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Effect of Mobile Phone Radiations on HD- EEG Signals and Preventive Measures

Research Article

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Abstract

Background: Mobile Phones and other wi-fi devices have become an integral part of our life. Now that we have so much dependency on technology, it's become almost impossible to extricate ourselves from this. Considering the widespread use of these devices and the public's concerns for health and safety, it is important to find out the possible harm caused by these Radiofrequency Radiations (RFR) emitted by Mobile Phones and other wi-fi devices, ways to protect ourselves from this harm and use of technology responsibly.

World Health Organization/ International Agency for Research on Cancer had classified radiofrequency electromagnetic fields as Group-2B, possibly carcinogen in 2011[1].

The present study has analyzed the effect of Mobile Phone Radiations exposure on human brain activity in healthy human volunteers and the efficacy of one of the products called Envirochip which mitigates the adverse impact of these radiations on Brain waves when it is fixed on the Mobile Phone being used.

Materials and Methods: A total of 30 healthy participants were enrolled in this study, out of which, data of 29 subjects was analyzed as data of one subject was removed due to noise in the recorded data.

Result and Discussion: Electroencephalography (EEG) was recorded for 80 minutes with five minutes interval between each condition for each subject. Cleaned data was extracted from the Net station tool and power spectrum analysis was done.

Conclusion: There was increased activity in the alpha, beta, theta and gamma bands of EEG during Radiofrequency exposure from Mobile Phones. Fixing the Envirochip on Mobile Phone showed statistically significant improvement in the effects of the Mobile Radiations on EEG brain activity in the alpha and theta bands. However, changes observed in gamma and beta bands were not significant statistically. $P < 0.05$ was considered statistically significant.

Keywords: Electroencephalography (EEG), Mobile Phone Radiations, Brain, Radiofrequency Radiations (RFR), Envirochip.

Introduction

In today's world, it is hard to imagine life without the Internet, Mobile Phone and other wireless devices. These devices have become our daily companion for everything we do, be its office work, banking and payments, children's studies or staying in touch with our loved ones staying in remote locations.

While Technology seems to have become a blessing for us, at the same time it can be a curse also when it comes to the impact of these Radiofrequency Radiations on health and well-being. Effect of Radiofrequency Radiations / Electromagnetic Radiation can be classified as:

- Thermal Effects
- Non-Thermal Effects

The thermal effects are caused due to the heat that is generated due to the absorption of radiation. The Specific Absorption Rate (SAR) value has been fixed and specified for mobile phones to limit the thermal effects. However, more research is going on to study the Non-Thermal effects of these radiations which are far more harmful than the Thermal effects. The Non-Thermal effects may range from burning and tingling sensation near the head, fatigue, heart palpitations, lack of concentration, nausea, dizziness, delayed reaction time, sleep disturbance, loss of memory, headache, effect on heart and brain etc.

Since the brain has greater exposure to these Radiofrequency Radiations than the rest of the body while using Mobile Phone, it becomes all the more important to analyze the effect of these RFR on brain activity or EEG. A study revealed that pulsed radiations from Mobile Phone use can trigger human brain evoked potentials (EPs) [2]. Another study showed that when a Mobile Phone is placed on the ear, its radiations are electrically detected by the brain, resulting in increased cortical activity [3].

A study published in PubMed in 2004 concluded that excessive use of the mobile phone is a risk factor for developing a higher prevalence of fatigue, headache, dizziness, tension and sleep disturbances [4]. It is evident from the results of the study that the percentage of participants showing symptoms of headache was the highest which shows a great impact on the brain. A randomized crossover study found that just 50 minutes of exposure to cell phone radiations directly alters the production of brain glucose metabolism in adult [5].

According to an article published in the National Library of Medicine, 18 epidemiological studies provided evidence that EMFs from cell/mobile phones can produce neuropsychiatric effects including headache, memory changes, and EEG changes [6].

There have been many other well-researched and published studies that claim that there is an increase in the alpha and beta activities after exposure to the Electromagnetic Fields (EMFs) [7-10]. A study also found that the alterations in the theta and gamma bands were correlated with EMFs induced working memory deficit [11].

A recent study published in Frontier in Neuroscience found that there was increased activity in the theta, alpha, beta and gamma bands during EMF exposure [12]. The study concluded that EMF exposure can impair human health, performance, cognitive function and brain activity.

Also, there are a few studies on the subject that claim that the effect on the brain is not attributed to mobile radiations or the result is inconclusive.

The present study was aimed to investigate the effects of mobile phone radiations on brain activity when participants were exposed to RFR of Mobile Phones and to examine the efficacy of Envirochip in neutralizing the same. Changes in the frequencies of these EEGs can be interpreted as scientific evidence of an indication of the impact of the exposure to Radiofrequency Radiation used in mobile communication on brain activity [13].

Materials and Methods

Ethics approval and consent to participate

The Protocol of the study was approved by the institutional ethics committee, All India Institute of Medical Sciences, New Delhi and all methods were performed in accordance with the relevant guidelines and regulations. Informed consent was obtained from all subjects and/or their legal guardian(s).

