Sheilding Effectivenss of Aluminium Sheet for Radiation Hazard from Cell Towers

Deepa Vijayakumar Thulasi, S. Amala Shanthi

Abstract: ***The radiation from mobile towers affect tissues in the human body. The electrons are stripped away from atoms by splitting some chemical links. In our paper the shielding performance of various materials like aluminum sheet, mumetal, and super-alloy with different thickness is evaluated in terms of reflection loss (RL), re-reflection factor (RRF) and absorption loss (AL). Aluminum acts as a good corrosive in marine, and atmospheric environment. This is very appropriate for the decorative applications, due to its high reflective property. The composition of the particular material contains 16% iron, 5% copper, 2% chromium, and 77% nickel. The soft ferromagnetic alloy of mumetal contains the nickel iron with high permeability, and it is suitable for shielding against low-frequency magnetic fields. It contains 32%-67% iron, 15%-22% chromium, and 9%-38% nickel. The power density values obtained from the shielding effectiveness are converted into specific absorption rate and it is compared with the ICNIRP standard value to show the effectiveness of shielding material. While comparing with the other materials, it is observed that aluminum sheet is the most radiation absorption and protective shielding material against the radiation from cell towers.***

Index Terms: ***Shielding algorithm, reflection loss, absorption loss, re-reflection factor, thickness of the material.***

I. INTRODUCTION

Electromagnetic radiations have enlarged its methodology to the areas like industrial and domestic heating, medical, telecommunication, lighting, etc. In spite cellular phones have many bad effects, human beings are not much bothered about it rather than its user-friendly nature. In addition Mobile towers are increasingly established near public areas for better coverage. Interactions of an electromagnetic radiation from mobile towers with Deoxyribonucleic acid (DNA) result in many health problems [1].

Exposure to high-frequency electromagnetic radiations (HF EMR) on cells will increase the Specific Absorption Rate (SAR) on human where the reactive oxygen species (ROS), was produced with huge pathogenic potential. Lipid peroxidation and DNA damage are important crisis due to exposure of radiation [2]. The antioxidants available in the tissue was used to deactivate ROS free radical obtained from the oxygen metabolism. The oxidative stress obtained due to the increase production of ROS than the antioxidant searching capacity. Continuous usage of cell phones stimulates plasma membrane Nicotinamide adenine dinucleotide (NADH) oxidase. This effect can result in increased production of oxygen species (OS) and subsequent carcinogenesis [3]. ROS cause many oxidative damages to DNA, mainly nuclear and mitochondrial. In addition, ROS can interfere with normal signaling process of cells, resulting in the deviation of gene expression, and development of cancer [4]. The ROS level in brain gets increased due to the long time usage of cell phones. In brain, the endothelial cell damage was induced by more reactive peroxynitrite radicals obtained by combining superoxide radical and nitric oxide [5, 6].

Polyunsaturated fatty acids (PUFA) is a kind of lipid which was more liable to ROS than the mono- saturated fatty acids (MUFA) and by performing oxidative degradation in PUFA Malondialdehyde (MDA) was generated [12,13]. The process that was performed initially in lipid was lipid peroxidation and damage of cell membrane [7, 10]. Nitration of guanine bases, deamination of guanine and adenine, base oxidation, and strand breaks are involved in peroxynitrite to damage DNA [8, 11]. Cysteine and methionine are particularly prone to almost all ROS [9]. The important line of defense system with antioxidant enzyme against ROS was superoxide dismutases (SODs) in addition to that superoxide anion radical was also made available over ROS [14, 15]. The superoxide concentration was regulated by enzymatic antioxidant by performing dismutation in superoxide and convert it into hydrogen peroxide, and it was again changed into water or else water and oxygen (catalase) [16]. N-acetyl cysteine is a high bioavailability cysteine prodrug which apply an oxidative effects by increasing glutathione, intracellular antioxidant, and also stimulate its production from cysteine [17]. Catalase (CAT) was an enzyme obtained from aerobic cell was used to reduce the oxidative stress by decomposing the hydrogen peroxide (H2O2) into dual reaction based on its catalytic and peroxidase activities [18, 19]. The oxidative stress application complete the radiotherapy cytotoxic effect so inter discrete genetic vulnerability produced by enzyme variability was applied to radio toxicity. ROS was neutralized by manganese superoxide dismutase (MnSOD) and CAT but it was produced by endothelial nitric oxide (NO) synthase (eNOS) and myeloperoxidase (MPO) [20].In order to prevent the generation of ROS the radiation from cell towers must be minimized. The unwanted radiation hazards are passed to the whole body of humans thereby resulting in the generation of ROS .In order to prevent its generation the exposure affecting the human body must be minimized.

