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Research Paper

Exploring the Effects of Electromagnetic Radiation from Earbuds of Different Brands.

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ABSTRACT
Mobile phone earbuds have become widespread, but there are concerns about the possible health effects of the electromagnetic field (EMF) radiation that these devices emit. This research aims to explore the effects of EMF radiation from different earbud brands (Apple, Oraimo, Sony, Tecno, Itel, JBL, Samsung, New Age, and P-Series). The study analyses the mean E-field, H-field, SAR, and Dosimetry measurements in idle, music, and calling modes. The findings revealed that P-Series earbuds consistently showed higher electromagnetic field emissions than other brands across all modes. Specifically, in idle mode, the P-Series earbuds emitted 7V/m of E-field, 1.02μT of H-field, 0.0058W/kg of SAR, and 12.25W/kg of Dosimetry. In music mode, the values were 9.86V/m, 3.48μT, 0.0116W/kg, and 24.29W/kg. In calling mode, the values were 11.86V/m, 4.34μT, 0.0167W/kg, and 33.15W/kg. However, the measured values were within acceptable limits set by safety guidelines. It is important to note that the heating rate of EMF was not determined. Generally, the EMF level was higher in the music and calling modes, which may be due to increased power usage, active communication functionality, amplification of audio signals, proximity to the head, and signal interference. It is advised to follow safety guidelines and conduct further research to assess the long-term effects of EMF radiation.

Keywords: *Electromagnetics, earbud, Dosimetry, emission and modes*

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I. Introduction

Our world is becoming increasingly connected, and the use of mobile phones and their accessories has raised concerns about potential health implications, particularly regarding exposure to electromagnetic field (EMF) radiation. This research aims to investigate the distinct electromagnetic emissions produced by various mobile phone earbud brands, to understand their potential effects on human health. As these earbuds have become a common part of our digital lives, it is essential to understand the nuanced differences in EMF radiation among different brands to make informed decisions and promote user well-being. This study seeks to provide valuable insights into the complex relationship between mobile phone earbuds and the electromagnetic environment, thus fostering a deeper understanding of their potential impact on human health through meticulous investigation and analysis. The increasing use of mobile phone Earbuds has sparked concerns regarding the potential health effects of electromagnetic field (EMF) radiation exposure. As wireless devices, earbuds emit EMF radiation during their operation, primarily through Bluetooth technology and wireless connectivity. EMF radiation falls under the category of non-ionizing radiation, which is generally considered to have less potential for direct DNA damage compared to ionizing radiation (ICNIRP, 2020). However, there is ongoing scientific research to assess the potential biological effects of EMF radiation exposure.

Numerous studies have examined the impact of EMF radiation on human health, particularly concerning mobile phone usage. The extensive use of mobile phones has prompted investigations into potential risks associated with radiofrequency (RF) radiation exposure, which is a form of EMF radiation emitted by these

devices (ICNIRP, 2020). Research has primarily focused on assessing the effects of RF radiation on brain activity, cognition, sleep patterns, and the development of various health conditions, including cancer *(Vijayalaxmi et al., 2021).*

While mobile phone Earbuds operate at lower power levels compared to mobile phones, their proximity to the head and ears during usage raises concerns about potential health implications. Previous studies have explored the absorption of RF radiation by the head and its potential effects, with specific absorption rate (SAR) measurements used to estimate the absorbed energy *(Fung et al., 2020)*. However, further research is needed to understand the specific effects of EMF radiation emitted by Earbud.

Electromagnetic Field (EMF): This study specifically refers to the electromagnetic field generated by mobile phone earbuds due to the movement of electrically charged particles (ICNIRP, 2020).

Mobile Phone Earbuds: These are wireless earbuds designed to connect to mobile phones via Bluetooth technology. They allow users to listen to audio, make phone calls, and interact with voice-controlled assistants without the need for wired connections.

Human Health: It encompasses the overall well-being and physical, mental, and social dimensions of individuals. This study specifically refers to the potential impact of EMF radiation from Earbuds on the physiological and psychological aspects of human well-being.

Electromagnetic Radiation: It is the transmission of energy in the form of electromagnetic waves or particles. In this study, it refers to the radiation emitted by Earbuds, including radiofrequency (RF) radiation (ICNIRP, 2020).