Subjects

The study was performed on 30 healthy subjects having age between 18-40 years (mean: 36.43±5.85). The study was conducted at the All India Institute of Medical Sciences, New Delhi, India. All enrolled subjects were healthy and it was ensured that none of them had any ailment like vision and hearing complications. They were also interviewed about coffee/ tea intake, last night's sleep quality and any kind of work/home related stress before their data was taken because these factors may affect the results. None of the participants had any history of neurological diseases. Participants voluntarily agreed to participate in the research and their EEG was recorded in all the conditions including with Envirochip and without the Envirochip. Written consent was obtained from all the subjects before initiating the study. Subjects and technicians were blinded to the conditions (baseline, with the phone, with Envirochip etc.) of the study. The Procedure of the study was approved by the institutional ethics committee, All India Institute of Medical Sciences, New Delhi. The study has been registered by the clinical trial registry of India (CTRI/2017/07/009090, registered on: 21/07/2017).

Equipment and Procedures

EEG system

Brain activity was recorded using high density EEG (Philips Neuro (EGI Inc.), USA) with Hydrocele Geodesic sensor net (HCGSN 300), based on a 10/10 international system. This system constitutes128 channel dense array (Tucker; 1993), the sampling rate was set at 250 Hz. We used different sized nets (51-54 cm, 54-56 cm, and 56-58 cm) as per the head circumference of the subjects. The electrode impedance was kept below 50 kΩ in accordance with the recommendations of the manufacturer. The vertex (Cz) electrode was used as a recording reference. For the transmission of the signal from the scalp to the electrode, the electrolyte (KCl) was applied. Electrodes were used as an interface between the subjects and the EEG system for the recording of the specific brain activity. A specific amplifier (Net Amps 300) was used to display the low noise and high sensitivity of EEG waves. The band pass filter was set as 1.0 Hz to 70 Hz and the notch was kept as 50 Hz to remove the electrical noise., Net Station software was used during recording and analysis was performed in Net Station Tools,

EEGLAB and BESA (Brain Electrical Source Analysis 6.0) tools.

Mobile Phone and Envirochip application

A standard android mobile phone (black) of 2500 mAh battery was used and the Envirochip was fixed at the backside of the mobile phone at the specified location (Figure 1a and Figure 1b; Manufacturer: Syenergy Environics Ltd). The mobile phone was held using the specific band called blindfold next to the left ear of the subjects. The same mobile phone was used for all the participants to eliminate the possibility of any deviation in the subject's conditions. As per the manufacturer, the Envirochip when fixed at a certain location on the electronic devices works by changing the nature (waveform) of emitted RFR from systemic to random, rendering them non-bio-effective and neutralizing the harmful impact of the Mobile Phone radiations on the human body.

Experimental design

Total six sessions were performed for each subject; the average duration of the total protocol was approximately 80 minutes per subject. Five minutes interval was given between any two consecutive sessions to reduce the heat generated by skin contact and the android Mobile Phone and to nullify the effect of accumulated exposures. Normal brain activity was recorded in all the subjects to establish the baseline.

In another session, the baseline was recorded with a Mobile Phone affixed next to the subject's left ear with the help of a blind mask. The same Mobile Phone was used for the whole study. No other wireless apparatus was present in the near field and far-field of the mobile device, no credit / debit cards were kept in the subject's pocket. All the subjects were instructed to remove all the ornaments/ jewelry/ other metals from their body which might affect the recording of the EEG data.

The mobile phone was placed next to the left ear in each case and was held in place with the help of the blind mask. The third and fourth categories of recording involved the Mobile Phone affixed next to the subject's ear while the phone was ringing and in call mode. In both the conditions, EEG was recorded with and without the Envirochip [i.e. ring with Envirochip (RMC), ring without Envirochip (RWC), call with Envirochip (CMC) and call without Envirochip (CWC)];. Rings and Calls were made with another android Mobile Phone. For the measurement of resting state EEG, the recording was performed in a supine position, maintaining the task free state in all the subjects. It was ensured that no other sound was present in the room which might affect the brain activity/EEG of the subject, at the time of testing.

EEG data analysis

After the recording, EEG data was analyzed using Net Station 5.0 tool offline. All prominent artifacts (eye movement, muscle, electrical noise) were detected and removed visually. A total of 20 noise-free epochs (1 second each) were selected. Following this, Independent Components Analysis (ICA) in EEGLAB (Swartz Centre for Computational Neuroscience, San Diego, USA) was performed for the further cleaning of data by removal of electrocardiographic and muscle generated artifacts. Power frequency plots of the selected epochs for different sessions were plotted along with their topographical maps (Figure 2a, 2b, 2c, 2d, 2e and 2f). As a primary outcome of the study, power

1(a) 1(b)

Figure 1 (a) and figure 1 (b): EnviroChip (White and black colour) on the back side of mobile phone.

