\lambda t}$ Various research reports in regard of biological impacts are to be freely consulted for review to see whether any close agreement with the approximated quantitative prediction exists.

3. Presentation

Nuclear Fission and Energy

Since most of the nuclear activities such a test of atomic weapon, nuclear power plants, nuclear explosions take place as result of nuclear fission of heavy atomic nuclei. In the process, heavy nuclei split in to multiple fission fragments followed by emission of high energetic neutrons. In nuclear fissions in power plants atomic bombs and in most of the nuclear weapons except hydrogen bomb(fusion) is that uranium U-235 is enriched as compared to U-238 as the former is more efficient nuclear fuel in both controlled and uncontrolled nuclear reaction .More over Pu-239 is also used as a fuel. Let us take the most common binary fission process ${}_0n^1 + {}_{92}U^{235} \rightarrow {}_{92}Ba^{141} + {}_{36}kr^{92} + 3\,{}_0n^1 + Q$, Q is energy released in fission. According to Einstein mass energy equivalence relation $Q = \Delta E = \Delta mc^2$, Δm is the mass defect. To quantify the amount of heat energy released, we must work back with Einstein relation

$$\Delta m = M(U^{235}) + m({}_0n^1) - [M(Ba^{141}) + M(Kr^{92}) + 3m({}_0n^1)]amu$$
$$= 235.0439 + 1.0087 - [140.913 + 91.8973 + 3\times 1.0087]\ amu$$
$$= 0.2153amu,\ \ \Delta m \approx 931.5 \times 0.2153 \approx 200.4430\ \ Mev$$

In each fission, apart from fission fragments, three (3) highly energetic neutrons emitted and in the n^{th} $progession$ 3^n neutrons emitted. Surprisingly, in extremely small time scale10^{-9}= $.000000001$ Sec. each fission is completed. As a result in fission of 1Kg uranium alone, the amount of energy release is so large, sudden and violent and we have to express it in atomic scale Mev unit.

$$1kg\ of\ U^{235}\ \ contains = \frac{6.02\times10^{23}\times10^{3}}{235} = 2.56\times10^{24}\ \ number\ of\ uranium\ atoms$$

$$Q \approx 200\times2.56\times10^{24}\ Mev \approx 10^{14} = 100000000000000J$$

$$\approx energy\ can\ be\ obtained\ \ from\ 400\ tons\ of\ \ TNT$$

$$i.e\ 50\ kg\ U^{235} \approx energy\ \ librated\ \ from\ 20,000\ tos\ of\ \ TNT$$

$$\approx energy\ \ liberted\ \ from\ 287,50,000\ tons\ of\ coals$$

Heat budget and surrounding environment

Surprisingly, 50 Kg of U-235 Yields that much of enormous energy that can be obtained from combustion completely of 287,50,000 metric ton of coals. Since in a typical fission of a single U^{235} results 200Mev of energy, out of which 170 Mev is carried by fission fragment as their kinetic energy , while 2 to 5 Mev by fission neutrons and 15-18 Mev by $\beta\ and\ \gamma$ and γ rays may carry up to 7Mev alone due to radioactive disintegration of fission fragments and remaining 10% by neutrino in β decay, which are left in excited unstable states after fissions. Since, most of energy carried by fission fragments and energetic neutrons there after converted in to heat energy to the surrounding matter. If we consider such a typical fission of natural uranium (atom bomb) nuclear weapons (fission) theoretically calculated then about 85-97.5 % energy is emitted as collective kinetic energy of the fission fragment and neutrons. Apart from this, in nuclear explosion of 1kg U-235 can produce heat of 88,000,000,000KJ/Kg [6] through the fission reaction

$$U^{235} + n^{1} \rightarrow Rb^{90} + Cs^{143} + 3n^{1}, H = 88,000,000,000KJ\ /\ Kg$$

This implies frequent nuclear test and nuclear activity would adversely affect the heat budget of the environment and would lead to the adverse effect of the surrounding over a It is to be noted an average 2.5 neutrons are emitted from each fissionable uranium. *That amounts to say , if we ignore the any other loss or dissipation of the kinetic energy except those of converted in to form thermal and infrared radiations and emissions of radio particulates due to the blast in nuclear fission, then one can theoretically show how much damages could a explosions (test of atomic weapons) bring about in terms thermodynamic equilibrium or thermo dynamical parameters and radioactive hazards in the environment.* If N_i is the total number of fission fragment of each kind and f_i be the degree of freedom associated with each ,H_d is the direct heat produced for the entire process then , temperature of the surrounding may be approximated to be as given below

$$\sum N_i f_i \frac{1}{2} k_B T' + H_d = H \Rightarrow T = 10^{6}\ \deg ree\ centegrade$$

As a result with in a area of 2km due to the heat produced causes havoc and temperature rise up to order of10^6 degree centigrade which burns everything around the blast and blast waves are set up due to sudden expansions of air which can dash all the buildings [3].Since ,the radiation intensity varies inversely as the square of the distance from the source whereas the blast intensity varies as the cube of the distance from the source. Therefore heating effect more ikely to spread over a huge area and over ranges the blast effect.