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In this paper an effective approach for reducing the exposure of radiation towards the human being using the Aluminum sheet is proposed and performance is evaluated in terms of shielding effectiveness and compared with other materials like mumetal and super alloy. The layout of this work is summarized as, the introduction is given in section I, proposed methodology is derived in section II, shielding algorithm is given in section III, results are discussed in section IV, and finally the conclusion part is added in section V.

II. PROPOSED METHODOLOGY

Now a day's the life style of human was altered by cellular phones and it became an essential part in everyone's life. Increasing number of cellular phones cause lot of ill effects to living organisms. The radiations are transmitted by this cell towers without any interruption. The cellular radiation from base station affects whole body of human, and causes major diseases to the human. This can be limited by suitable shielding material between the building and the base station.

A. Selection of shielding material

Several parameters have to be considered for the selection criteria of shielding material, mainly the permeability is imperative in order to select the shielding materials. While the selection of suitable materials with low permeability, it is appropriate for better shielding, according to that the appropriate materials are selected. The radiation can be avoided through the proper placement of protection measures. In this work, the aluminum sheets are considered to avoid the radiation hazards from the cellular base stations. As distance between cellular base station and shielding material increases the radiation gets reduced.

III. MATHEMATICAL MODELLING

A. Effectiveness of shielding

One of the ways to eliminate the penetration of the electromagnetic fields into the living tissues is achieved by the proper enclosure of meta- materials termed as shielding. Its performance is measured in terms of shielding effectiveness which depends upon the re-reflection factor, reflection loss, and absorption loss of plane wave (PW), magnetic field (MF), and electric field (EF). The effective shielding of the magnetic field is given by,

$$SE_{Mag} = \alpha_L + \beta_m - CF_{Mag} \quad (1)$$

Where the magnetic field is SE_{Mag}, the absorption loss is α_L, reflection loss is noted by β_m, and the RRF is denoted by CF_{Mag}.

The effective shielding of the EF is given by,

$$SE_{Elec} = \alpha_L + \beta_e - CF_{Elec} \quad (2)$$

The electric effective shielding is SE_{Elec}, RL for electric field β_e, and the RRF for electric field is CF_{Elec}.

The effective shielding of the plane wave is given by,

$$SE_{PW} = \alpha_L + \beta_p - CF_{PW} \quad (3)$$

The plane wave shielding effectiveness is to be SE_{PW}, RL of the plane wave is β_p, and the RRF of the plane wave is CF_{PW}.

The absorption loss is the radiation absorption rate from the cell tower, by the shielding material and it is given by,

$$\alpha_L = c \times t \times \sqrt{f \mu_0 g_0} \quad (4)$$

Where c denotes, distance of building and base station, thickness of the material is defined as t, the frequency is f, permeability of the material is μ_0, and the conductivity of the material is g_0.

When the reflection loss occurs, the part of the energy is reflected back to the source. The reflection loss varies with the frequency deviation of magnetic field as well as in electric field.

For magnetic field

$$\beta_m = 20\log\left[\frac{k_1}{d\sqrt{\frac{fg_0}{\mu_0}}}\right] + k_2 d\sqrt{fg_0/\mu_0} + 0.354 \quad (5)$$

For electric field

$$\beta_e = k_3 - 10\log\frac{\mu_0 f^3 d^2}{g_0} \quad (6)$$

For Plane Wave

$$\beta_p = 168 - 20\log\sqrt{f\mu_0/g_0} \quad (7)$$

The distance from the source to the shielding is denoted as d and $k_1 = 0.0117, k_2 = 5.35 k_3 = 322$ if "d" is in meters.