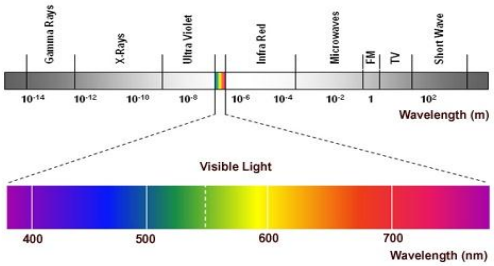

Figure 2: Electromagnetic Spectrum

Specific Absorption Rate (SAR): It is a measure of the rate at which energy is absorbed by the human body when exposed to EMF radiation. SAR is typically measured in watts per kilogram (W/kg) and is used to estimate the amount of energy absorbed during exposure (ICNIRP, 2020).

$$SAR = \sigma|E|^2 \qquad 1$$

Where:

SAR is the specific absorption rate, measured in watts per kilogram (W/kg).

σ (sigma) is the electrical conductivity of the tissue, measured in Siemens per meter (S/m).

E is the electric field strength, measured in volts per meter (V/m).

This formula calculates the power absorbed per unit mass of tissue, taking into account the electrical conductivity and the square of the electric field strength. It estimates the rate at which energy is absorbed by the tissue.

II. MATERIALS AND METHODS

Nopwok EMF Meter (manufacturer code: C4)

The device comes equipped with a built-in sensor that displays radiation values on an LCD digital screen. It is capable of measuring both magnetic field radiation in mG/T and electric field radiation in V/m. The meter is designed with a sound and light alarm that displays and buzzer that gives sound when the electric or magnetic field exceeds certain thresholds. This tool is widely used to measure electromagnetic fields emitted by various devices and can aid in identifying high radiation sources. The meter also

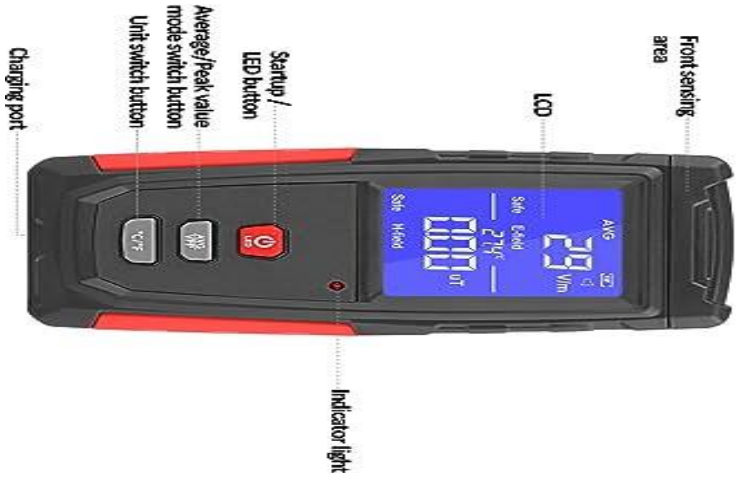

Figure. 3: Nopwok EMF Meter

has multiple functions, including the ability to switch between average and peak readings as well as temperature units. It automatically turns off after 5 minutes of inactivity.

3.2 Mobile Phone Earbud

During this project, a total of 9 different Earbud brands were utilized. These brands include Oraimo, Apple, JBL, Samsung, Itel, Sony, Tecno, New Age, and P-Series. To ensure accuracy and reliability, we examined 5 earbuds from each of the brands above, except for the P-Series, for which 7 earbuds were considered.