(ii) Although the amount heat radiation differs that results from different components used in power plant, but typically at an average 60%-70%of heat release in Nuclear power plants [5].All the heat are not used to run turbines. In nuclear power plant water is drawn from river, lakes or vast ponds and passes through the cooling system and return back to water body. This water may be contaminated by heavy metals and salt as well which disturbs not only the heat budget of aquatic system but also pollute the aquatic system. The result is that there is thermo dynamical imbalance of the aquatic system .For an example in South Texus power plant discharge canal 30^0F more warmer than the rest of the part. That result some of species and the fishes hatch early and some species die early . Study reports proved that the population of some species of fishes have significantly dropped down in some region of US [5]

Biological impacts on human

Out of each fission energy 3.5% alone carried away by gamma radiations. That is the frequency of gamma radiation turns out to be in fission

$$E_\gamma = hv_\gamma = 7Mev = 7\times1.6\times10^{-13}J \Rightarrow v_\gamma = \frac{7\times1.6\times10^{-13}}{6.62\times10^{-34}} = 1.69\times10^{21}Hz$$

Since this high frequency of γ (electromagnetic radiations) is most penetrating and 100 and 1000 times more penetrating than harmful α,β radiations. Although electromagnetic radiation is charge less radiation, yet due to large energy of γ radiations it can burn the human body and can damage the human tissue as with this much of energy it can ionize the molecular atoms in human body. Moreover, the fission fragments do not always emit only β,γ but may also emit $\alpha\ particles$,which are four times heavier than that of proton and have typical kinetic energy in the radiao decay ranging from 4.19 to 6.78Mev, therefore have tremendous velocity of the order which can be calculated as follows

$$\bar{E}_\alpha = \frac{1}{2}mv^2{}_\alpha = \frac{4.19+6.78}{2}Mev = 5.486Mev \Rightarrow v^2{}_\alpha = \frac{2\times 5.486\times 10^{-13}}{4\times 1.67\times 10^{-27}} = 1.6422\times 10^{14}$$

$$velocity\,of\ \ alpha\ particle \quad v_\alpha \approx 10^7\, m/s,$$

Physically, speaking with such energy, the alpha particles in form of radiation is well enough to highly ionize the atoms and molecular atoms and can produce burning effect in radiation victims. Moreover , the beta particles which have velocity of the order velocity of light and found to be one of the most swiftest particles in physical world have energy ranging from 2Mev to 3Mev.This assigns beta 100 times strong penetrating power than that alpha and 100 times more ionizing than gamma .*The above calculations show all the emitted particulates in form are not only ionizing but also penetrating although* α *is least penetrating* .Because of high penetrating power β can enter in to the few mm thick aluminum while γ can penetrate through several centimeter of thick iron and lead. This is one of the reasons, why nuclear radiation of such particulates are harmful to human body. As such radiations can ionize and even can leave the atoms in excited states. Hence, the constituent atom can form different molecular structure before the electron could return to the normal state[3].*Thus it can even break the structural pattern of DNA by breaking their bonds. If radiation changes enough DNA molecules, cells can not replicate them begin to die. It is reported that cells cannot control their divisions grow out of control turn to be cancer [5].It may affect genetically and delay parenthood may be one of its consequence. [8]*

(iii)Nuclear fallout- Due to the violent energy release in explosion of nuclear weapons in submarines and other part near earth surface ,it has always the risks that the high energetic radiation (already shown) in addition to thermal pressure the particulates and blast may spread over considerable crop area and water body , and settle downs there. The soil might be carried up to the clouds by the blast

$$D_R \propto \frac{dD_R}{dt}\ ,\ \ D_R \propto t\ ,\ \ \propto A_E\ ,\ D_R\ \ \propto \frac{1}{r^2}\quad \because I_R \propto \frac{1}{r^2} where\ I_R\ is\ the\ inensity\ of\ radiation$$

However, radiations doses effect differently but various reports found to be in disagreement in quantity.