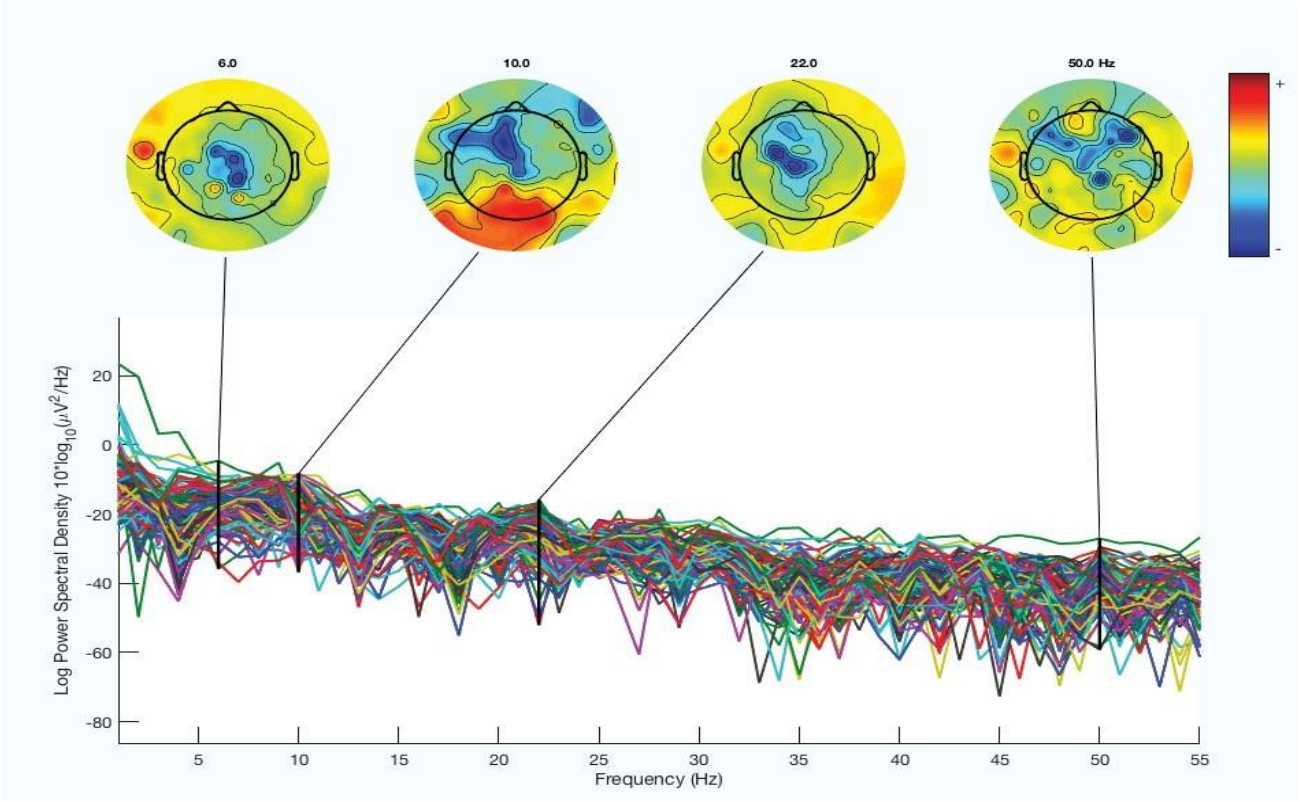

Figure 2a: Baseline data: Activity of Theta (4- 7Hz), Alpha (8-13 Hz), Beta (14-30 Hz), and Gamma (31-70 Hz) bands in all healthy subjects. Blue- least activity Green- low activity Yellow- normal activity and Red- highest activity in brain.