B. Correction Factor of Re-Reflection

The correction factor of Re-reflection for radiations in plane wave, magnetic and electric field was calculated and it was shown below,

$$CF = 20\log\left|1 - \xi 10^{\frac{-\alpha}{10}}(\cos 0.23\alpha - i\sin 0.23\alpha)\right| \quad (8)$$

Where α denotes the absorption loss, and ξ denotes the two boundary reflection coefficient.

$$\xi = 4\,(1-p^2)^2 - 2p^2 + i2\sqrt{2p}(1-p^2) \Big/ \left[\left(1+\sqrt{2p}\right)^2 + 1\right]^2 \quad (9)$$

Where p denotes the pre-calculation parameter.

For magnetic field

$$p_m = 4.7 \times e^{-2}/d \times \sqrt{\frac{\mu_0}{f g_0}} \quad (10)$$

For Electric field

$$p_e = 0.205 \times e^{-16} d\sqrt{\frac{\mu_0 f^3}{g_0}} \quad (11)$$

For Plane Wave

$$p_p = 9.77 \times e^{-10}\sqrt{\frac{\mu_0 f}{g_0}} \quad (12)$$

$$power = dB2power(SE) \quad (13)$$

$$powerdensity = \frac{Power \times Gain}{4\pi d^2} \quad (14)$$

$$ElectricFieldstrength = \sqrt{Powerdensity \times 377} \quad (15)$$

$$SAR = \frac{g_0 \times (ElectricFieldstrength)^2}{TissueDensity} \quad (16)$$

Gain =1.5dB.

Tissue density = 1.027mg/cm3.

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I. SHIELDING ALGORITHM

Input parameters: Thickness of the material, constant parameters, frequency, permeability, conductivity, distance.
Step 1: Calculate absorption loss
Step 2: Calculate Reflection loss in plane, electric, and magnetic fields.
Step 3: Calculate Re-reflection factor for all fields.
Step 4: Find the effective shielding of all fields using step 1 to 3.
Step 5: Convert the shielding effectiveness into power in dBm.
Step 6: Calculate power density value and electric field strength.
Step 7: Calculation of SAR value and comparison with ICNIRP value

IV. RESULT AND DISCUSSION

The absorption loss of the shielding material of thickness t=0.000889 inches in Electric field, magnetic field and plane waves is shown in fig 1. It has found out that for various shielding materials like Aluminum, mumetal, super alloy have the frequency up to 10 GHz, the absorption loss increases with increase in frequency. The radiation is absorbed highly by the aluminum sheet compared with super alloy and mumetal. The reflection loss of the shielding material of thickness t=0.000889 inches, in EF, MF and PW it is shown in fig 2.

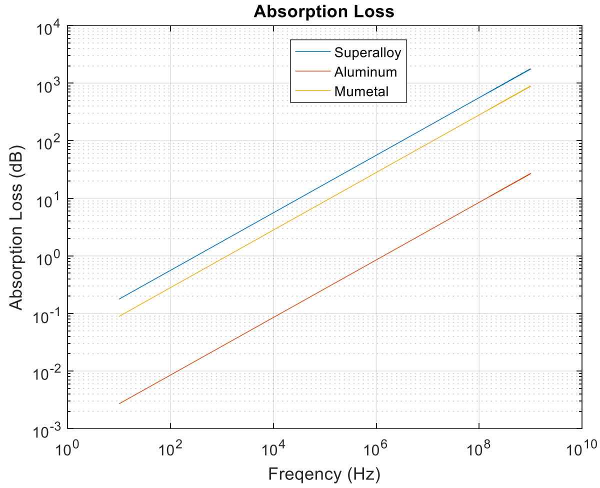
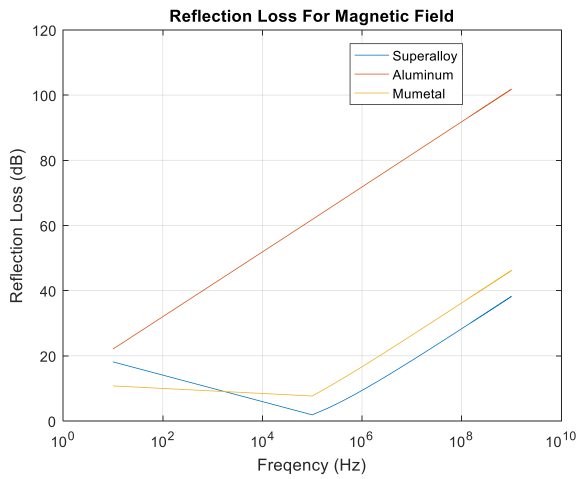
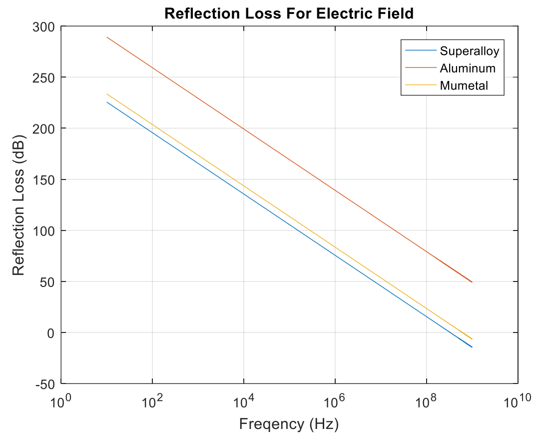