Ways of Nuclear pollution

[1] ***Melt down in power plant***-Due to the overheating of the nuclear reactors as it may happen ,nuclear core may melt down due to failure of cooling system, when it allows one or more fuel element to exceed the melting point. *As a result, harmful radiation contaminate the environment. In March 1979, failure of cooling system disabled one of the reactor at Three miles island in Pennsylvania and certain amount of radioactive materials escaped.[3]*

[2]**Leakage in power plant**-The leakage of excessive radiations directly affect the power plant workers and found to be suffering from various diseases, even causes death above 6-10 sievert.

[3]Other technological cause-A leak of radioactive water from power plant .Tritium which is deliberately produced in power plants may be contained with the water .Tritium $_1H^3$ is radioactive, which can emit lower energy beta particle. The primary concern is the drinking water in addition to biological magnification leading to tritium in crops and food consumed by animals[13]

and under air pressure may travel and settles downs in other part of habitant. This would poison the water body and foods[2](iv) Other study reveals over radiations doses from this fall out and direct impact ,may causes changes in the constitution of blood[2]The radiations may attack and destroy all parts of thyroid gland if over exposed to radioactive – iodine-131[7],[9](v)A heavy dose of radiation could damage lymphoid tissue and bone marrow [2].

As per Research report of ref.[9] the radiation dose and its impacts are tabulated below.

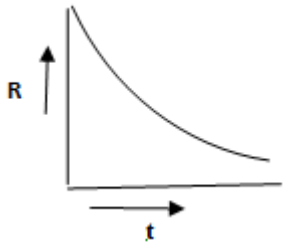
Dose-rem	Impacts
20-100	Temporary reduction in white blood cell
100-200	Fatigue, vomiting, diarrhea, hair fall , reduction of resistance to infection
200-300	Serious radiation sickness such as skin disease
300-400	Marrow destruction
400-500	May make severly ill and serious inability , mental disorder, sleeping

This table shows that the damaged caused by radiation depend on doses butexact mathematical calculation is not possible due to various factors that depends on individual victim , strength and nature of radiations. Mathematically speaking, the research made so far seem to yield the following relation the dose absorbed varies inversely as the square of distance from the radiation source provided that dose is equivalent to intensity of radiations(neglecting biological effect)and linearly proportional to the time of exposure and area of exposure and dose rate

[4]Nuclear wastes-Mathematically speaking, radio activity is long term never ending process which follows exponential law of decay. $N = N_0 e^{-\lambda t}$ *as* $N = 0$ *at* $t = \infty$ In other words the problem is that the fuel rod used in power plants and wastes result from explosions remains radioactive over the long interval of times ,may ranging from several hundred of years to even million of years depending upon the quantity of initial wastes and rate of radioactive disintegration which can be seen from the plotting of activity 'R' vs time 't'. Hence, the disposal of waste is still a big challenge as right location is easy to specify but difficult to find stable geologically.

$$N = N_0 e^{-\lambda t}, R = -\frac{dN}{dt} = -(-\lambda N) = \lambda N$$

$$\Rightarrow R = \lambda N_0 e^{-\lambda t} \Rightarrow R = R_0 e^{-\lambda t}$$



Here, R is the activity of the decay at any time 't, R_0 is the initial activity at t=0. The spent nuclear fuel U-235, Pu-239 include a wide variety of carcinogenic radio nuclides such as strontium(Sr)-90,iodine(I)-131,Caesium(Cs) and includes some of long lived transuranic radioactive isotopes such as Am-241,Pu which need a great care to be disposed the waste.