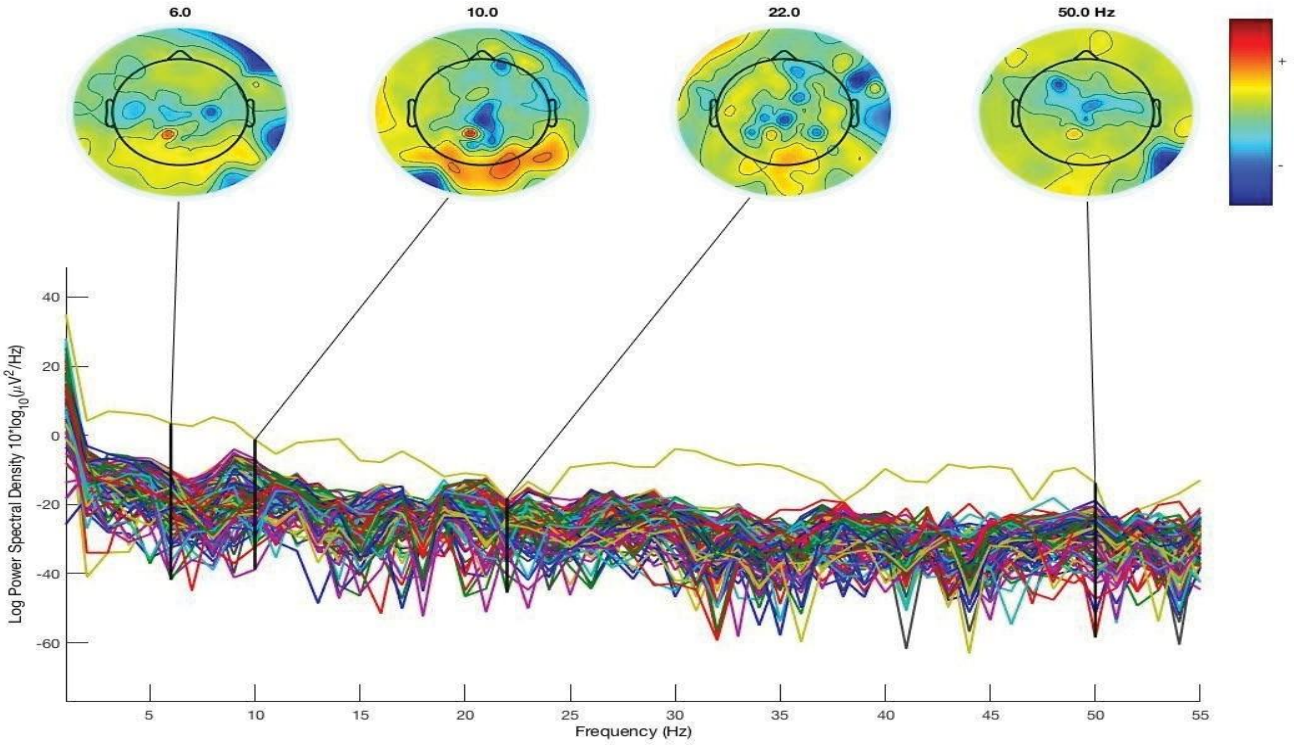

Figure 2b: Activity of Theta, Alpha, Beta and Gamma waves at **baseline with phone** in all healthy subjects. Blue- least activity Green- low activity Yellow- normal activity and Red- highest activity in brain.

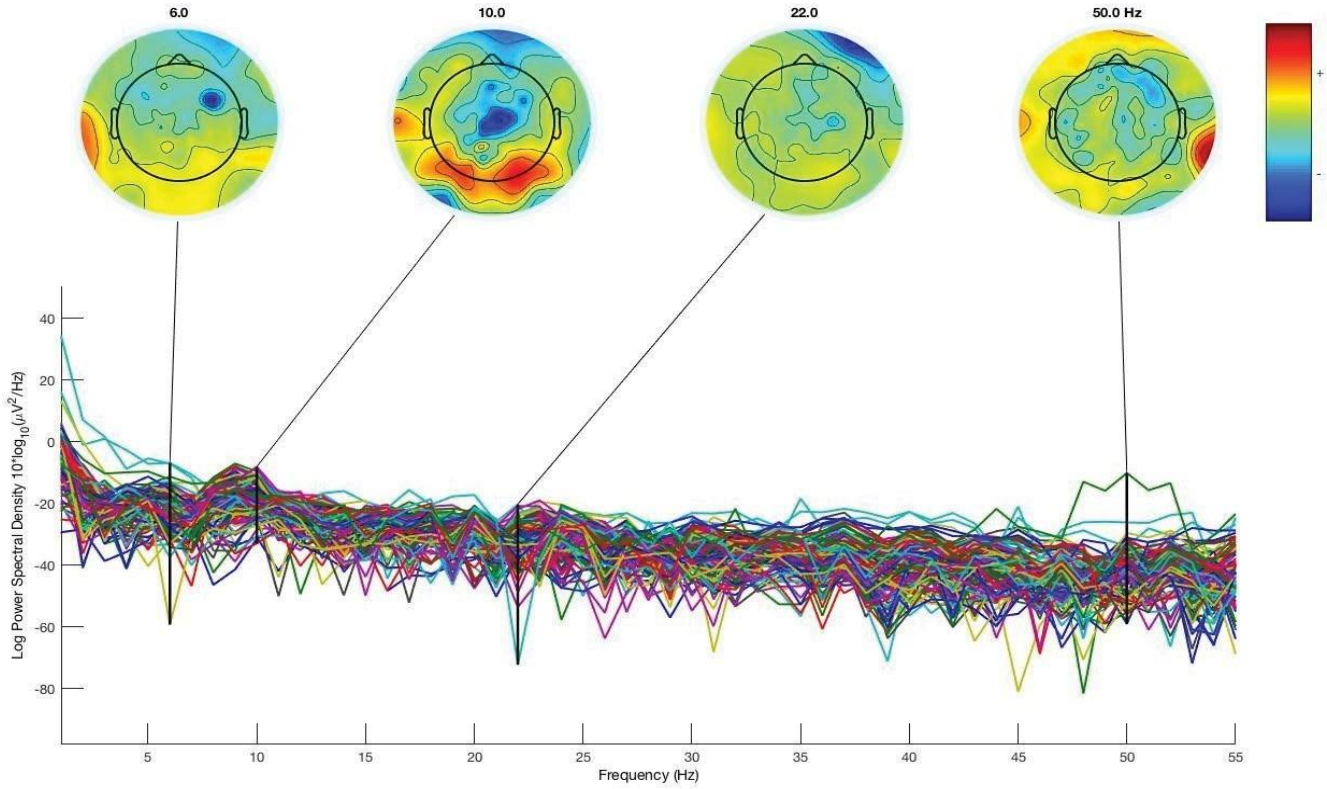

Figure 2c: Activity of Theta, Alpha, Beta and Gamma waves at **Call without Envirochip (CWC)** in all healthy subjects.
Blue- least activity Green- low activity Yellow- normal activity and Red- highest activity in brain.