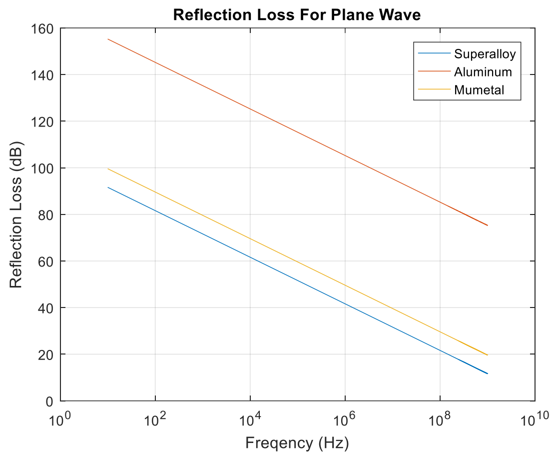
Fig 1: Absorption loss for different materials



a). RL for MF

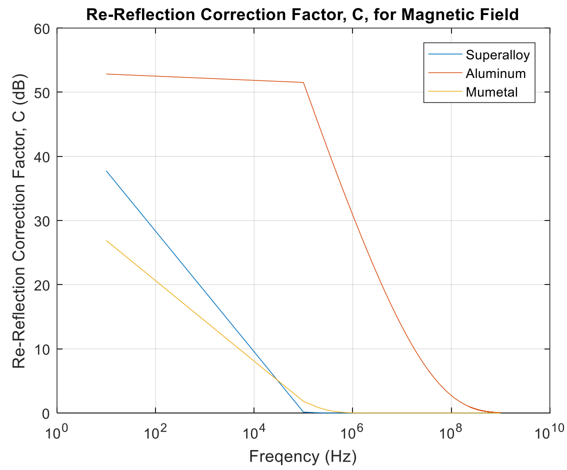


b). RL for EF

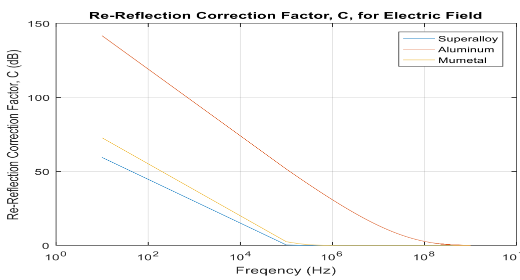


c). RL for PW

Fig 2: Reflection loss



a). MF



b).EF

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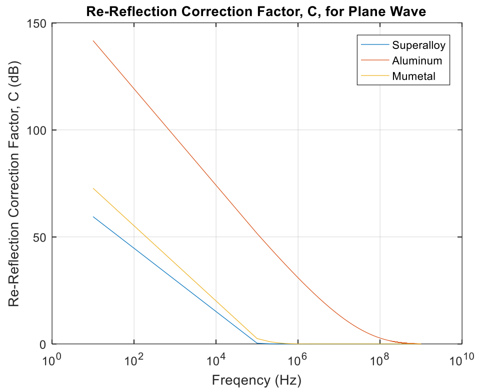
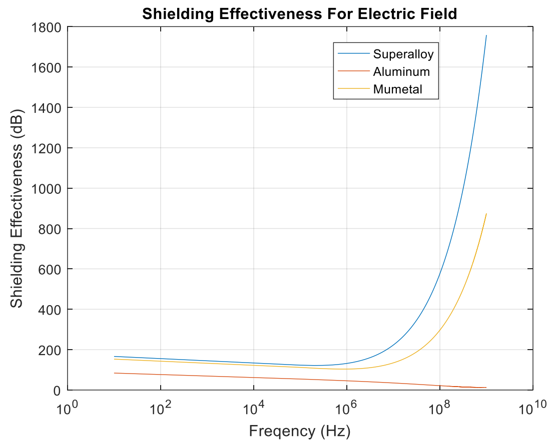
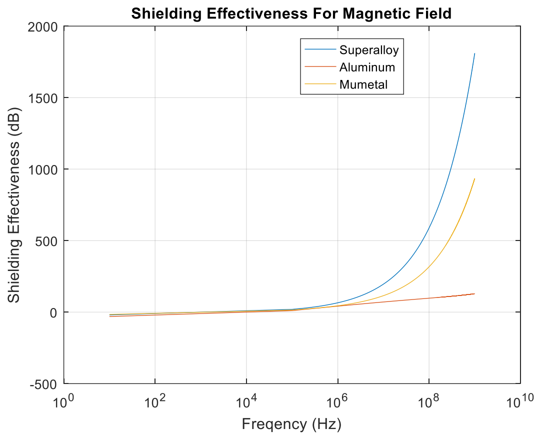


c). PW

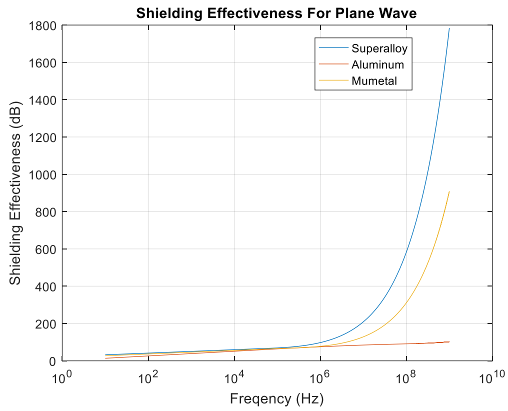
Fig 3. RRF



b). EF



a).MF



c). PW

Fig 4. Effectiveness of shielding

Table 1: Parameters used for the calculation of shielding effectiveness

Thickness	Absorption loss, α_L											
t1=0.000889 inches	αL1=(0-34.8338)											
t2=0.000576 inches	α_{L2}=(0-22.5695)											
Distance	RLβ											
	MF				EF				PW			
d_1=20m	β_{m1}=403.4976				β_{e1}=571.7724				β_p=461.5926			
d_2=30m	β_{m2}=411.6069				β_{e2}=563.6631							
d_3=100m	β_{m3}=435.6863				β_{e3}=539.5836							
