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RESEARCH ARTICLE

BUILDING ALLIED MANAGEMENT OF HEALTH IN ANTHROPOCENE EPOCH.

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Abstract

The building materials during post Holocene were local materials now replaced by man mediated concrete, steel, aluminum, glass, PVC, sheet rock *etc.* in the present Anthropocene epoch. The sky scrapers need to be energy efficient, low water demand and waste generation, heat comfort and hazardless. The construction parameters are the R value, U factor, physical properties, shading coefficients; solar heat gain coefficient, volatile organic compounds and other ionizing radiations of the materials those are deteriorating human health. The heat comfort and fatigue reduction technologies for cool and radiation less buildings, active and passive cooling methods are discussed. The recommendations of international working groups like Indian Green Building Council, Leadership in Energy and Environmental Design, Green Rating for Integrated Habitat Assessment, and The United States Agency for International Development are discussed related to human health. The challenge for the modern construction is to find replacement of construction materials to the present radiation causing materials to provide building related safe human health with rising temperature. The study investigates the present building material parameters in the new epoch and its effect on human health and a management strategy have been developed.

Introduction:-

All living beings have to strive for a place to live with comfort without fear. The Homosapiens learnt to construct there houses from other living beings. The caves, the tree tops were considered safe initially. Gradually the growth of population forced them to live in community for food, safety, vernacular, antenatal and geriatric care. Hominids in India followed either the Bastu (concept of space) or the Bastu Purusha (energy, power, soul and cosmic rays) Mandala (architecture) up to 19th century. All the monuments and palaces in India were constructed according to Bastu Purusha Mandala in ancient times. The model of construction was Pukka, Semi Pukka or Kachha houses with good lighting and ventilation. But the 11400 years old Holocene era has been overtaken by the Anthropocene epoch since 1945. Anthropogenic activities have changed the earth's climate, soil, land, lithology, limnology, oceans and biosphere. The changes are so rapid that the man has dominated the lithosphere, the hydrosphere and the atmosphere. The humans have generated 208 numbers of new minerals and metals within last 70 to 80 years. The changes are so fast that it is considered the Anthropocene epoch has commenced from 1945 Mishra S. P. 2017[1].

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The Anthropocene Epoch:-

The commencement of the new epoch is taken as the day of first atomic testing and explosions in 1945. The atmospheric radiation and formation of Carbon dioxide accelerated from 1945 onwards. Further it is observed that human dominance over the nature of the earth's stratigraphy are due to continuous nuclear tests, missile launching. The development in science & technology, agriculture, urbanization and industrialization occurred to meet the need of burgeoning population. Over exploitation of land, forests and excess use of fertilizer, pesticides for agriculture and changes in construction materials have made the earth human oriented. After World War II, smart and green building concept and use of sheet rock and stucco in building construction have brought revolutionary changes in life style and exposure to radiations accelerated from 21st century onwards. The damages made at Hiroshima and Nagasaki during World War II is in two stages first at the time of explosion and in long run it was from fallout. The worst effect is still present which reminds us the catastrophe. (https://www.epa.gov/radiation /radiation-health-effects)

The beginning of the Anthropocene:-

Human are continuously exposed to radiation by surrounding materials that can cause cancer, genetic hereditary defects and damage to DNA. These include smoking, chewing tobacco, asbestos, UV lights, chemicals and dyes, hormones and toxins through eatables etc. Some invisible radiations are permeable through walls and human tissues even on exposure (European Nuclear Society https:// www .euro nuclear.org/info /encyclopedia/r/radiation-effect-whole-body.htm). These radiations are α, β, γ and X-rays. In those radiations, protons, electrons and neutrons are energized which can penetrate living tissues which affect normal biological processes. The radiations can only be obstructed by thick concrete walls and water columns at less cost.

The return of the pre-Holocene epoch is considered due to the present anomalous climatic behavior. [redacted] The formation of 9.2 million km² Sahara desert, the conversion of 42mtr [redacted] deep, 6800Km^2 area of Aral basin to shallow swamps, freezing of Niagara fall due to drop of temperature in polar vortex are the imprints of climatic changes in the Anthropocene epoch. The anomalous terrestrial phenomena and abrupt climatic swings are the polar vortex havocs with Nigeria falls (2014), severe chilled weather in north USA, north Europe and Canada, devastating floods in Europe (2012) and Africa (2015), drought in Spain (2012), migration of bears' by chilled Scandinavia winter, huge forest fire and record breaking heat waves in Australia and slamming of VSCS along India and Haiti in 2013, 2014 and 2016. The unstable sea, desertification of Sahara and the Aral Sea from forests and green land in last 100 to 200 years, abnormal changes in CO_2 level in the atmosphere are the portents that indicate the shift to Anthropocene epoch from the Holocene epoch on the earth (Fig 1(a) and Fig 1(b).

The working Group:-

The International Commission on Radiological Protection (ICRP) in 1928, the International Atomic Energy Agency (IAEA), World Health Organization (WHO), International Labor Organization (ILO), Nuclear Energy Agency (NEA) and the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) are the regulatory bodies issued norms for safety standards to protect the human from hazards of radiation. European Union set standard that an adult in a concrete apartment with average activity concentrations of 40 Bq/ kg, 30 Bq/ kg and 400 Bq/ kg for radium, thorium and potassium receives an annual effective dose of about 0.25 millisieverts (mSv). It is excess in dose in the outdoors. **Somali et al, (1998)**[2] found very high concentrations of 226Ra (865-2,383 Bq/ kg and the average absorbed dose rate was 296 nGy/ h for buildings constructed by the coal-slags Tatabanya, Hungary.

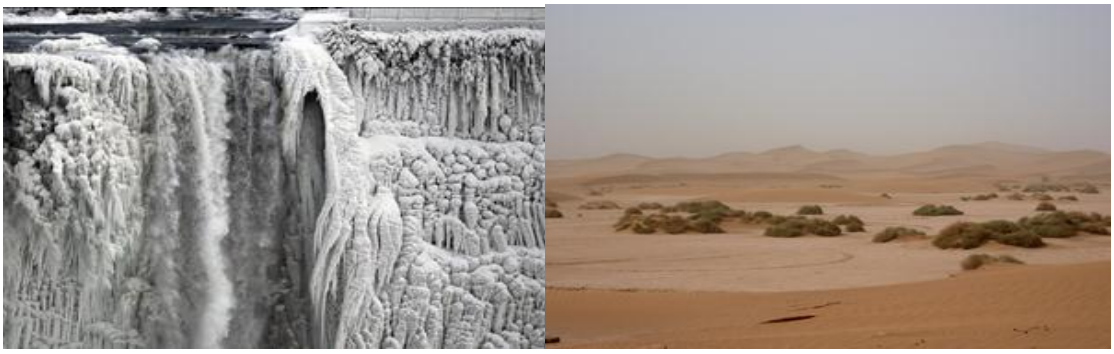

Fig 1 (a):- The U.S. side of the falls froze before they could reach the bottom (Steven Mithen) **Fig 1(b)** In geological terms, the Sahara became a desert overnight. Gaetan P123 /Wikimedia Commons, CC BY-SA