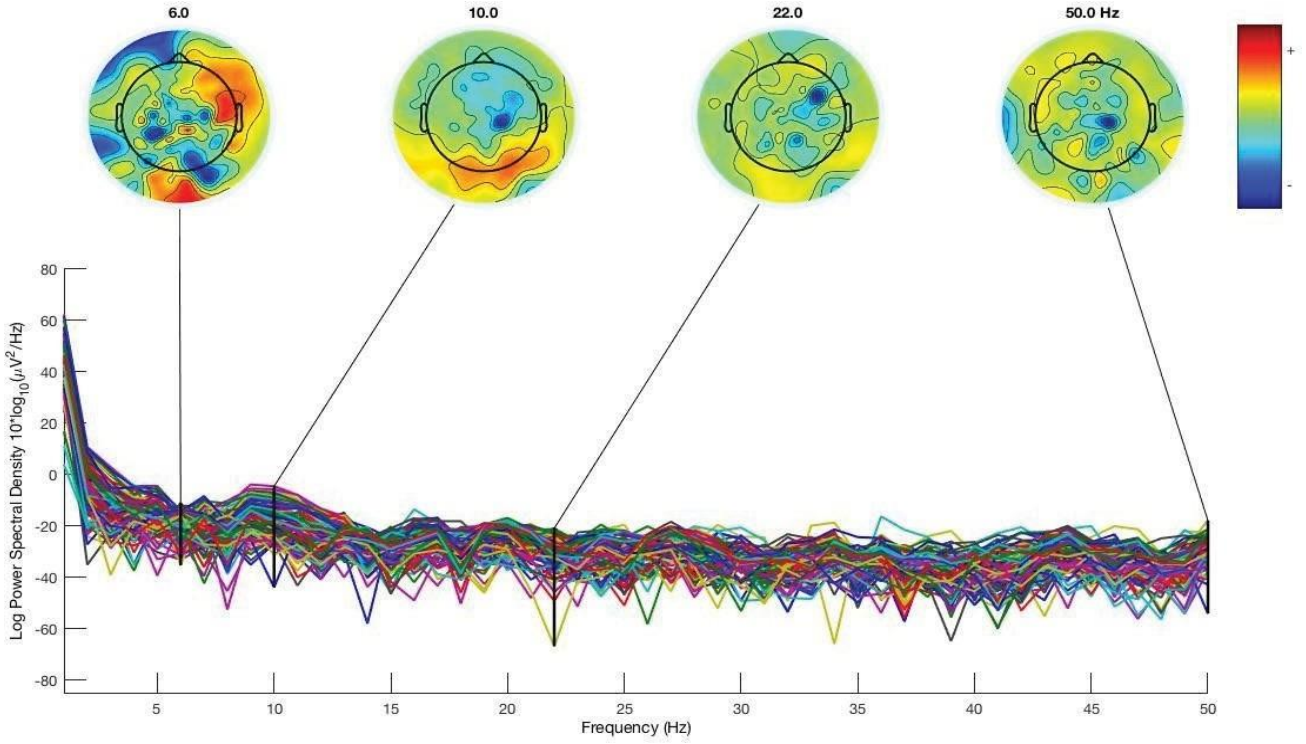

Figure 2d: Activity of Theta, Alpha, Beta and Gamma waves at **Call with Envirochip (CMC)** in all healthy subjects.
Blue- least activity Green- low activity Yellow- normal activity and Red- highest activity in brain.