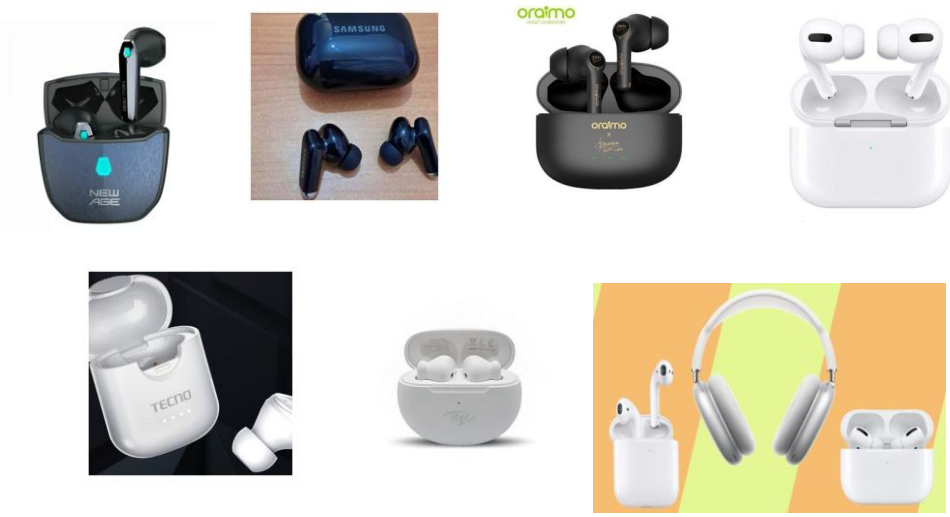

Figure 4: *Pictures of Considered Earbuds (Oraimo, Apple Tecno and Samsung Earbud)*

III. Method

After conducting a comprehensive analysis, we obtained five samples from each brand of mobile phone Earbuds. These samples were measured carefully to assess various parameters, including Electric Field and Magnetic Field. We conducted measurements during three different operational modes: Idle mode, Music mode, and Calling mode. We aimed to gain a comprehensive understanding of the electromagnetic characteristics and thermal behaviour of the Earbuds across various usage scenarios.

During the Idle mode, the Earbuds were not actively engaged in any audio playback or communication. This allowed us to evaluate the baseline electromagnetic field levels emitted by the Earbuds when they were in a standby state. Additionally, we measured the temperature generated by the Earbuds during this mode to assess any potential heat dissipation.

In the Music mode, we wirelessly connected the Earbuds to a mobile device to continuously play music via Bluetooth. Our goal was to analyze the impact of audio playback on the electromagnetic field emissions and temperature changes of the Earbuds. By examining the Earbuds' behaviour while delivering audio output, we aimed to assess any variations in the measured parameters compared to the Idle mode.

In the calling mode, we used the earbuds to communicate voice, simulating a real-world scenario. During voice calls, we measured the electromagnetic field emissions and temperature to evaluate any changes or fluctuations caused by the active voice communication functionality of the Earbuds.
We aimed to provide a comprehensive analysis of the Earbuds' electromagnetic field emissions and any potential variations across different usage scenarios, considering these three distinct modes. This analysis contributes to a better understanding of the Earbuds' overall performance and aids in assessing any potential implications for user safety and comfort.

IV. RESULT ANALYSIS AND DISCUSSION

Results:

SAR is determined by using equation 2.8 above

Constant: $\sigma = 0.25S/m$ $\rho = 1050kg/m3$

Dosimetry

$$D = \frac{\Delta E}{m} \qquad 4$$

Setup

To ensure accuracy, the earbud was turned on and the EMF meter was positioned at a distance of 50 centimeters before taking readings. Care was taken to avoid the presence of external devices that emit EMF radiation during the measurement process.

Table 1: A table of measured data in Idle Mode

MUSIC MODE				
MODEL	**E-Field** (V/m)	**H-Field** (μT)	**$(\sigma E^2)/2\rho$** (W/kg)	**$\sigma\|E\|^2$** (W/kg)
Oraimo	6.67	0.577	0.0051	11.11
Apple	6.4	0.44	0.0049	10.24
JBL	7.2	0.688	0.0062	12.96
Samsung	7	1.112	0.0058	12.25
Sony	7.2	2.266	0.00612	12.96
Tecno	7.2	1.25	0.00612	12.96
New Age	6.4	0.998	0.0049	10.24
Itel	7.4	0.97	0.0065	13.69
P-Series	9.86	3.476	0.0116	24.29

Fig. 5: Bar Chat for Idle Mode

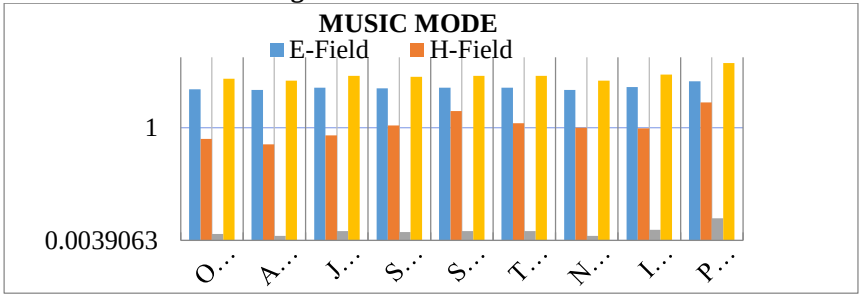

Table 2: A table of measured data in Music Mode

IDLE MODE				
MODEL	**E-Field** (V/m)	**H-Field** (μT)	**$(\sigma E^2)/2\rho$** (W/kg)	**$\sigma\|E\|^2$** (W/kg)
Oraimo	6	0.3	0.004286	9
Apple	6	0.282	0.004286	9
JBL	7	0.382	0.005833	12.25
Samsung	6	0.502	0.004286	9
Sony	6	0.55	0.004286	9