Aim of study:-

The working group are investigating about the selection of the building materials including the orientation of the building, visible transmittance and remittance, Shading coefficients (SC), solar heat gain coefficient (SHGC), Conduction gain (U-Value), Voltaic organic compounds, UV ray transmittance, spectral selectivity, glazing colour and sound transmission. The study investigates present building material parameters in the new epoch and its effect on human health and a management strategy have been developed to reduce the health hazards." Is the building where we are staying is safe for our ancestors?" is the million dollar question of the day

Review of Literature:-

Safe heat stresses for a worker is 25° C room temperature for his paramount performance. The minimum accident rates is at working temperatures below 21° C, the optimum to be higher than 27° C reported by **Allen et al 1978[3], Olli et al from U.S. Department of Energy, (2006)[4]. Stranden E, (1976, 1979)[5]& [6],** assumed the gamma dose as 10 Bq/ kg of ^{226} Ra, 7 Bq/ kg of ^{232}Th and 130 Bq/ kg of ^{40}K are equal whereas **Goustav 2012[7]** considered 370 Bq/kg of ^{226}Ra, 259 Bq/kg of ^{232}Th and 4810 Bq/kg of ^{40}K can produce the same gamma dose rate. **Beretka et al., (1985)[8], Gustavo (2012)[7] and Ravishankar (2017)[9]** reported about heterogeneity of radioactive nuclides in building materials. They have radium equivalent activity (Raeq) given as $R_{aeq} = AR_a + 1.43A_{Th} + 0.077A_k$, Where AR_a, A_{Th} & A_K is the specific activities of Radon-226, Thorium-232 and K-40 respectively in Bq/Kg.. The average concentrations of ^{226}Ra, ^{232}Th and ^{40}K available in the frustum of earth are about 40 Bq/ kg, 40 Bq/ kg and 400 Bq/ kg respectively received indoor and the effective dose is 0.25 mSv/year as per **as per European Commission 1999[10]. Trevisia et. al., (2012)[11], Gustav et al., (2012)[7],Bavarnegin et. al., (2013)[12]** reported that the naturally occurring radioactive materials (NORM) for earth as building materials contain in average ^{226}Ra, ^{232}Th and ^{40}K radio activity concentration are 35, 30 and 400 Bq/kg. The Radioactive decay chains of 40K emit α, β and γ radiations cause radiation hazards to humans. **Ravisankar et al 2017[9]** reported that ^{226}Ra as a building material is radio logically most important as the decay chain segment starts there. During mid-sixties of 20th century, the amount of radiation in Germany was about 0.2 millisieverts /year (mSv/ year) which have reduced to 0.005 mSv/year in 21st century. The reduction in the exposure was on account of precautionary measures. The National Council on Radiation Protection Report -160 tells that out of total 3.11 mSv/year radiation in US, the building materials contribute 0.07 mSv /year. The in-house dose in China, Ireland, India, Nigeria, Norway and the Netherland has back ground radiations ranges 0.1 to 1.3 mSv/year (https://hps.org/publicinformation /ate/q9778.html). In Czech Republic the range was 0.4mSv to 0.6 mSv /year in 1999. Australians receive radiation exposure of 1.5 - 2.0 mSv/year

Kamal, (2012)[13], Al-Obaidi et al., (2014)[14] and **Subramanian et al., (2017)[15]** narrated about the climate responsive buildings of Nepal, Bushehr architecture of ancient Iran. They are famous for their natural cooling within the buildings in hot and humid region. Traditional building Architecture in Ghana, Gohar Mahal (palace) in Bhopal, old residences in Athangudi village, Tamilnadu, and many architectural buildings of ancient past had taken care of their natural lighting and ventilation. Old buildings in India were made vernacular, heat efficient and well ventilated. Radiation caused by anthropogenic activities is 20% on public exposure in the globe and 1% exposure from left outs of nuclear activities, coal and geothermal radiations, (http://www.world-nuclear.org/information-library/safety-and-security/radiation-and-health/ nucl ear-radiation-and-health-effects.aspx). **Elis et al (2017)[16]** reported that biological and socio-cultural evolutions in construction of buildings are not instantaneous and it is always a process. **Kiyohiko S., (2012)[17]** reported on epidemiologic study that the present survivors at Hiroshima and Nagasaki, after the atomic bombing 1945, concerning more than 76,000 people having 5,000 mSv exposure were having deaths due to cancer. **Sharma et al (2014)[18]** reported that one ton of the common used building material, Portland cement produce CO_2 of one ton and NO_2 (6Kg) by consumption of a large amount of raw materials **Chouhan et al (2016)[19].** Anthropocene epoch had left 7 foot prints like nuclear weapons, fossil fuel, new materials, changed geology, fertilizers, global warming and mass extinction **Sam Wong (2016)[20] Subaiah et al., (2010)[21]** reported that the dose contribution of γ – ray radiations reflected by the walls are significant when the soil thickness > 45.5cm with concrete wall thickness is 21.5cm. Radiation, convection and conduction are the methods of energy flow in a natural passive design of a building,

Climate and the building biology:-

As per the climatic condition [redacted], the houses built are Kachha (Warli) houses in Maharashtra, Assam (bamboo sticks or Karvi with mud plaster) were constructed to get relief from heat and humidity. The circular earthquake resistant Bhonga houses are constructed in Rajasthan. Varieties of native residential houses used in different parts of the world are Wigwam homes, Wattle and daub houses (USA), long houses (USA), tepees (USA and India), Grass houses (Wattle and daub houses), Chicki's (India and USA) , Brush shelters (USA, Africa and

Asia), Igloos (Canada and polar region), Earthen house (all over the world), Plank houses (in hills and jungles all over the world) and Pueblos (Adobe houses in east Asia and USA). Those houses were of Holocene period and the best sheltering places according to climate and radiation (Figure 1).