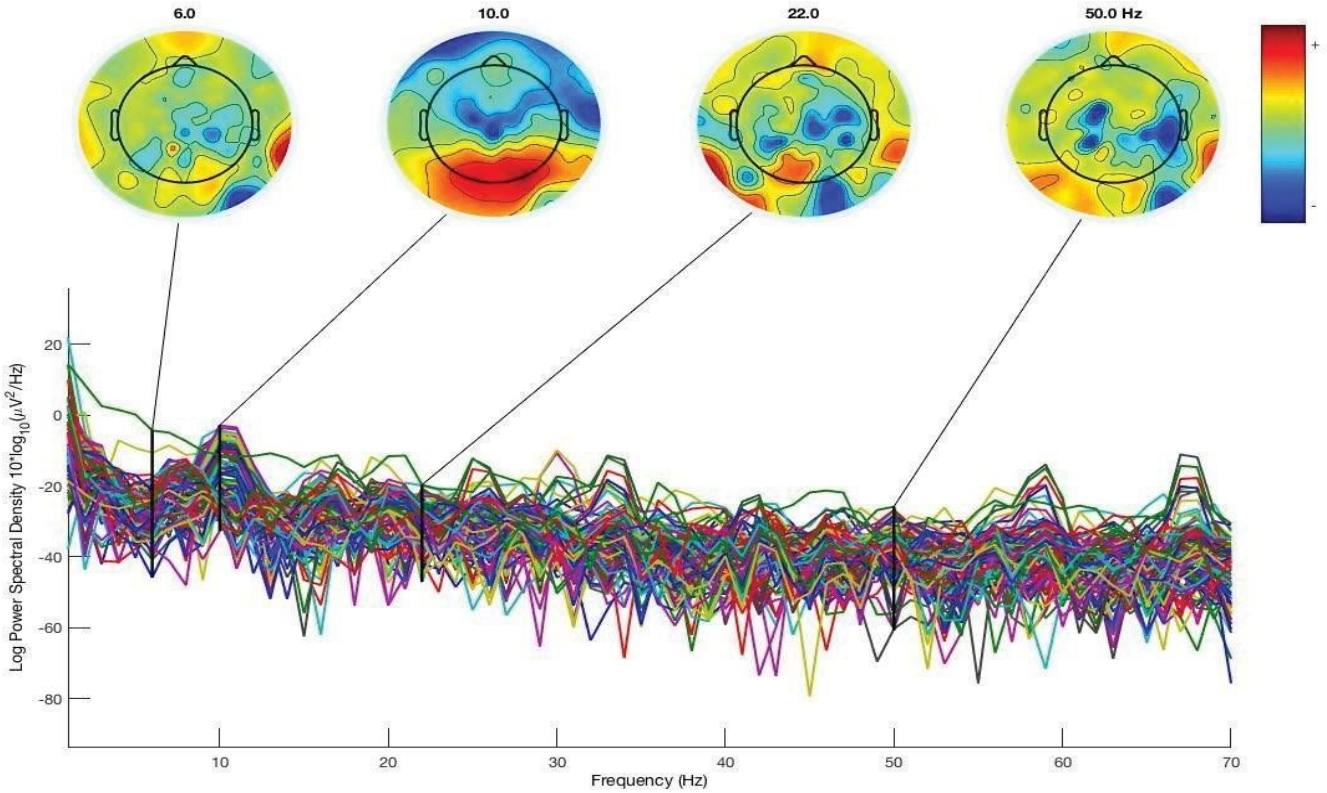

Figure 2e: Activity of Theta, Alpha, Beta and Gamma waves at **Ring without Envirochip (RWC)** in all healthy subjects.
Blue- least activity Green- low activity Yellow- normal activity and Red- highest activity in brain.