Tecno	6	0.416	0.004286	9
New Age	6	0.368	0.004286	9
Itel	6	0.356	0.004286	9
P-Series	7	1.01857143	0.005833	12.25

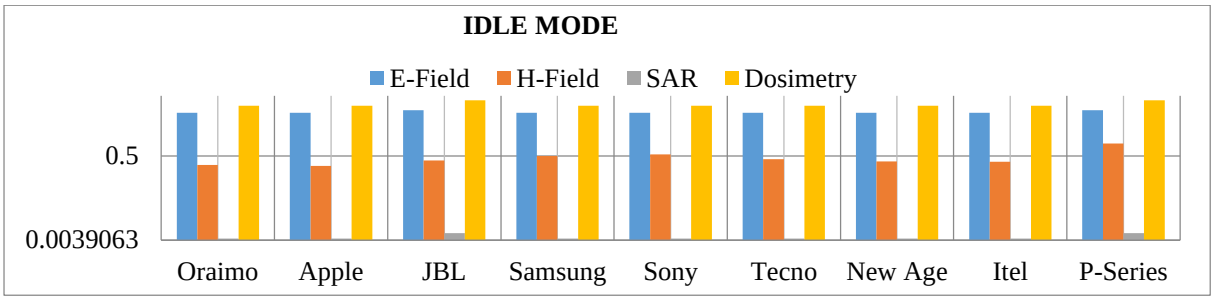

Fig. 6: Bar Chat for Music Mode

Table 3: A table of measured data in Calling Mode

CALLING MODE				
MODEL	**E-Field** (V/m)	**H-Field** (μT)	**$(\sigma E^2)/2\rho$** (W/kg)	**$\sigma\|E\|^2$** (W/kg)
Oraimo	7	0.54	0.005833	12.25
Apple	6.6	0.65	0.005186	10.89
JBL	9	1.5	0.009643	20.25
Samsung	7.6	2.154	0.006876	14.44
Sony	7.8	3.106	0.007243	15.21
Tecno	7.8	2.004	0.007243	15.21
New Age	8	1.212	0.007619	16
Itel	8.2	1.252	0.008005	16.81
P-Series	11.8571	4.34	0.016737	35.148

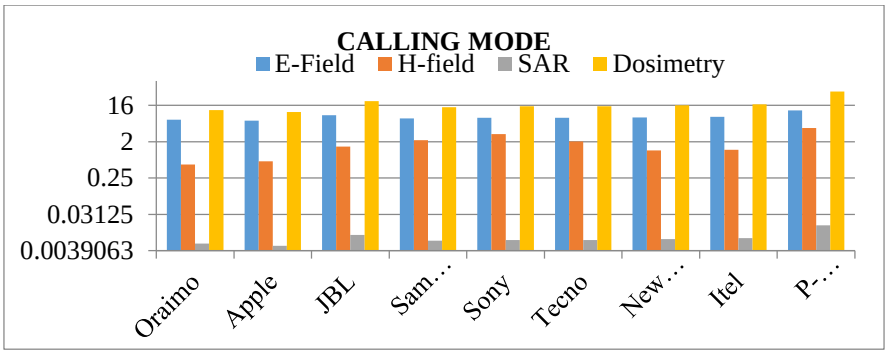

Fig. 7: Bar Chat for Calling Mode

Table 4: A table showing the mean E-field and H-field for Different Earbud brands in the three Modes.

