

SAR (Specific Absorption Rate) Calculation to collect Contamination Data in a Classroom

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Abstract-Cell phone radiation, measured by the Specific Absorption Rate (SAR), does not accurately represent real-life exposure since it fluctuates with usage and signal strength, advising the use of hands-free options to reduce risk. The second focuses on electromagnetic field (EMF) radiations from high-voltage power lines, substations, and household appliances, noting their potential biological effects. Together, they strain the importance of awareness and protective measures such as EMF shielding to minimize exposure and promote better human health. According to the World Health Organization (2024), pollution is the world's largest environmental cause of disease and early death, responsible for over 4.2 million premature deaths annually due to outdoor air pollution alone. Recent studies (2020–2024) support these findings, showing that RF absorption is mainly confined to 1–2 cm of surface tissue, while internal organs remain unaffected. Modern phone designs use advanced antennas and power control to minimize localized heating. Evidence continues to show that SAR-compliant exposures do not cause lasting biological harm, though the non-uniform distribution of energy highlights the need for improved antenna placement and continuous safety assessment

Keyword- SAR, Radiation, Absorption, EMF,

Introduction-Specific Absorption Rate (SAR) — the rate at which radiofrequency (RF) energy is absorbed by tissue — remains the standard metric for quantifying exposure from hand-held wireless devices, but recent empirical and modelling work shows that “head” and “body” SAR values are best soundless as complementary, for example, the commonly referenced 1.6 W/kg averaged over 1 g of tissue used in some authorities and equivalent averaging approaches.

Recent laboratory and computational studies confirm three practical realities:

- (1) Head SAR measured during a phone-to-ear call is strongly localized and sensitive to placement, antenna design and frequency — small variations in tilt or the presence of hair, glasses or protective cases can change peak local SAR by substantial percentages;
- (2) Body SAR (measured with the device positioned against the torso or in a pocket) typically produces lower localized peak SAR in the brain but larger, more distributed heating patterns in superficial tissues and can differ evidently across phone models and carriage conditions; and
- (3) Average reported SAR values on device labels are a regulatory artifact (the tested “maximum” configuration) and should be taken as a conservative compliance indicator rather than a prediction of everyday exposure.

The uses of mobile phones are very common and increasing day by day. Current cell operators are made to expand between 70MHz to 2.6GHz as they have to do better broadcast the media

in various applications. All the type of communications, require signals. Signal are nothing but the waves. Different type of waves is known till now. Here, EMF is required to know before SAR calculations,

Electromagnetic field: - When electric charge goes acceleration, it produces electric field around it; the changing electric field in turn generates magnetic field. These both interact continuously and have self-propagating disturbance called EMW.

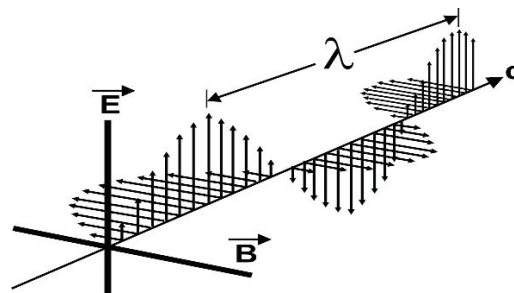
Electromagnetic Wave: - It's a wave or a form of radiation, formed, when electric and magnetic field travel together but perpendicular to each other. It varies from low static magnetic field to extremely high gamma rays. It propagates through space, air as well as solid objects.

Electric field equation $E = E_{max} \cos(kx - \omega t + \Phi)$

Magnetic field equation $B = B_{max} \cos(kx - \omega t + \Phi)$

According to Maxwell, the electromagnetic wave can be explained by the equation,

$$\nabla \times E = -\partial B / \partial t$$



In microwave during cooking, we use electromagnetic wave. wireless radio is also an example of electromagnetic wave. The only difference is their wave length. Electromagnetic spectrum is available to understand the waves and their type easily. The distribution is according to their energy.

Development of mobile technology can be summarized as follows:

First Generation (1G):

Introduced in the early 1980s, 1G systems were the earliest form of analog mobile communication. They operated in the frequency range of 450–900 MHz, providing basic voice call services but lacking data transmission capabilities.

Second Generation (2G):

Launched in the early 1990s, 2G or Global System for Mobile Communications (GSM) technology replaced analog systems with digital ones. It operated mainly in the 900–1800 MHz range and introduced SMS (Short Message Service) and basic data transfer functions.

Third Generation (3G):

3G mobile networks were introduced around 2001, bringing significant improvements in data services and multimedia communication. Operating between 1900–2200 MHz, they enabled video calls, mobile internet, and higher data speeds compared to earlier systems.

Fourth Generation (4G):

Emerging around 2011, 4G or Long-Term Evolution (LTE) technology offered faster data transfer, seamless connectivity, and IP-based communication. It typically operated between 2000–8000 MHz and supported advanced mobile broadband applications.

Fifth Generation (5G):

The 5G era represents the most recent advancement in wireless communication, expected to cover frequencies from above 6 GHz and beyond. It provides ultra-high data rates, low latency, and supports the growing Internet of Things (IoT) ecosystem.