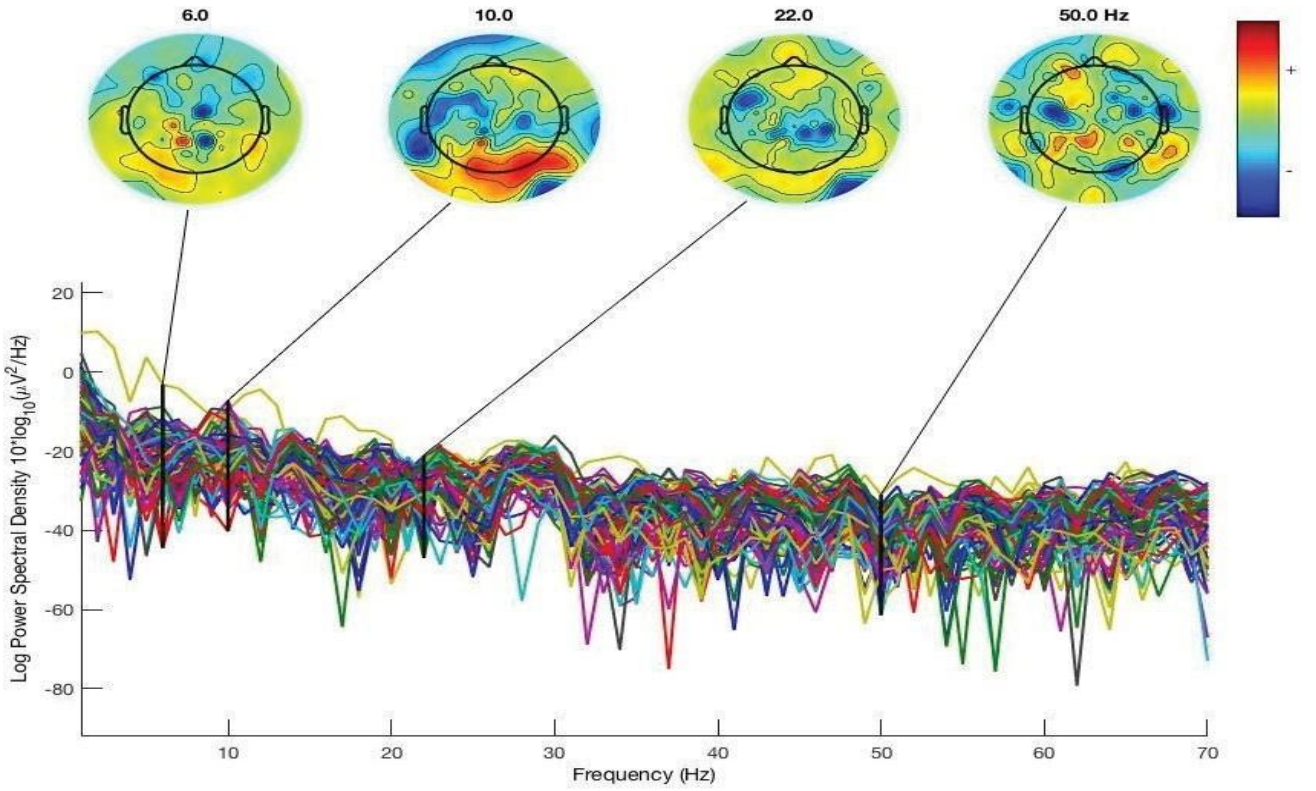

Figure 2f: Activity of Theta, Alpha, Beta and Gamma waves at **Ring with Envirochip (RMC)** in all healthy subjects**.**
Blue- least activity Green- low activity Yellow- normal activity and Red- highest activity in brain.

Variables	Theta Wave				Alpha Wave			
	Median	Minimum	Maximum	P-value	Median	Minimum	Maximum	P-value
Baseline	26.09	9.75	81.47	0.029*	39.08	4.16	180.72	**0.007***
Baseline with mobile phone	26.02	5.06	130.93		31.46	4.48	252.76	
CMC	34.46	13.72	99.58		50.05	9.89	122.67	
CWC	24.58	8.22	104.60		36.97	5.24	93.35	
RMC	28.70	9.61	92.53		45.08	8.54	157.59	
RWC	29.50	12.40	112.37		46.58	7.45	161.25	
Variables	**Beta wave**				**Gamma wave**			
	Median	**Minimum**	**Maximum**	**P-value**	**Median**	**Minimum**	**Maximum**	**P-value**
Baseline	15.45	3.78	31.11	**0.629**	4.41	0.23	8.43	**0.075**
Baseline with mobile phone	15.12	4.21	50.27		3.56	0.13	8.58	
CMC	15.55	7.21	35.68		3.86	0.47	25.35	
CWC	14.41	6.55	72.92		3.57	0.22	6.72	
RMC	17.09	7.23	37.16		4.44	0.78	16.50	
RWC	15.33	6.69	14.05		4.14	0.87	19.14	

Table 1: Power spectrum frequency of different waves (alpha, Theta, Beta and Gamma)
(Data represented as Median (minimum - maximum), CMC =Call with mobile phone chip, CWC=Call without mobile chip, RMC= Ring with mobile phone chip, RWC= Ring without mobile chip, * significant p value<0.05)

Variables	Theta wave		Alpha wave		Beta wave		Gamma wave	
	Z-score	P-value	Z-score	P-value	Z-score	P-value	Z-score	P-value
Baseline vs Baseline phone	-0.530	0.596	-0.31	0.754	-0.724	0.469	-1.730	0.084
CMC vs CWC	-1.676	0.094	-2.97	0.003**	-0.227	0.820	-1.822	0.068
RMC vs RWC	-1.070	0.284	-1.957	0.050*	-1.708	0.088	-0.519	0.604
Baseline vs CMC	-2.768	0.006**	-0.94	0.347	-0.811	0.417	-0.410	0.682
Baseline vs CWC	-0.616	0.538	-1.005	0.315	-0.141	0.88	-0.133	0.184
Baseline vs RMC	-0.876	0.381	-1.91	0.056	-1.287	0.198	-0.876	0.381
Baseline vs RWC	-0.746	0.456	-0.789	0.430	-0.205	0.837	-0.411	0.681
Baseline_phone vs CMC	-2.087	0.037*	-1.26	0.206	-1.135	0.256	-1.297	0.194
Baseline_phone vs CWC	-0.951	0.341	-0.162	0.871	-0.249	0.804	-0.119	0.905
Baseline_phone vs RMC	-1.762	0.078	-1.957	0.050*	-1.524	0.127	-1.546	0.122
Baseline_phone vs RWC	-1.654	0.098	-1.049	0.294	-0.357	0.721	-1.654	0.098

Table 2: Comparison between baseline to baseline-phone, CMC to CWC and RMC to RWC.
(Data represented as Z score. vs= versus, CMC =call with mobile phone chip, CWC=Call without mobile chip, RMC=Ring with mobile phone chip, RWC=Ring without mobile chip, ** highly significant (p<0.005), * significant p value<0.05)

spectral analysis of different bands (theta, alpha, beta and gamma) was performed using Fast Fourier Transformation (FFT) algorithm. The FFT was performed using the Brain Electrical Source Analysis software package (BESA 6.0). The data was analyzed by differentiated assessment of the EEG frequencies in the theta (4- 7Hz), alpha (8-13 Hz), beta (14-30 Hz), and gamma (31-70 Hz) bands.