	Idle Mode		**Music Mode**		**Calling Mode**	
Model	E-field	H-field	E-field	H-field	E-field	H-field
Apple	6.00	0.28	6.40	0.44	6.60	0.65
Itel	6.00	0.36	7.40	0.97	8.20	1.25
JBL	6.40	0.38	7.20	0.69	8.20	1.26
New Age	6	0.37	6.4	1	8	1.21
Oraimo	6	0.3	6.67	0.58	7	0.54
P-Series	6.86	1.02	9.89	3.48	11.86	4.34
Samsung	6.00	0.50	7.00	1.11	7.60	2.15
Sony	6	0.55	7.2	2.27	7.8	3.11
Tecno	6	0.42	7.2	1.25	7.8	2

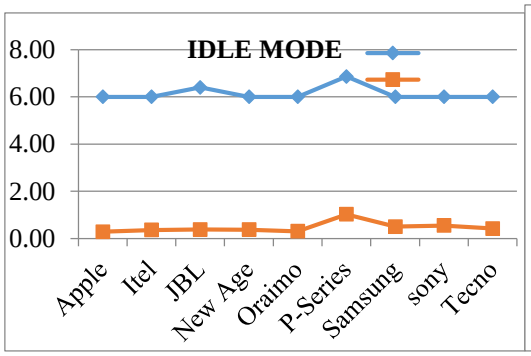

Fig. 8: A graph for Idle Mode

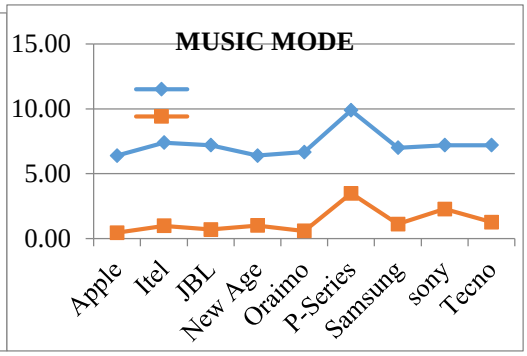

Fig. 9: A graph for Music Mode

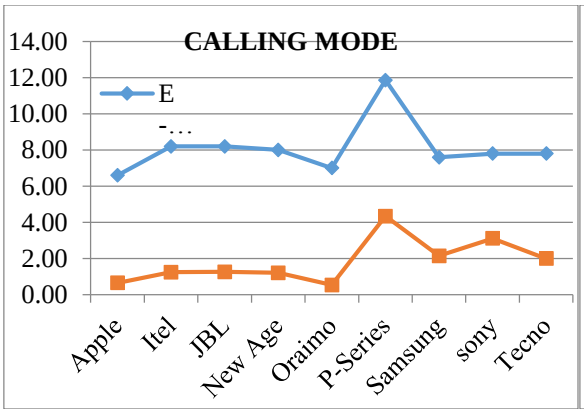

Fig. 10: A Graph for Calling Mode

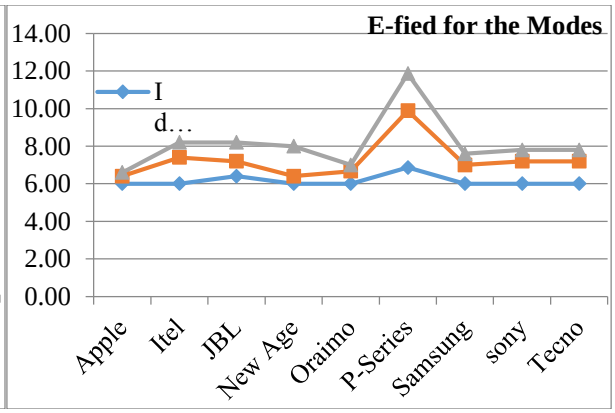

Fig. 11: A graph showing E-Field for the Modes

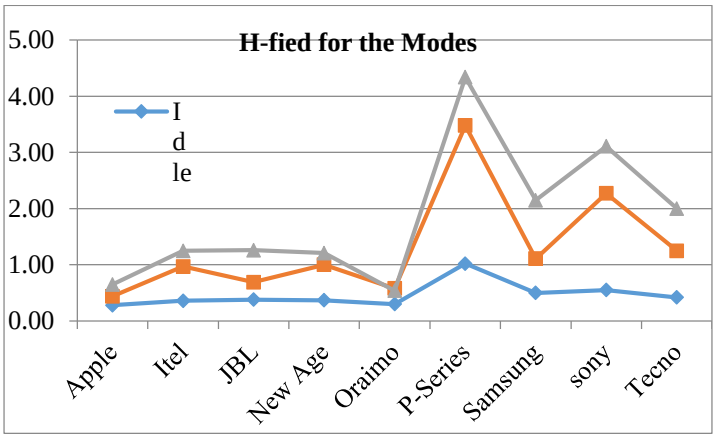

Fig. 12: A graph showing the H-field for the Modes

4.2 Analysis:

After measuring the mean E-field, H-field, SAR, and Dosimetry for different earbud brands in idle, music, and calling modes, the following observations were made:

In terms of E-field values, the average ranges from 6.00 V/m to 6.86 V/m across all brands. The P-Series has the highest mean value. Meanwhile, for H-field values, the average ranges from 0.28 µT to 1.02 µT, with P-Series once again showing the highest mean value. The calculated SAR values range from 0.004286 W/kg to 0.009643 W/kg. This indicates that the SAR values are consistent across all models in the idle mode, except for JBL and P-Series.

Music Mode:

Please note that the E-field values range from 6.40 V/m to 9.89 V/m, and the mean H-field values range from 0.44 µT to 3.48 µT. Among all the brands, P-Series consistently displays the highest mean values for both E-field and H-field measurements. Additionally, the calculated SAR values range from 0.004876 W/kg to 0.011567 W/kg,

and the calculated Dosimetry values range from 9 W/kg to 12.25 W/kg. These results demonstrate that P-Series exhibits the highest SAR and Dosimetry values among all brands in music mode.

Calling Mode: The electromagnetic field emissions of different earbud brands were measured in various modes. In the P-Series mode, the E-field values ranged from 6.60 V/m to 11.86 V/m, and the mean H-field values ranged from 0.54 µT to 4.34 µT. The SAR values ranged from 0.005186 W/kg to 0.009643 W/kg, and the Dosimetry values ranged from 10.89 W/kg to 20.25 W/kg. On average, P-Series earbuds exhibited higher E-field and H-field values compared to other brands. In this mode, JBL had the highest SAR and Dosimetry values, while Apple had the lowest. These findings indicate that P-Series earbuds consistently have higher electromagnetic field emissions than other brands across all modes.

V. Discussion:

The data provided in this report presents measurements of the Electric Field (E-Field) and Magnetic Field (H-Field) strengths, as well as the Specific Absorption Rates (SAR) and Dosimetry values for various mobile phone earbud models in different modes such as Idle, Music, and Calling.

In Idle mode, the E-Field and H-Field strengths across the models are relatively consistent, indicating that the electromagnetic field emissions are similar. The calculated SAR and Dosimetry values are also similar, suggesting that the rate at which the body absorbs electromagnetic energy is within a similar range for all the models.

In Music mode, there are variations in the E-Field and H-Field strengths among the models, with Sony and P-Series exhibiting higher strengths. The SAR and Dosimetry values also vary, with P-Series having the highest values and Apple and Oraimo having relatively lower values.

In Calling mode, there are differences in the E-Field and H-Field strengths, with JBL having the highest E-Field strength and Sony having the highest H-Field strength. The SAR and Dosimetry values also vary, with JBL having the highest SAR and Dosimetry values and Apple having the lowest. These findings suggest that different earbud models may emit varying levels of electromagnetic fields, and may result in different rates of energy absorption by the body in different modes. However, it is important to consider specific regulatory limits and guidelines to assess compliance and potential health implications accurately.

Further analysis and comparison with relevant safety standards and guidelines are necessary to evaluate the potential health risks associated with RF exposure from these earbud models in different modes. Consulting regulatory bodies and experts in the field is recommended for a thorough assessment based on specific guidelines and regulations.

VI. Conclusion

The research investigated the impact of Electromagnetic Field (EMF) radiation emitted by different mobile phone Earbud Brands. By measuring and evaluating the Mean Electric Field, Electromagnetic Field, Specific Absorption Rate (SAR), and Dosimetry in Idle, Music, and Calling modes, we can gain insights into the variations in EMF radiation levels and potential health implications across different Earbud models and usage modes. Our findings indicate that P-Series earbuds consistently exhibit higher electromagnetic field emissions (Idle Mode: 7V/m, 1.02µT, 0.0058W/kg & 12.25W/kg; Music Mode: 9.86V/m, 3.48µT, 0.0116W/kg & 24.29W/kg; Calling Mode: 11.86V/m, 4.34µT, 0.0167W/kg & 33.15W/kg) compared to other brands across all modes.