Distance	Re reflection Correction factor CF											
	MF				EF				PW			
d_1=20m	p_{m1}=4.4e-10	ξ_{m1}=2.0e19	ξ_{m1}, α_{L1}	CF_1	p_{e1}=7.7e-23	ξ_{e1}=6.6e44	ξ_{e1}, α_{L1}	CF_7	p_p=4.1e-16	ξ_p=0.2e-10	ξ_p, α_{L1}	CF_{13}
			ξ_{m1}, α_{L2}	CF_2			ξ_{e1}, α_{L2}	CF_8				
d_2=30m	p_{m2}=2.9e-10	ξ_{m2}=4.5e19	ξ_{m2}, α_{L1}	CF_3	p_{e2}=1.1e-22	ξ_{e2}=2.9e44	ξ_{e2}, α_{L1}	CF_9				
			ξ_{m2}, α_{L2}	CF_4			ξ_{e2}, α_{L2}	CF_{10}			ξ_p, α_{L2}	CF_{14}
d_3=100m	p_{m3}=8.8e-11	ξ_{m3}=5.1e20	ξ_{m3}, α_{L1}	CF_5	p_{e3}=3.8e-22	ξ_{e3}=2.6e43	ξ_{e3}, α_{L1}	CF_{11}				
			ξ_{m3}, α_{L2}	CF_6			ξ_{e3}, α_{L2}	CF_{12}				
CF1=(8.8e-2-731.52), CF2=(8.8e2-788), CF3=(9.05e2 -747.73), CF4=(9.05e2-804.21), CF5=(9.5e2-798.89), CF6=(9.5e2-852.37), CF7=(2.06e3-1.9e3), CF8=(2.06e3-1.96e3), CF9=2.04e3 -1.89e3), CF10=(2.04e3 -1.9e3), CF11=(1.99e3 – 1.8e3) ,CF12=(1.99e3-1.90e3), CF13=(6.9e-15 – (-1.5e2)),CF14=(6.9e-15 – (-97.00))												