Houses in Post Anthropocene:-

Construction sector has been identified as 23-40% of GHG producers. This makes the building industry the most plausible potentials against the horror of change in climate at present. It is high time to return to our earthen houses of the Holocene epoch **Olukoya Obafemi (2016)[21]**. Aluminum was a new building material of 19th century. It is popular material for partition walls, doors and windows with global consumption is 500 MMT. Concrete, the most common building material in 20th century for construction has annual production of 50 BMT. The urbanization has invited concrete to all the new buildings and the quantity of concrete is good enough to accommodate 1Kg/m^2 of the settlement areas. Similarly plastic a complex material of early twentieth century is so popular today that the production has reached 500 MMT and it is polluting every square meter of land on the earth **Sam Wong, (2016)[20].**

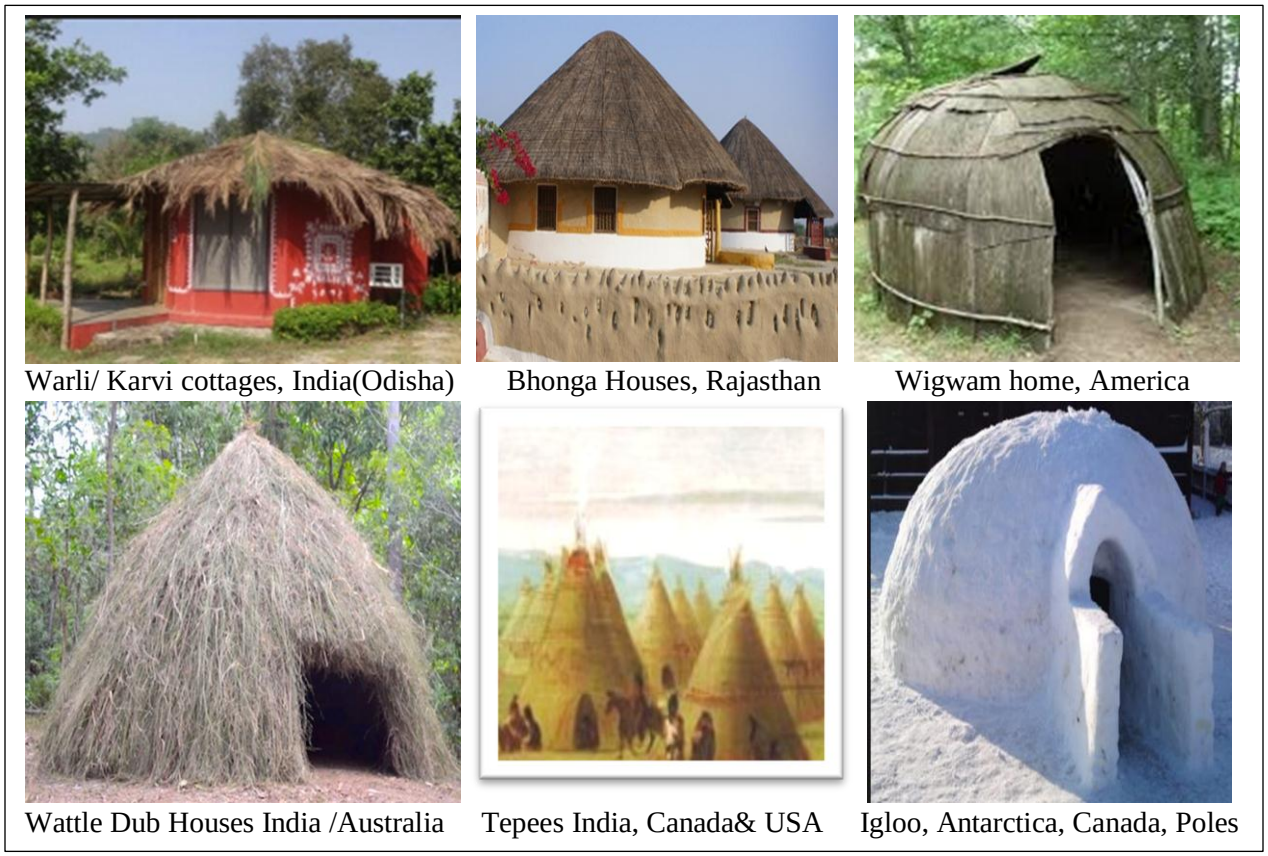

Figure 1:- Climate oriented different types of dwelling houses around the world in post Holocene

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) have defined thermal comfort as "that condition of mind which expresses satisfaction with the thermal environment". R-values of insulation of building materials and facings determine the efficacy of insulation to heat and radiation across a wall. Higher the value of R or the lower value of U factor better is the protection from heat (https://www .archtoolbox.com /materials-systems/thermal-moisture-protection/rvalues.html).

U-Value, (the reciprocal of the R-value) of a building material is the coefficient of transmission. It is the rate of transmission of heat through the individual/composite materials, which comprise the building's inner and outer walls. Wood roof with fiber glass insulation give the best flat roof material as its U value is the least i.e. 0.04. R and U values, density, specific heat and thermal conductivity of different building materials are collected from GOI web site (mnre.gov.in/solar-energy/ ch4. pdf) and given in Table 1.

The value of R (m^2K/W in SI unit) is given as $R = \frac{l}{\lambda} = \frac{Area\ x\ Temp\ in \deg K}{W} = \frac{A*K}{W}$, Where λ (W/mK per l (m) are the thermal conductivity and the thickness of the materials. The resistance of the walls is expressed as U-factor is given by $U = \frac{1}{R_1 + R_2 + R_3 .....}$ m where R_1, R_2, R_3 are the R-values of a combination of materials used in the building construction. The conversion values for heat transfer coefficient in SI unit to BTU is given by one watt1 /m²/K [W/(m²·K)] = 0.176228 Btu (th)/ hour/foot²/°F. R- Values of different building materials are in Table 1.

Table 1:- The R, U and thermal conductivity of Building materials (https://www. quora.com/What-is-the-insulation-r-value-of-an-adobe-wall,http://courses.washington.edu/arch 3431/assignments/R.pdf and http://www.toollending. com/UCBxweb/homework /ASHRAE , http://inspectapedia.com/insulation/R-Value_of_Soil.php