Impacts of electromagnetic radiation

The gamma ray which is electromagnetic can cause ionize and has high penetrating power has chance to interact with the human cells and burn .Most of the researcher are of the view that the radio frequency which ranges from 1KHz to 20Khz are used in telecommunication , radio broadcasting and television broad casting have some negative impacts on human .It is to be noted that out of all modes of propagation (the radio signals are transmitted in form of ground wave ,sky wave and space wave).But, the greater chance of interaction with human on earth surface through ground wave and sky wave but greater than 1000km, space wave cannot be used for transmission .So, long distance transmission likely to increase the more interaction of radio transmission with the people on the earth as the energy repeatedly reflected back to the earth through ionosphere[10]. The pointing vector (intensity) or EM radiations varies as like as nuclear radiation as $\langle S \rangle = I_{EM} \infty \frac{1}{r^2}$ This suggests the risk of radio frequency is maximum near the antenna and decreases .On the ground. People who live and work at the top of multi floor building for long time near radio signal receiver has greater risk of interaction with radio frequency. Various research tend to establish that the radio frequency radiation can increase headaches, tumors , sleeping disorder but the accurate impacts are yet be confirmed . Recently, in some petrol pumps in India sudden fire incidents have been reported, the root cause behind the incident has been reported to be the interaction electromagnetic radio frequency that generated from cell phone. Some of the medical experts are of the view that excessive exposure to radiation to EM radiation may cause leukemia and brain cancer .**An important united stae government study reveals cell phone radiations elevate the risk of cancer and according to report of IARC-2011 ,RF radiation is carcinogen**[12].However, some infra red radiation may burn the body as they produce heating effect on radiation is passing through the matter and cause dehydration and low blood pressure[11].Our eyes ca not detect infrared radiations and greater risk that unknowingly such radiations may affect us. Recent medical reports [13] reveals that x rays are able to ionize atom and has large frequency ranging from 10^{16} to10^{19} Hz, can cause mutations ,therefore lead to cancer later in life and it is estimated 0.4% of cancers in America caused by CT scans .According tone one study , by the age 75 , the risk of cancer increases by 0.6%-1.8%.

Historic Nuclear disaster- The worst environmental disaster in history technological is the release of 50 tons of radioactive at Cherbonyl , Ukraine, in 1986 caused many casualties , the radiations released was 200 times than the total given off by Hirosima and Nagasaki atomic bombs[3] which spread ove Europe and contaminated soil, crop, agriculture due to emission of Cesium,strontium.

4. Future Consequence

In contrast to EM radiations ,the nuclear radiations is much more destructive as per the long term environmental aspects are concerned .A typical nuclear power plant in a year generates 20 metric ton of used nuclear fuels per year and over the past of decade , the entire industry has produced 76,430 metric tons of used fuel[12].As typical test and explosion in which fision occurs yield a temperature of the order 10^6 degree centigrade in addition to the heat contribution from various nuclear power plants. If the race of nuclear test go on increasing globally along with set up of number of power plants ,then its adverse consequence would appear in heat budget of the earth environment very soon, which may be proved fatal for plants and human due to the establishment of thermal equilibrium .The direct consequence is temperature rise of the environment. More over wastes from nuclear fuels are transuranic and have risk of continuous radio disintegrations over a long period that may likely affect the future generation and our environment. Besides, every kind of nuclear activity including fission, fusion, radioactivity is harmful to some extent due to the thermal, electromagnetic, nuclear particulates radiations. On the other hand seeing the enormous destructive powers of energy release, there has been a made race between the super powers for acquiring and stock piling more and more such nuclear weapons. But, the radioactive wastes, emitted particulates and the smoke may hang out in the sky over a large area of the surface of earth. This will cause to form a harmful layer that absorbs all the solar radiation s and blocks the solar energy to reach the earth surface and may damage the ozone layer. This would result a **Nuclear winter** causing enormous damages to the environment including plant kingdom and if it happens, the earth environment will no longer be suitable and safe to live .This situation may be called **Nuclear holocaust,** a future threat to all living beings on earth. As such a situation prevails, the temperature of the earth surface will significantly drops down causing hazards for all living organism.

5. Remarks and Conclusion

Since most of the activities of power productions in Nuclear world involves nuclear fission of heavy isotopes. This is not environmental friendly due to its radioactive by products which remain as threats for almost all the times to come and the disposal of such wastes in stable geological place beneath the earth is a big challenge as the earth quake effect, Volcanic eruption, tectonic plate movements that may result

that the radioactive elements might mix up with and contaminate ground water. Later which may flow into sea, rivers etc. To have alternative source of power , Nuclear fission may be one of the choice , through fusion of abundant deuterons isotope available in sea water. The advantages of fusion over fission is that no radioactive product is produced and more thermal energy can produced.

$$(d-d): {}_1H^2 + {}_1H^2 \rightarrow {}_2He^3 + {}_0n^1 + 3.27Mev \quad or \quad (d-t)\ {}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0n^1 + 17.6Mev$$
$${}_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + {}_1H^1 + 4.03Mev$$

But, the practical difficulty to initiate nuclear fusion in laboratory it requires extremely high temper of the order 10^8 k and plasma confinement .*This practical problem is being addressed in search of Cold Nuclear fission reactors.* Other alternative non polluting sources may be referred to non conventional renewable source such as solar energy, ocean thermal energy, wind energy which are environmental friendly as far as radiations are concerned.

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