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The RL increases for the magnetic field but decreases for electric field and plane wave. The RRF increases for the magnetic field but decreases for EF and PW is shown in fig 3. In fig 4 the shielding effectiveness of the three materials of a super alloy, mumetal, and aluminum in an electric field is 1750db,890dB, 0dB, in magnetic fields are 1800dB, 900dB, 90dB, the plane waves are 1800dB, 850 dB, 100dB respectively. From the observed results shows the aluminum act as best shielding in 0 to 10 GHz compared with mumetal and super alloy.

Table 2: Power in dBm with shielding

For electric field						
	L=20m		L=30m		L=100m	
Frequency	Shielding effectiveness	power in dBm	Shielding effectiveness	Power in dBm	Shielding effectiveness	Power in dBm
10	-2.32E-121	-2.32E-121	-9.72E-120	-9.72E-120	-6.36E-115	-6.36E-115
10000010	-3.96E-126	-3.96E-126	-1.66E-124	-1.66E-124	-1.08E-119	-1.08E-119
20000010	-3.59E-122	-3.59E-122	-1.50E-120	-1.50E-120	-9.83E-116	-9.83E-116
30000010	-6.12E-127	-6.12E-127	-2.56E-125	-2.56E-125	-1.68E-120	-1.68E-120
40000010	-1.40E-124	-1.40E-124	-5.87E-123	-5.87E-123	-3.84E-118	-3.84E-118
50000010	-2.39E-129	-2.39E-129	-1.00E-127	-1.00E-127	-6.55E-123	-6.55E-123
60000010	-1.92E-122	-1.92E-122	-8.05E-121	-8.05E-121	-5.27E-116	-5.27E-116
70000010	-4.67E-127	-4.67E-127	-1.96E-125	-1.96E-125	-1.28E-120	-1.28E-120
80000010	-2.97E-123	-2.97E-123	-1.24E-121	-1.24E-121	-8.14E-117	-8.14E-117
90000010	-7.22E-128	-7.22E-128	-3.02E-126	-3.02E-126	-1.98E-121	-1.98E-121
100000010	-1.16E-125	-1.16E-125	-4.86E-124	-4.86E-124	-3.18E-119	-3.18E-119
110000010	-2.82E-130	-2.82E-130	-1.18E-128	-1.18E-128	-7.73E-124	-7.73E-124
For magnetic field						
	L=20m		L=30m		L=100m	
Frequency	Shielding effectiveness	power in dBm	Shielding effectiveness	Power in dBm	Shielding effectiveness	Power in dBm
10	-1.11E-20	-1.11E-20	-2.66E-22	-2.66E-22	-4.06E-27	-4.06E-27
10000010	-1.16E-25	-1.16E-25	-2.77E-27	-2.77E-27	-4.24E-32	-4.24E-32
20000010	-7.20E-20	-7.20E-20	-1.72E-21	-1.72E-21	-2.63E-26	-2.63E-26
30000010	-7.51E-25	-7.51E-25	-1.79E-26	-1.79E-26	-2.74E-31	-2.74E-31
40000010	-1.84E-17	-1.84E-17	-4.40E-19	-4.40E-19	-6.72E-24	-6.72E-24
50000010	-1.92E-22	-1.92E-22	-4.59E-24	-4.59E-24	-7.01E-29	-7.01E-29
60000010	-9.22E-22	-9.22E-22	-2.20E-23	-2.20E-23	-3.36E-28	-3.36E-28
70000010	-9.62E-27	-9.62E-27	-2.30E-28	-2.30E-28	-3.51E-33	-3.51E-33
80000010	-5.96E-21	-5.96E-21	-1.42E-22	-1.42E-22	-2.18E-27	-2.18E-27
90000010	-6.22E-26	-6.22E-26	-1.49E-27	-1.49E-27	-2.27E-32	-2.27E-32
100000010	-1.53E-18	-1.53E-18	-3.64E-20	-3.64E-20	-5.57E-25	-5.57E-25
110000010	-1.59E-23	-1.59E-23	-3.80E-25	-3.80E-25	-5.81E-30	-5.81E-30