Sl No	Type of Building material	Thickness of walls	R - Values	U values	Density	Specific heat	Thermal conductivity
		meter	W/(m^2.K)		kg/m3	(kJ/kg-K)	(W/m-K)
1	Earth, Dry, Mud		0.25	1	1622-2000	0.88	0.519
2	Clay, dirt		0.125	8			
	Sand and gravel	0.2m	0.1388	7.2	2240	0.84	1.740
3. (a)	Concrete block	0.1m	4.54		2410	0.88	1.740
	Concrete Block	0.2m	6.3	0.39			
(b)	Concrete Block	0.3m	7.26	0.36			
(c)	Poured dense conc.	0.05-0.3		0.55-0.99			
(d)	Conc. block hollow	0.2- 0.3	0.45	0.37-0.39	2410	0.88	1.740
4. (a)	Brick masonry	0.2m	4.54	0.25 -0.41	1820	0.88	0.811
(b)	Brick face	0.1m	2.50				
5. (a)	Soft Wood Lumber a) Nominal (0.05m)	0.037m	10.67	0.64	480	1.68	0.072
	b) 2x4	(0.09m)	24.85				
	c) 2x6	0.14m	39.04				
6	Plywood	6mm 10mm 12.5mm 16mm 20mm	1.76 2.67 3.57 4.37 5.33	0.57 0.37 0.28 0.23 0.19	640	1.76	0.174
7	Fiber board	12mm 20mm	7.49 11.69		979	1.42	0.279
8	Gypsum board	12mm 16mm	2.55 3.18		950	0.82	0.16
9	Plywood (Flooring)	20mm	5.28		640	1.76	0.174
	Particle board	16mm	4.65		750	1.30	0.098
	Hardwood	20mm	3.86		979	1.42	0.279
10	Tile	Linolium	0.28		290	1.34	0.058
11	PVC Sheet				1350	1.255	0.160
12	Fiber glass	< 30cm		1.2-0.027	2350	0.88	0.814
13	AC sheet				1520	0.84	0.245
14	GI sheet				7520	0.50	61.060

The above data indicate the insulation R-values of wood blocks are the highest and followed fiber board. Hence the wooden houses are generally cool and internal heat transfer is less. Wood or Ply board should be of first choice of selection among all the building materials but these materials are of low longevity and high inflammability. However the R-values of the walls and the ceiling are dependent on the properties of thermal mass, the material thickness and the construction technology.

Shading Coefficient:-

The Shading Coefficient (SC) is a non-dimensional measure of the solar heat transmittance properties between the glasses used to that of double-strength. The heat transferring power through a 3 mm thick clear float glass sheet with

a total solar heat gain coefficient of 0.87 has a shading coefficient of 1. Lower the SC value indicates higher the solar control over the 3 mm thick baseline clear glass.

$$(SC) = \frac{Solar\ heat\ gain\ by\ any\ galass + the\ shade\ given}{Solar\ heat\ gain\ through\ 3mm\ unshaded\ clear\ glass} \quad \text{and} \quad SC = SC_1 * SC_2$$

Where SC = Shading Coefficient, SC_1 = SC of another glass or a combination of another glass with effective shading and SC_2 = coefficient of effective shading from external shading devices

Solar Heat Gain Coefficient (SHGC):-

The tropical and peninsular region receives more heat from sun than other areas of the earth. This zone is uncomfortable due to incidence of excess cosmic radiation, long summer days, high temperature and high humidity. Thick roofs and walls, tall buildings with glazed shutters for the large openings are provided to reduce heat inside the houses.

The solar heat gain coefficient (SHGC) is the proportion of solar heat spectrum incident upon a glazing window/ skylight that admitted inside the building as heat. It is the ability of the glazing doors and shutters that protect gaining heat from solar radiation. During summer it is important to reduce solar heat gain of the buildings to reduce the air-conditioning loads. SHGC determine the overall fenestration product of the building (ISO-15099). Thus the ratio of total solar heat transmitted to the total solar heat incident comes within ranges 0.1 to 09. The lower value indicate the low solar radiation gain and the relation is (SC) = 1.15 x SHGC **(Samdras Nayyar 2013)[24]**

Volatile organic compounds (VOCs):-

Apart from houses, the educational complexes, temples and public places are more susceptible to volatile organic compounds (VOCs) and heating, ventilation and air conditioning (HVAC) problems of indoor air quality (IAQ). Presence of VOCs is ubiquitous in modern buildings both outdoor and indoor air. VOCs are found in furniture, paints, adhesives, solvents, carpets, sprayers and clothing (http://www.chemtronicsindia.com/ volatile_ organic_ compound.html). Particularly the infants and children in schools are more apt to poor indoor air quality. VOCs emitted as gasses due to building materials which are ingredients of aerosol sprays, wood preservatives, household illuminations, paints, varnishes; and many organic solvents used in cleaning, greasing, disinfecting, cosmetics, powders and pesticides.

The lamps, candles inside the temples, mosques and churches along with production and industrial processing of building materials (cement, steel etc) which add to the level of CO_2, suspended particles matter ($PM_{2.5}$ and PM_{10}) are added to air which cause problem to respiration especially for infants and geriatrics. The VOC criteria has been included in modern building construction which is included in Leadership in Energy & Environmental Design (LEED).The allied health hazards with VOC are conjunctiva irritation, allergies, headache, nausea, dyspeptia, emesis fatigue and dizziness

Heating, Ventilation and Air conditioning (HVAC):-

Moto of the natural sustainable building is to live with comfort, least fatigue and hazardless. The building must have provisions for adequate heating, ventilation and air conditioning (HVAC) facilities for the dwellers indoor with acceptable IAQ, thermal and environmental comfort. Proper ventilation includes circulation of air within the building. For basic comfort a room should have temperature 20 to 25^0C, relative humidity 30 to 60% and a slightly positive pressure to reduce outside air infiltration. The room should have several complete air exchanges per hour. If the temperature is too high, chilled water circulation is essential along with HVAC facilities.

The Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE) works to protect the Environment, improve IAQ, helping Energy Conservation, education to its Members and others HVAC related issues. Further HVAC & R (Refrigeration) activities in building sector are growing @ 20% as per D. Nirmal Ram, Principal Consultant, Cerebration Consultants & National President – ISHRAE, 2014.

HVAC system consumes 13% to 20% and 30 to 50% of the electrical energy of a residential building and commercial & official building respectively. To avoid HVAC & R (R for refrigeration) system, alternative technology or natural building materials are to be searched which shall give the modern comforts at the cost of less energy consumption possibly the use of non-conventional sources (Solar Photo Voltaic Modules).

Passive cooling processes:-

The natural cooling processes are by conduction, convection, radiation of heat. Exchange of heat to atmosphere is accomplished naturally by evaporation of water, by conduction to earth and radiation to stratosphere where the earth and its atmosphere are the infinite heat sinks. Passive cooling approaches for an energy efficient building are moderating/ dissipating heat by irradiative and reflective approach like high solar reflectance and thermal remittance. The methodologies and techniques involved are protection, modulation (amortization) and dissipation techniques **Geetha et al (2012)[24].** The Irradiative or reflective systems by cooling bring thermal. comfort, increases work hour, reduce energy consumption.. Roof transmits the highest heat of indoor in comparison to wall and floor depending upon the colour and roof thickness and thermo physical properties of roof materials **Givoni B., (1994)[25].** Modern buildings use coloured tiles in outer surfaces to have better aesthetics and save cost of maintenance. **Al Yacouby et al. (2011)[26]** reported that the dark coloured tiles used in the exterior surfaces have good reflectivity (4.9%). The lowest and highest percentage of reflectance was found from the grey tiles (2.9%) and red tiles (38%) respectively. However to pledge with green building concept, east Asian countries like Singapore, Malaysia and Thailand have laws to fix green tiles in their exterior walls/ roofs to maintain green building index.