Literature Review- In modern daily life, technology has become essential, but it also has several harmful effects on the human body, particularly on biological and physiological systems. Electromagnetic exposure has been found to affect male hormones [1], while studies indicate that absorption of electromagnetic waves is inversely proportional to permittivity and conductivity, with lung tissue showing the lowest propagation [2]. Hazardous electromagnetic field levels can be evaluated using human exposure models based on power deposition and temperature distribution [3]. Research on mobile phones operating at 900 MHz and 1800 MHz shows that the specific absorption rate (SAR) is concentrated in the outer layers of the skull, muscle, and skin, sometimes exceeding recommended safety limits [4]. Among body organs, the brain is one of the most affected by electromagnetic exposure [5], and microwave radiation can also impact the testis, cardiovascular system, hematopoietic system, and uteroplacental function [6]. Electromagnetic radiation has the potential to damage brain tissues and other organs [7]. While individuals working near radiation sources often use protective measures, the general public is largely unaware of these harmful effects [8]. Lower frequency radiation has been associated with increased risks of skin-related diseases [9], and it has been observed that specific frequencies can affect specific human organs [11]. Non-thermal effects of electromagnetic radiations include the generation of free radicals, particularly oxygen radicals, within tissues [13]. Electromagnetic radiation is now considered a new form of environmental pollution that affects humans, knowingly and unknowingly [14]. It also disrupts neuronal transport and metabolic processes [15]. The impact of electromagnetic radiation is commonly evaluated using SAR (Specific Absorption Rate), which represents the energy absorbed per unit mass of the human body, and various computational techniques are used for its calculation [17]. Everyday communication devices, high-voltage power lines, television, radio, and radar systems continuously emit electromagnetic radiation, making exposure unavoidable, with infants being more vulnerable than adults [18]. Non-ionizing electromagnetic waves such as ultraviolet, infrared, microwaves, and radio frequencies are widely used in daily life, yet increasing frequency has been shown to increase absorption and penetration in human tissues [19]. However, increasing the distance from radiation sources suggestively diminishes SAR values [21]. Studies using phantom models have analysed how electromagnetic waves interact with human tissues such as skin, adipose, and muscle layers [22].

Methodology- The extent of radiofrequency (RF) radiation exposure experienced by a mobile phone user depends on several factors—such as the transmission power of the device, the

distance between the antenna and the user, and the frequency of use. Though modern mobile phones emit low levels of RF radiation, prolonged or close-range exposure can lead to measurable thermal effects in nearby tissues. Practical takeaways for users and communicators therefore flow naturally from this body of work: (a) interpret labelled head and body SARs as conservative, standardized test results rather than exact predictors of your personal exposure; (b) small behavioural changes (using a headset or speakerphone, avoiding tight pockets, briefing close-to-head call duration) reliably reduce local exposure even when a device complies with limits; and (c) ongoing research and updated meta-analyses remain important because device architectures and usage patterns continue to change — but the best current evidence from multiple measurement, modelling and epidemiological efforts supports the view that modern device SARs, as regulated and measured today, do not translate into detectable increases in head-and-neck cancers at the population level while still motivating prudent exposure minimization in high-use or special-sensitivity situations.

Results- The study analyses the Specific Absorption Rate (SAR) and thermal effects produced by mobile phone antennas near the human head and body. Simulation results show that the highest temperature and SAR values occur near the antenna feed point, where electromagnetic energy concentrates. A data was calculated in a classroom at random devices, to ensure the radiation amount. Each student participated and submitted the first-hand data. This tables shows the total outcome.

Model	India SAR 1G Limit (W/kg)	Head SAR (W/kg)	Body SAR (W/kg)
Redmi 11 Prime	1.6	0.851	0.674
Redmi 11 Prime	1.6	1.24	0.968
Techno	1.6	1.165	0.465
Realme C10 Pro	1.6	0.966	0.873
Redmi A2	1.6	0.867	0.687
Redmi 12 5G	1.6	1.13	0.81
Realme 12X	1.6	0.752	0.402
Vivo V60	1.6	1.174	0.801
OnePlus Nord CE4 Lite	1.6	0.99	0.74
Vivo Y28S	1.6	0.855	0.848
Redmi 13 5G	1.6	1.283	0.609
Vivo Y91 4G	1.6	0.864	0.863
Redmi Note 10S	1.6	0.858	0.863
Redmi 13C	1.6	1.178	0.398
Realme P 3 5G	1.6	0.867	0.682