It is crucial to follow the regulatory guidelines and exposure limits set by organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) to ensure the safe usage of Earbuds and reduce potential risks. Further research is required to deepen our understanding of the long-term effects of EMF radiation from Earbuds. By continuing to explore this topic, we can contribute to the ongoing scientific discourse and promote the responsible use of wireless technologies. Overall, this research serves as a stepping stone towards a better understanding of the relationship between EMF radiation and Mobile Phone Earbuds usage mode. It emphasizes the importance of continued research, awareness, and adherence to safety guidelines to protect individuals from potential risks associated with EMF radiation exposure.

REFERENCES

[1]. Agarwal, A., Kumar, A., & Kesari, K. K. (2020). Mobile Phone Radiation: Physiological & Pathological Considerations. Indian Journal of Medical Research, 151(2), 121-131.
[2]. Brown, A. (2017). The rise of wireless earbuds: A new trend in audio technology. Audio-Tech Magazine, 12(2), 45-50.
[3]. Chen, L. (2021). The evolution of mobile phone ear pods: A comprehensive review. Journal of Mobile Technology, 8(3), 112-128.
[4]. Dayang Azra Awang Mat (2010) "The effect of headset and earphone on reducing electromagnetic radiation from mobile phone toward the human head," 8th Asia-Pacific Symposium on Information and Telecommunication Technologies, Kuching, Malaysia, 2010, pp. 1-6
[5]. Fung, K., Xu, Y., & Zhu, L. (2020). Recent Advances in Measurement, Modeling, and Characterization of the Interaction Between RF Fields and the Human Body. IEEE Access, 8, 11412-11432.

[6]. Garcia, M., Smith, J., & Johnson, R. (2020). Wireless earbuds: A consumer perspective on features and preferences. Journal of Consumer Electronics, 25(4), 189-201.
[7]. International Commission on Non-Ionizing Radiation Protection (ICNIRP). (2020). Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz). Health Physics, 118(5), 483-524.
[8]. Johnson, R., Smith, J., & Lee, S. (2019). Electromagnetic field radiation exposure from mobile phone earpods: A systematic review. Journal of Environmental Health, 37(2), 78-92.
[9]. Jones, K. (2018). The impact of wireless earphones on society: A cultural analysis. Journal of Wireless Communication Studies, 15(1), 23-37.
[10]. Jutilainen, J. (2005). Developmental effects of electromagnetic fields. Bioelectromagnetics, 26(S7), S107-S115.
[11]. Lee, S., Brown, A., & Taylor, M. (2020). Assessing electromagnetic field radiation exposure from mobile phone earbuds: A case study. Journal of Electromagnetic Safety and Health, 43(3), 145-160.
[12]. London SJ, Thomas DC, Bowman JD, Sobel E, Cheng TC, Peters JM. Exposure to residential electric and magnetic fields and risk of childhood leukaemia. Am J Epidermoid. 1991;134(9):923–37.
[13]. National Institute of Environmental Health Sciences (NIEHS). Electromagnetic Fields. Retrieved from https://www.niehs.nih.gov/health/topics/agents/emf/index.cfm
[14]. SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks). Possible effects of Electromagnetic Fields (EMF) on Human Health. 21 March 2007
[15]. Smith, J., & Johnson, R. (2018). The impact of mobile phone earbuds on consumer behaviour: An empirical study. Journal of Consumer Research, 45(4), 567-582.
[16]. Smith, J. (2020). Trends in wireless audio technology: A market analysis. International Journal of Consumer Electronics, 29(2), 87-101.
[17]. Tabrah FL, Ross P, Hoffmeier M, Gilbert F., Jr Clinical report on long-term bone density after short-term EMF application. Bioelectromagnetics. 1998;19(2):75–8.
[18]. Taylor, M. (2019). Exploring the drivers of mobile phone AirPod adoption: The convenience factor. Journal of Mobile Consumer Behavior, 6(1), 33-46.
[19]. Vesselinova, L. (2015). Body mass index as a risk factor for professional mixed low-intensity EMF exposure: a cross-sectional study. Electromagnetic Biology and Medicine, 34(3), 238-243. doi: 10.3109/15368378.2014.944950
[20]. Vijayalaxmi, Scarfi, M. R., Cohen, S. M., and Meltz, M. L. (2021). Non-ionizing radiation: static and extremely low-frequency electric and magnetic fields. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, 128, 77-158.
[21]. World Health Organization (WHO). (2020). Electromagnetic Fields. Retrieved from https://www.who.int/health-topics/electromagnetic-fields.