Radiation hazards:-

The daughter element Ra-226 is present in modern construction materials received by the inmates on exposure. The gamma radiation released from the building materials is also harmful particularly to children. Radiations are received from radon in air, medical environment and atomic energy sources. These radiations increased abruptly during the Anthropocene epoch. Receipt of radiation from soil, rock, air and many building materials and domestic consumables are also harmful in long run http://www.radiationanswers.org/radiation-sources-uses/ natural - radiation.html. The testing of atom bombs, nuclear explosions and missile launching has increased the radiation exponentially in the 21st century. Related deaths are also alarming. The radiation hazards after Anthropocene epoch and their impact is listed in table 2:

Table 2:-The anthropogenic radiation hazards during the years of Anthropocene

#	Year	Place/ country	Occurrence	Impact
1	1945, 6th Aug	Trinity explosion Bombing Hiroshima & Nagasaki, Japan	20KN, 15KN & 20KN TNT equivalent in World War II	The five-year death toll exceeded about 200,000 people in Japan
2	1948 Oct 6	7.3 earthquake hit Ash- gebat, Turk menistan	killed an estimated 110,000 people.	http://neic.usgs.gov/neis/eqlists/eqsmosde.html
3	1952	Ottawa/Canada London killer fog	Partial meltdown of the reactor's uranium fuel core To alleviate cold coal smoke caused dense fog	Chalk River contaminated Killed 12000 people
4	1957	Liverpool/UK Chelyabinsk, USSR	Fire in a graphite-cooled reactor Radiation from nuclear plant	200 sq. miles radiation contaminated Contaminated Kyshtym and Techa river,200 killed
5	1957	Ural, Kyshtym, USSR	Weapons factory exploded	10,000 people were evacuated
6	1976	Greifswald, East Germany	Libmin nuclear power plant; the radioactive core melted	fire, safety systems failed
7	1979	Harrisburg, Pa., USA	reactor lost its coolant	overheating and partial meltdown of an uranium core
8	1986	Chernobyl, Soviet Union	graphite core of reactors caught fire and exploded	Radioactive material spread over Soviet Union, Europe 31 dead
9	1987	Goiânia, Brazil	cesium-137 cancer-therapy machine was sold as scrap	four died ,244 people became contaminated
10	1991	The Kuwait 700 Oil Fire sabotage	The Gulf War oil spill, largest oil spill in history	World's greatest ecological/ economic ruins, acid rain and smog in Kuwait
10	1999	Tokaimura, Japan	U-238 nuclear plant release radioactive gases	Two died, &one seriously injured.
11	2003	Al-Mishraq, Iraq	Burning of sulphur plant	21 kilotons of toxic S per day

11	2004	Mihama, Japan	steam leaked from a nuclear power station	Four died and seven were severely burned.
12	2007	Kashiwazaki, Japan	Earthquake at Niigata fire, radiation leaks and burst pipes at a nuclear plant	Death of 9 old people and 1000 injured
13	2011	Fukushima Daiichi, Japan	reactor number 1 exploded followed by EQ and tsunami	Heavy fire and radiation level was from 1,000 mSv/hour to 600-800 mSv

Apart from the above catastrophe due to radiations, CO-60 and Iodine-131 radiation at Fleurus (Belgium), Stamboliysky (Bulgaria), in the year 2006 and 2008, Therac-25 exposure (AECL), Canada, Zaragoza radiation disaster, Spain 1985, Cobalt-60 radio therapy hazard Cost Arica were the imprints of radiation hazards in the globe.

Effects of radiation on human health:-

The effect of radiation may cause falling of hair, damage to brain cells, thyroid gland destruction, affect blood system, heart, gastrointestinal tract and the reproductive system of humans. Radiations are also carcinogenic. A 100 rems dose shall cause initial radiation sickness, like damages to WBC and cause vomiting and headache. Over 300 rem dose, hair falls temporarily. The effect of various doses of radiation on human health is given in Table 3:

Table 3:- The effect of various doses of radiation on human health

#	radiation exposure (gray or Gy)	% persons exposed	Impact on human health
1	up to 0.5 Gy	100%	slight changes in blood count
2	0.5 to 1 Gy	10%	vomiting, nausea and fatigue for one day
3	1 to 1.5 Gy	25%	No deaths Vomiting; nausea, radiation syndromes;
4	1.5 to 2.5 Gy:	25%	Deaths, vomiting and nausea, radiation syndromes;
5	2.5 to 3.5 Gy:	100%	Vomiting and nausea on 1st day, radiation syndromes, 20% of deaths by 2 to 6 weeks, 3 months convalescence for survivors
6	5 to 7.5 Gy:	100%	vomiting and nausea in 4 hours, radiation syndrome, 100% death, few survivors with about 6 months convalescence;
7	10 Gy	100%	vomiting and nausea within 1 to 2 hours, no survivors
8	50 Gy	100%	Immediate serious illness, death to all exposed within a week.

The SI Units of radiation is the absorbed energy/ unit mass of tissue is the Sievert named after Rolf Maximilian Sievert. i.e. 1 Joule/kg = 1 Gray or 1 mSv is the dose produced by exposure to 1 milligray (mG) of radiation. 100 rad => 100 rem (1 mSv = 100rem) where rem= roentgen equivalent in man. The REM (roentgen equivalent in man) is the other unit of radiation.