Table 3: Power in dBm without shielding [27]

Power Values		
L=20	L=30	L=100
2.89E-13	5.70E-14	4.62E-16

The above table 2, shows the power in dBm with shielding. The effectiveness of the shielding can be checked out through the shielding algorithm. Here the material is considered as aluminum sheet, and it is varied with the thickness.

The power is calculated for with shielding and without shielding.

Table 3, shows that the existing method, that is without shielding. In case of the proposed system, the power values are varied with the distance, and when it is compared with the existing values all the intensities are negative. Hence the power values are reduced by using the aluminum sheet as shielding material.

Now the electric field strength obtained from power density values are converted into SAR values and comparing with the standard SAR value denoted by ICNIRP it is observed that the signal absorption rate lies within the safe limit.

Table 4: Calculation of SAR

SAR Value for Magnetic Field		
L=20m	L=30m	L=100m
-4.31E-14	-4.58E-16	-6.30E-22
-4.50E-19	-4.78E-21	-6.57E-27
-2.79E-13	-2.96E-15	-4.07E-21
-2.91E-18	-3.09E-20	-4.25E-26
-7.14E-11	-7.58E-13	-1.04E-18
-7.45E-16	-7.91E-18	-1.09E-23
-3.57E-15	-3.79E-17	-5.22E-23
-3.73E-20	-3.96E-22	-5.44E-28
-2.31E-14	-2.45E-16	-3.37E-22

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-2.41E-19	-2.56E-21	-3.52E-27
-5.91E-12	-6.28E-14	-8.63E-20
-6.17E-17	-6.55E-19	-9.01E-25
SAR Value for Electric Field		
L=20m	L=30m	L=100m
-9.00E-115	-1.67E-113	-9.86E-110
-1.53E-119	-2.85E-118	-1.68E-114
-1.39E-115	-2.59E-114	-1.52E-110
-2.37E-120	-4.41E-119	-2.60E-115
-5.44E-118	-1.01E-116	-5.96E-113
-9.27E-123	-1.72E-121	-1.02E-117
-7.45E-116	-1.39E-114	-8.17E-111
-1.81E-120	-3.37E-119	-1.98E-115
-1.15E-116	-2.14E-115	-1.26E-111
-2.80E-121	-5.21E-120	-3.07E-116
-4.50E-119	-8.38E-118	-4.94E-114
-1.09E-123	-2.04E-122	-1.20E-118

Table 5: Constant parameter values used in this work

S. No	Values
1	C= 131.4
2	k1= 0.0117
3	k2= 5.35
4	k3= 322

The above table 5, shows that constant parameters values which are used in the input parameters to avoid the radiation hazards from the cellular base station.

II. CONCLUSION

The radiation hazards from cell towers can result in certain issues to the human health. By using the protection measures like shielding materials, the radiation hazards from cell towers can be minimized to a certain extent. Accordingly, the characteristics like reflection, absorption loss, a re-reflection factor of various materials like aluminum, super-alloy, and mumetal is evaluated. Finally, the SAR values are calculated and compared with the existing standard values denoted by ICINRP is about 0.08 for whole body. It is observed that the SAR values are within the safe limits by using aluminum as the shielding material. The power in dBm is calculated and the effectiveness is checked with and without shielding. The proposed method has used some parameters and the values selected are given in the Table 5. The comparison tables are provided based on the power with and without shielding and the signal absorption rate can be minimized using proper shielding materials. By using the shielding materials the effect of radiation from cell towers can be minimized and thus human beings are protected from unwanted radiation.

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