Statistical analysis

The statistical analysis was performed using Sigma Plot (version: 13.0, SYSTAT Software Inc., Chicago, USA). Shapiro-Wilk test was used to check the normality of the data. As the data was skewed, the Friedman test was applied to compare more than two parameters in a group while the Wilcoxon rank sum test was used to compare the difference and changes between two variables. A significance level ($p< 0.05$) was set for all the statistical analyses.

Result

Out of 30 subjects, 29 subjects (10 (34.5%) females and 19 (65.5%) males; age: 26.48±5.95) were taken for the final analysis. One subject was excluded due to excess electrical noise in more than half of the channels. The frequency of all the bands (theta range: 4-7 Hz, alpha range: 8-13 Hz, beta range: 14-30 Hz, Gamma range: 31-70 Hz) was taken for the final presentation. Data was pooled and demonstrated the mean of all the conditions as a baseline, baseline with a mobile phone, RMC (Ring with Envirochip), RWC (Ring

without Envirochip), CMC (Call with Envirochip) and CWC (Call without Envirochip). A total of six conditions were checked to analyze the significant impact of the Mobile Radiations on brain activity and the efficacy of Envirochip in correcting the same.

Comparison between all conditions of theta waves

In this study, we have found significant changes (p=0.029; Table 1) between all the six conditions for theta wave activity of all the participants. When we compared normal baseline and baseline with the phone to CMC (call with Envirochip), significant changes were observed between them (z= -2.768; p=0.006 and z=-2.087; p=0.037; Table 2) respectively. No significant results were observed in any other condition as shown in Table 2. Graphical representation with the specific frequency range (at 6 Hz) has been shown in Figure 2a, 2b, 2c, and 2d as a baseline, baseline with the phone, CWC (call without Envirochip) and CMC (call with Envirochip) respectively and the figure depicts the association of brain activity in the particular theta range. Detailed data of mean and standard deviation of all the conditions are shown in Supplementary Table 1 and Supplementary Table 2.

Comparison between all conditions for the alpha wave

We have compared all the conditions for the alpha wave and found highly significant changes (p=0.007; Table 1) between all the six conditions. While comparing CMC (call with Envirochip) and CWC (call without Envirochip), we found highly significant changes between these two (p=0.003; Table 2). Also, we found significant changes between RMC (ring with Envirochip) and RWC (ring without Envirochip) and between baseline with Phone and RMC (ring with Envirochip) conditions. (Table 2). Figures 2a, 2b, 2c, 2d, 2e and 2f represent the specific frequency range at 10 Hz which was associated with alpha brain activity. Detailed data of mean and standard deviation of all the conditions are shown in Supplementary Table 1 and Supplementary table 2.

Comparison between all conditions for beta and gamma waves

There were no significant changes in the beta wave when we compared all the conditions within the group (p=0.629; Table 1 and Table 2) while the gamma frequency band showed a trend towards significance in within-group comparison (p=0.075; Table 1). We also compared two groups to see the changes in beta and gamma wave, we found some trend toward significance between RMC (ring with Envirochip) and RWC (ring without Envirochip) (p=0.080; Table 2) in the beta band and between CMC (call with Envirochip) and CWC (call without Envirochip) (p= 0.068; Table 2) in theta band activity graph as shown in figure 2a,2b,2c, 2d, 2e and 2f at 22 Hz and 50 Hz respectively. However, none of the changes were statistically significant in the Beta and gamma band. Detailed data of mean and standard deviation has been shown in the supplementary table 5.

Discussion

The increase in brain activity in alpha and theta bands indicates enhanced excitability of the brain during Radiofrequency exposure from the Mobile Phone. The subjects received six exposures with an interval of 5 minutes between each measurement and the same Mobile Phone was used to analyze the difference in the results. Several experiments, empirical observations and evidence establish that radiations emitted from Mobile Phones pose serious threats to human health and cognitive functions [14-16]. The results of this study demonstrated that RFR emitted by Mobile Phones can be the reason for the changes in brain activity. It was also demonstrated that the application of Envirochip on the Mobile Phone can reduce the increased brain activity mainly in alpha and theta bands induced by RFR exposure from the Mobile Phone. The results of the present study have the same findings as previous EEG studies in the research field confirming and extending their observations. Previous research has shown increases in alpha activity by EMF exposure [17]. Further, the alterations in the theta waves demonstrated here also the confirm results of the previous studies [11].

Conclusion

The present study revealed that prolonged exposure to the Radiofrequency Radiations emitted by Mobile Phones can affect brain activity and Envirochip has the potential to reduce the excitability in alpha and beta bands. However, this was just a primordial study interpreting conclusively the changes in brain waves by radiation and, hence, effects of Enviro Chip warrant further study using several other indices of human health and a large study population.

The findings of the present study are important for today's working environment as Mobile Phones have become an essential part of our daily life. Seeing that their use has increased considerably, the dimensions of the problem are more. Since we can't stop using technology to our advantage, we have to find ways to protect ourselves from harm.

It is also suggested to read the Mobile Phone's manuals, use hands free and follow the recommended talk time and distance guidelines mentioned in the Mobile Phone manual.

Declarations

Availability of data and materials

All data are included in the manuscript.

Competing interests

The authors declare no competing interests.

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