Radiations from building materials:-

Uranium (^{238}U) and Thorium (^{232}Th) and Radon (^{222} Ra) considered as the naturally available radioactive materials, on decay give different sister products where ^{222}Ra is important because they are traced in many naturally occurring building materials like earth, brick, stones, fine and coarse aggregates, cementing materials, [redacted] gypsum and many others. Brick and stone produce more radiation than wood. According to National Council on Radiation Protection Report 160, brick has radioactivity (3.0 mSv) whereas building materials contribute 0.008 micro Sievert (µSv) combined. The acceptable dose to avoid risk of health hazards is 1 mSv/y (100 mrem/y) as per Linnea Wahl, Certified Health Physicist, 2011 https://hps.org/ public information/ate/q9778.html.Some national sample surveys of common building materials were conducted to find the radioactivity concentrations their radon which is available in air with exhalation rates were found to be in the range of [5 to 25]. The European Commission recommends the design level of annual average radon dose of gas concentration of 200 Bq/ m^3 and radiation dose 1msV/year for workers at industry and domestic field **Goustav et al., (2012)[7].**

The activity concentration of building materials:-

The US National Council on Radiation Protection Report-160[27] noted that the brick veneer houses contribute 0.008 µSv/ hour. The specific activities index of different materials containing 226Ra, 232Th and 40K, an index, called "Raeq". Annual average human dose limit is accepted as < 0.3 mSv as per **Koch et al., (2008)[28].** The activity concentration index (I) is calculated as $I = \frac{C_{Ra}}{300\ Bq/Kg} + \frac{C_{Th}}{200\ Bq/Kg} + \frac{C_K}{3000\ Bq/Kg}$ where C_{rab}, C_{Th} and C_K are the ^{226}Ra, ^{232}Th and ^{40}K activity concentrations (Bq/kg) in the building materials. Considering the presence of doors/

windows the annual radiation dose is corrected as $I = \frac{C_{Ra}}{740\ Bq/_{Kg}} + \frac{C_{Th}}{520\ Bq/_{Kg}} + \frac{C_K}{9620\ Bq/_{Kg}} < 1$ where the value of the symbols are stated by **Vanasundari et al (2012)[29].** The standard activities of few building materials are in Tab- 4

Table 4:- The specific radiation activity of some common building materials (Goustav et al, 2012)[7], (msv/year(https://www.euronuclear.org/info/encyclopedia/r/radiation-exposure-building-mat), http://www.bfs.de/EN/topics/ion/environment/building-materials/radionuclides

	Goustav et al.2012,			BfS Av. value(The Federal Office for Radiation Protection)			Additional building materials exposure
Sl No	(^{226}Ra)	(^{232}Th)	(^{40}K)	(^{226}Ra)	(^{232}Th)	(^{40}K)	
	Bq/kg	Bq/kg	Bq/kg	Bq/kg	Bq/kg	Bq/kg	
Earth	32 - 53	41 - 75	518 - 843				
Sand/quartz	3 - 39	3 - 56	12 - 1008	15	16	380	0 to 0.1
Gravel	10 - 33	ND - 33	14 - 9333				0.2 to 0.4
Wood	ND - 10	ND - 4	4 - 166				-0.2 to 0
Limestone	ND - 24	ND - 11	ND - 205				0 to 0.1
Granite	ND–160	ND- 354	24 – 2355	100	120	400	0.4 to 2
Marble	1 - 63	0.4- 142	9 - 986				0.4 to 2
Cement	13 - 107	7 - 62	48 - 564				0.1 to 0.2
Concrete	18 - 67	3 - 43	16 - 1100	30	23	450	0.1 to 0.2
Conc. (LWC)	10 - 60	6 - 66	51 - 870	15	10	200	0.1 to 0.2
Bricks	7 - 140	8 - 127	227 - 1140	50	52	700	0.1 to 0.2
Gypsum	1 - 67	0.5- 190	22 - 804	20	<20	<20	0.2 t0 0.4
Tiles	33 - 61	45 - 66	476 - 788				
Ceramics	25 - 193	29 - 66	320 - 1049				
Clay	4.97	30.38	339.98	40	60	1000	Ravisankaret.al,2017
Ash				42	57	147	

The limits of commonly used building materials have a radioactivity index. Bulk and minor used materials have the indices are less than 0.5. It is 2 when dose is 0.3 mSv/y. The yearly activity concentration of the most penetrative γ radiation, from average concrete for ^{226}Ra, ^{232}Th and ^{40}K is 40, 30 and 400 Bq/Kg. The annual excess dose for all concrete structures is 0.25 mSv and wooden structures 0.10mSv (https://ec.europa. eu/energy/ sites/ener/ files/documents /112 .pdf. People in flight, living in granite houses are exposed to high rate of radiations 0.16 mSv/dose and 1.0 mSv/year respectively. Medical staffs exposed to X-rays/CT scan which are of very high radiation of 2.6 mSv. Buildings made up of bricks or concrete have more radiation than the wood or mud. Some wooden pre-fabricated or pre-assembled building units with building material containing are having less natural radioactivity.

Radon, the ionizing radiation:-

Air inside the building should be free from Radon which invites lungs cancer as they contain short-lived alpha emitters. It enters the rooms through cracks and openings. The radioactive naturally occurring Radon-222 is produced from terrestrial radiation (rocks and soil). The amount of average annual exposure to ionizing radiation by ablation is 0.2 to 10 msv out of total natural availability which is 1 to 13 msv (Australian Radiation Protection and Nuclear Safety Agency (2015), http://www.arpansa.gov.au / Radiation Protection/Factsheets/ isionising.cfm. The Building Regulations England and Wales 2000, the Building Regulations Scotland 2004 and Building Regulations Northern Ireland (as amended 1990), supported by Building Research Establishment reports BR211, BR376 and BR413 respectively require to adopt the recommended standard doses of radon as proposed by their law in the buildings and buildings extensions (workplaces and dwellings) constructed after 2000.

RF and EMF radiations:-

Building materials possess radionuclides which are even detrimental for human health. People are exposed to harmful natural radiation from these radionuclides every day. Modern people cannot live without using mobiles, laptops, ear phones Television, radio, auto door openers, microwave ovens, GPS system, radio, baby monitors, buzzers, computers, digital watches Electronic gadgets, electrical appliances *etc.* which generate low frequency waves but generate direct radiations and non-ionizing radiations.

Radio frequency (RF) and Electromagnetic field (EMF) are the nonvisible radiations which should be included in construction health science studies in the Anthropocene epoch. These radiations are received from human body and manmade electrical fields. The harmless, acceptable and optimum doses are 1mG, 3mG and 20mG but the ambient dose is 0.75- 1mG respectively. The acceptable ranges of electrical frequencies of electromagnetic fields should be 15Hz to 10000Hz. Radio frequencies limit in building premises are 10 KHz to 6 MHz, Remote controls, Wireless networks, cell phones, hidden cameras baby monitors, home phones and many electronic equipment used for domestic purposes are the source of RF radiation within our homes http://www.ietbuilding health. com/ electromagnetic-inspections.html.

Asbestos and the health risk:-

A man working in asbestos factory or exposed for long period to asbestos materials can suffer from asbestosis or mesothelioma. It is the 5000 year old building and domestic fire resistant roof materials. Asbestos became important building material during 20th century (Christian Nordqvist and :http://www.medicalnewstoday. com/ articles /219615.php,RobertaC.Barbalace https: //envir onmentalchemistry.com/yogi/environmental /asbestosis tory 2004 .