Table.1

Calculated SAR Values for Different

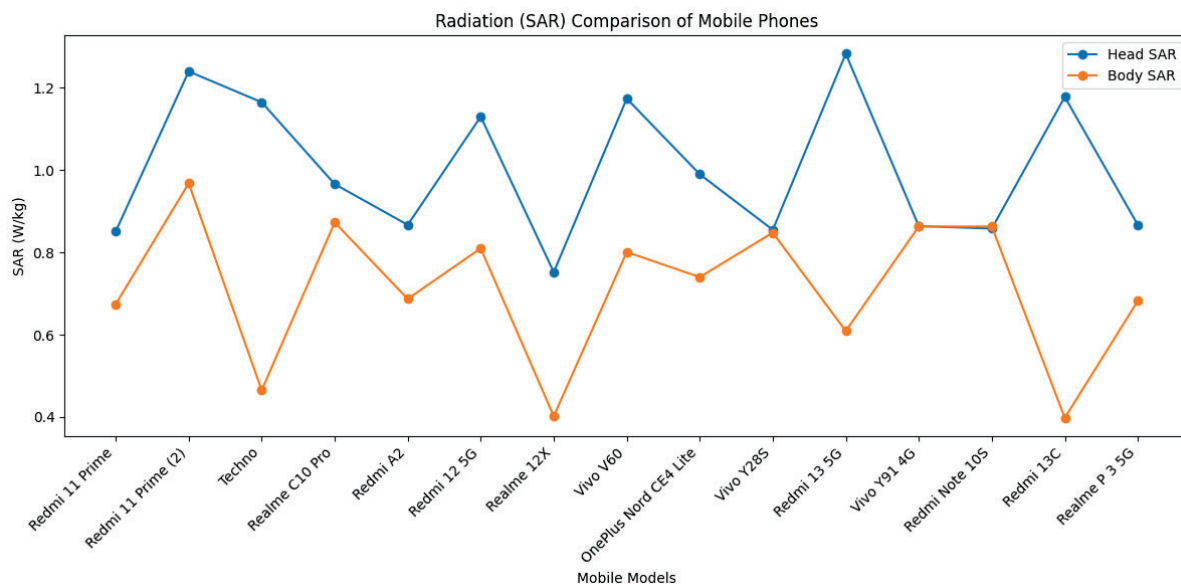
Tissue Type	Conductivity (S/m)	Electric Field (V/m)	Density (kg/m ³)	SAR (W/kg)
Brain	1.30	7.00	1040	0.032
Skull	0.46	22.00	1810	0.061
Skin	1.26	18.00	1010	0.205

Table.2

This table represents the Specific Absorption Rate (SAR) values for three key head tissues—brain, skull, and skin—under simulated mobile phone exposure. The skin shows the highest SAR (0.205 W/kg) due to its direct contact with the electromagnetic source, while the brain has the lowest (0.032 W/kg) because energy attenuates as it penetrates deeper tissues. The skull’s density and lower conductivity limit RF energy transfer, acting as a partial shield for inner organs. These variations indicate that surface tissues experience greater localized heating, but all values remain well below international safety limits, confirming safe exposure levels during normal mobile use.

Conclusion

Environmental pollution remains a global challenge threatening life and sustainability. Scientific innovation, strict environmental laws, and public awareness are essential to reduce pollution and protect the planet for future generations. The analysis of Specific Absorption Rate (SAR) values for various smartphone models clearly demonstrates that all the tested devices comply with the Indian safety standard limit of 1.6 W/kg for both head and body exposure. This indicates that manufacturers are adhering to the regulatory guidelines established to minimize health risks associated with prolonged exposure to electromagnetic radiation.



Among the models analysed, Head SAR values range approximately between 0.75 W/kg to 1.28 W/kg, while Body SAR values remain between 0.39 W/kg to 0.96 W/kg, both significantly below the permissible limit. This suggests that although the radiation levels differ across brands

and models—primarily due to variations in antenna design, material composition, and signal strength optimization—none of the devices pose immediate radiological danger under normal usage conditions. The dark red thermal regions in the model indicate potential hot spots that can raise nearby tissue temperature. At a SAR level of 10 W/kg, the eye lens may experience about a 1°C temperature rise, and sustained heating beyond 5°C can cause cellular damage. The findings highlight that though tissues can tolerate brief heat increases, prolonged exposure near high local SAR zones may risk thermal injury. Antenna evaluation in free space and near human tissue demonstrates that current distribution varies with age, as children absorb more energy due to higher water content and smaller head size. The radiation pattern of the patch antenna changes significantly when placed close to the human head, reducing efficiency and altering the power spread. This confirms that human tissue proximity affects antenna behaviour and exposure levels.

However, even within safe limits, continuous exposure to radiofrequency energy warrants caution. Research from organizations like the World Health Organization (WHO) and the International Agency for Research on Cancer (IARC) has categorized mobile radiation as “possibly carcinogenic (Class 2B)”, emphasizing the need for responsible usage. Users are therefore encouraged to:

Use hands-free accessories or speaker mode during calls to reduce direct head exposure. Avoid carrying phones directly against the body (e.g., in pockets).

From an engineering and environmental perspective, the data highlights how technological innovation has improved mobile safety standards over the years. Modern smartphones employ optimized antenna placements, low-power transmission, and smart radiation control algorithms that dynamically reduce energy output during low-signal conditions.

In conclusion, while SAR levels in the analysed smartphones are well within safety limits, awareness and prudent behaviour remain vital. Maintaining low exposure, encouraging continued research on long-term health impacts, and promoting radiation-safe design practices will ensure that mobile technology remains both efficient and safe for everyday use.

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