Surface finishing materials:-

Tiles and Terracotta are decorative materials used for surface finish. Coloured tiles radiate the highest 226 Ra radiation of 66.11 Bq/Kg. The activity concentration of radiations or the γ ray irradiation associated with the 226 Ra contributed by different tiles in decreasing order are black granite< orange marble< green granite< vitrified tiles < plain tiles < coloured tiles and for 232Th the increasing order black granite < green granite < plain tiles < orange marbles < coloured tiles < vitrified tiles **Senthil Ku. et al., (2014)[30].** From various coloured granites/tiles the order of irradiation is black granite (23.49 Bq/kg) <. Green granite (61.96 Bq/kg) < Plain tiles (135.66 Bq/kg) < vitrified tiles (161.41 Bq/kg) m < coloured tiles.

Building material Management in Anthropocene:-

Design of a sustainable green building emphasizes on the energy efficiency, conservation, longevity, better indoor air quality (IAQ), low running and maintenance (R/M) cost, efficient local indigenous materials, improved occupants health, easy accessibility, environment friendly, provision for recycling and reusing all wastes. IGBC (Indian Green Building Council), LEED (Leadership in Energy and Environmental Design) and GRIHA (Green Rating for Integrated Habitat Assessment) are working to accomplish green revolution in India. The benefits of green building are Reduction in energy and operating cost by 40% to 50% and water by 20 to 30% providing a healthy surrounding with optimum security and thermal comfort at very low VOCs by using modern technology, equipment's and ecofriendly building materials.

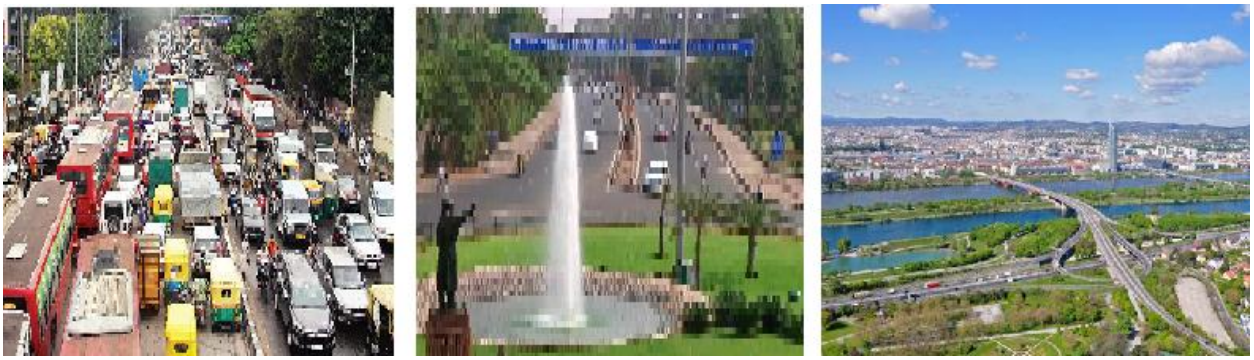

Fig.2 (a):- The present 67 year old city, (b) the future planned smart city, (c) the land scape of the city Bhubaneswar

Plastiglomerate:-

Plastiglomerate, are a new mediated material of 21st century, originated from melting plastic and agglomerated with rock fractions. Plastics when ignited by humans during disposal of trash, Tsunami debris, solid wastes or fishing get liquefied and after cooling the plastiglomerate are formed either in situ or clastic. The plastiglomerate can be the future Anthropocene building materials building materials as found from Kamilo beach of Hawaii Island **Corcoran et al., (2014)[31].** Similarly Simonkolleite [$Zn_5(OH)_8Cl_2 \cdot H_2O$] is a man mediated mineral found in copper mines at Rowley mine, Maricopa County, Arizona. Robert Hazen. The American mineralogist with his team from Carnegie Institution for Science have identified 208 anthropogenic human mediated mineral species (out of total existing

5200 species) accepted by the International Mineralogical Association (IMA). These new minerals shall be the building materials of future https://phys.org/news/2017-03-human-caused-minerals-bolsters-argument-declare.html#jCp. Guiyu, in China is the place for redressing of e-wastes of the world from 1980's where during recovery the waste plastic from electronic industry is burnt which is affecting about 5500 families http://www.chron.com/news /slideshow/15-man -made-disasters-82388.

Pandemics:-

When pandemic (global outbreak of diseases) occurs, is likely to be prolonged and widespread. Holocene pandemic diseases are different from that of Anthropocene. Holocene Pandemics diseases were the plague (the black death), Spanish flue, The Plague of Justinian, Cholera, Small pox, Typhus, Measles and Tuberculosis which became less invasive at the awake of the Anthropocene. More deadly and apocalyptic pandemic diseases are more aggressive after the Anthropocene epoch are Severe Acute Respiratory Syndrome (SARS from 2003), HIV/AIDS, Ebola, Chikungunia, Swine flu, Dengu and many others. The occurrence of [redacted] these diseases require shift of the diseased or the non-diseased. Schools, work, transportation and other public services are to be altered to minimize their risk during the pandemic.

Naturally cooled buildings:-

To have a comfortable environment and minimization of energy, passive cooling techniques are employed in tropical humid climate. Traditional architectural buildings and modern multi storied flats do not have provision for passive cooling. Modern buildings in Anthropocene era can adopt those energy efficient concepts and use those construction materials and techniques to have a comfortable living. Flat, white and low sloped roofed with irradiative materials should be the first choice. The mud made roof top below thatched cooled roof (Attu houses) in countries like India are popular. Maintaining the high value of window to wall ratio (WWR), recommended by ETTV and RETV, adjusting U and SC values and suitable opaque enclosure to provide higher heat performance of the building should be the choice **Sumit Kumar et al., (2015)[22].**

Active strategies of cooling:-

Modern construction emphasizes on fast, cost effective and no care strategies ignoring IAQ and thermal comfort. Traditional buildings constructed considering the acceptable thermal comfort but the recent buildings are lacking thermal insulation, natural ventilation and protection from radio nuclides. Forced – air HVAC systems, central air conditioning, heat pumps, LED lights, radiant photo voltaic panels and many other electric gadgets have reduced the energy of the inner home but not outside the buildings. Solar radiation can be reduced in buildings by proper ventilation, geothermal heat pumps, radiant facades and other modern technology applications. Perfect thermal insulation, multiple glazing and controlled ventilation can control the indoor heat and humidity of the buildings. A thin commercial film made up of polymethylpentene (TPX) by **Dr Yang's and Dr Yin's (2017)[32]**, a transparent plastic sheet, mixed tiny glass beads of 50 µm thick, and painted with silver (inner coating) on one side laid on the roof top shall reflect incident sunlight back through the plastic, keep the building cool from a temp 39^0 C to 20^0C.

Soil as building materials:-

To have easy, accessible, low cost of construction, use of industrial by-products, wastes and residues containing elevated concentrations of radioactive material are done as building materials (fly ash, clinkers and slag *etc.*) due to economic and environmental reasons. The national regulatory authorities should ensure that "annual doses are restricted to a few mSv for the worst-case scenarios. The Holocene mud built houses, the oldest sky scrapers (Manhattan of the desert) Shibam city, Wadi Hadharamout valley, Yemen is to be remodeled and adopted in modern urban housing technology.https://www.slideshare.net/drboon/mudbrick-highrise-buildings-architect ural -inkages -for-thermal-comfort-in-hadhramout-valley-yemen

VOC concentrations:-

Construction sites should have low VOC concentrations. Building materials and indoor air are to be taken care of the initial materials used for construction (shuttering, centering, framing, concrete and other materials) and also during finishing. After construction the indoor parameters to be measured for air quality parameters like humidity, CO_2 , NO_2, GHG's and other VOC's, HVAC, IAQ as per American Industrial Hygiene Association (AIHA -2017) norms.

HVAC & R considerations:-

LEED-Rating through 'India Green Building Council' provides building owners, architects, consultants, developers, facility managers and project managers tools have provided norms to adhere to. They need to design, construct and

operate smart and green buildings as per the norms. **Sudarshan et. al. (2014)[33],** *Territory Vice President and Business Head – HVAC & Transport, India Climate Business Unit, Ingersoll R and India & SAARC) has advocated for an e*fficient, adequate designed and sized HVAC equipment that increases heat comfort and depletes energy costs for dwellers a health environment with GHG emissions. HVAC installations should be cost effective, easy installation and running maintenance. The gadgets, appliances and technology used should provide heat comfort and easy air circulation, least radiation and architectural. Well ventilated, centralized air conditioning system, with sealed ducts and proper filtration to maintain recommended IAQ in building construction must be complied.

Green and Smart Buildings:-
Green buildings are the housing in green environment, which involve both structurally ecofriendly and resource competent during the life cycle of the building. The Indian Green Building Council (IGBC), Leadership in Energy and Environmental Design (LEED) and many other countries have stipulated certification of buildings like certified silver , gold and platinum depending upon their performance on health of the dwellers (by LEED). These buildings should have optimum Energy/ power use, water conserved, efficient waste management, effective transport system and effective building planning in long run.

Radiation moderation:-
Small exposures of radionuclides from building materials are common. Necessary management should be done to controls on exposure levels where they are above normal dose levels. Indoor Radon and 226 Ra dose should be < 200 Bq/m3, γ- radiation should be < 1 mSv/year (European commission 1999). Smart city buildings should be constructed as per the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRE) have stipulated norm about energy efficient buildings and materials for absorbing/ adsorbing radiation the ameliorate the radiation hazard in buildings. For natural radon, millions of buildings need to be remediated to avoid effects of radon. Recycling and reuse of domestic waste, provision for quality water should be ensured at the building premises. Solar Photo Voltaic cell with low power AC/DC appliances can be used in the buildings to save radiations within the buildings. Modern new buildings should have average radon concentrations should not exceed 100 becquerel/m^3 /year as per recent study by Environmental Radioactivity - Medicine - Occupational Radiation and Protection - Nuclear Hazards Defense (http://www.bfs.de/EN/topics/ion/environment/radon/protection /protection.

Protect buildings from radon:-
Radon proof artificial membranes are installed in buildings for protecting the building from Radon-222,. The process is to collect clean gravel, pebbles or aggregate and provided below the slab/ flooring system. Cover the coarse aggregates by a polyethylene sheet. Completely seal the foundation and provide a catheter from the aggregate bed to the top of the roof through the walls http://www.hse.gov.uk /radiation /ionising /radon.

The radon pathway is to be blocked to restrict the quantity of 226Ra entry in the buildings so that the indoor radon pre-set level is not cut across during unfavorable conditions. The radon concentration is accepted for radon in old and new dwellings are 200 Bq/cum and 150 Bq/cum recommended by the International Commission on Radiological Protection **ICRP report 103, (2007)[34]** and **Ila et al., (2006)[35].**

The most important part is fixing recommended dose for radiation particularly due to atomic explosion impacts. For example after Chernobyl power plant explosion (1986) thousands of pregnancy women aborted on fear. A detailed study is necessary on low level radiation and fixing minimum radiation doses as at times radiation exposure become a part of medical care.

Disposal of nuclear wastes:-
To avoid nuclear waste hazard, life-saving nuclear medical procedures like mammograms, thyroid testing centers are to be widely available and minimum use of X-rays and CT scans *etc.* to avoid anthropogenic radiations. The buildings in Anthropocene epoch needs to be remediated to provide long life to human race. Hospitals should maintain and properly educate to patients and their relatives for proper disposal of feces, cohabitation prohibition and radionuclide limited water treatment plants must be legalized. Air travel is to be minimized as there is radiation exposure due to cosmic rays.

Conclusion:-
Design of green building focuses on low emissions and high energy efficiency. Planning & Design should emphasize on a sustainable and environmentally sensitive habitat. The best building material choices are local

available mud, stone and reinforced with local straw/wood as in Greece, Egypt and India, China, Yemen and in many other countries of the world. Those building materials should be fire resistance, low radioactive, abundant and constructed by local labors, low cost, simple indigenous construction technique. These muds built houses can be multi storied, energy efficient, thermal proof and biomass fuel saver. The environment friendly mud built buildings have high thermal capacity, low thermal transmittance and conductivity which shall save the extant urbanized population should live in green, smart houses at a comfortable temperature. Modern building radon radiations should be within 100 Bequerrel/m^3/year. A boon of Anthropocene epoch, smartphones, mobiles, Laptops and tablets using the Universal Mobile Telecommunication System (UMTS) should be a 3G standard while Long term Evolution (LTE)) should be of 4g standard and should have less specific absorption rate (SAR). Similarly the buildings should constructed where the building parameters such as high SC value, high U value, low VOC,SHGC va specific absorption rate (SAR) value, not in an area where radiation of any kind is high.

Keeping the facts in view it is high time to think of less industry, minimum urbanization, least atomic explosion as energy sources. The building materials should be sun dried mud bricks, mud as mortar, thatched roof, grasscrete, Hempcrete, wood/bamboo houses, rammed earth, specially manufactured concrete and natural colouring of the houses if we want to live in a healthy Anthropocene epoch.

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