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Mitigating human health exposure on radio frequency smog base station.

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Abstract

In modern era, communication technologies need a significant development. Nowadays, the massive pollution caused by Radio Frequency Electromagnetic Field (RF-EMF) radiation is considered as the greatest environmental hazard. Hence, the present analysis proposes a suitable solution to mitigate the Radio Frequency (RF) pollution or smog due to base station installation in hot spot areas. On the basis of mitigating the Radio Frequency (RF) frequencies, an extensive amendment has to be made on the design of base station, decrease of signal transmission between the entities and distance. Further, heterogeneous networks security will increase the signalling transmission of user authentication. This paper analyses the disaster occurring in human health owing to Radio Frequency (RF) field interference taking place in Small Cell Base Station (SCBS). Also it limits the span of the electromagnetic field interference among base station and Authentication, Authorization, and Accounting (AAA) server. On the basis of authentication, it also focuses the reduction of communication signal transmission between the entities. It also describes the performance metrics of base station which mainly depends on power consumption for transmission and reception, radiation pattern, distance between the entities and the message transmission that leads to vast decrease the R. F. smog and interference.

Keywords: Radio frequency, Electromagnetic field, Mobile base station, Human health care, Authentication signal reduction.

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Introduction

The all over the world, long term exposure due to base-station Radio Frequency Electromagnetic Field (RF-EMF) radiation has been recognized as serious health concern. Research efforts have increased in response to complaints from public and recommendation from World Health Organization's (WHO's), all government sectors announced limitation of usage frequencies against the base-station installation. Numerous solutions have been given to meet heterogeneous wireless communication demand.

This analysis discusses the adverse effects of Radio Frequency Electromagnetic Field (RF-EMF) interference in Small Cell Base Station (SCBS) particularly in hot spot areas.

Therefore, these networks automatically regulate the transmitter power in the base station based upon the users distance. If the base-stations are situated nearer to the user, then it would produce the low level of electromagnetic field, while far away from user, it produces high level electromagnetic field. Similarly, when the base stations are situated nearer to the mobile phone users, the transmitter power required by the mobile phone is low. If base stations are situated far away from the user, then the power required is generally higher, and produces higher electromagnetic field [1,2]. Hence, nearer the base station, lower the electromagnetic field and better the reception. Several previous studies conducted earlier reported that base stations works at lower power that leads to low interference of Radio frequency (RF) pollution. Further, the electromagnetic field level also low in the base stations which is similar to broadcast television and radio.

This paper evaluates the interference of Radio Frequency (RF) from mobile base stations and their adverse effect on human beings. Various studies [3-5] have identified that these Radio Frequency (RF) fields could cause carcinogenic to human. Even though various study have stated the adverse effect, there is no previous evidence of environmental exposure to Radio Frequency (RF) fields comes from base stations may enhance the cancer risk or any other risk. The radio frequency affected the normal biological cells of the individual by inducing the electromagnetic effects at increase in temperature. These effects are attributed to the induced electromagnetic inside the biological cells of the body which is possibly more harmful. Individuals who are living nearer to the base station or frequently exposed to the emissions of low level wireless antenna have felt various severe symptoms at the time and after

its use such as fatigue, dizziness, ringing in the ears, headache, heart palpitation, tingling sensation in the skin of the head, burning, loss of memory, sleep disturbance, lack of concentration, reaction time and disturbance in the digestive system etc. The interference of base station electromagnetic waves and some medical devices are reducing the risk in newer design of small cell coverage. Since the cellular base stations are successfully extenuating radio frequency signal interference through thoughtful radio system knowledge with proper cell planning, frequency and bandwidth allocation. Methodology of this paper proposes the protocol based on Small Cell Base Station (SCBS) network which has been widely recognized as a solution to effectively reduce the radio frequency pollution and power consumption. This will support in attaining the spectral efficiency goal and depletion of radio frequency pollution by solving the 'capacity hotspot' problem where there is a high level of subscriber concentration (Figure 1).

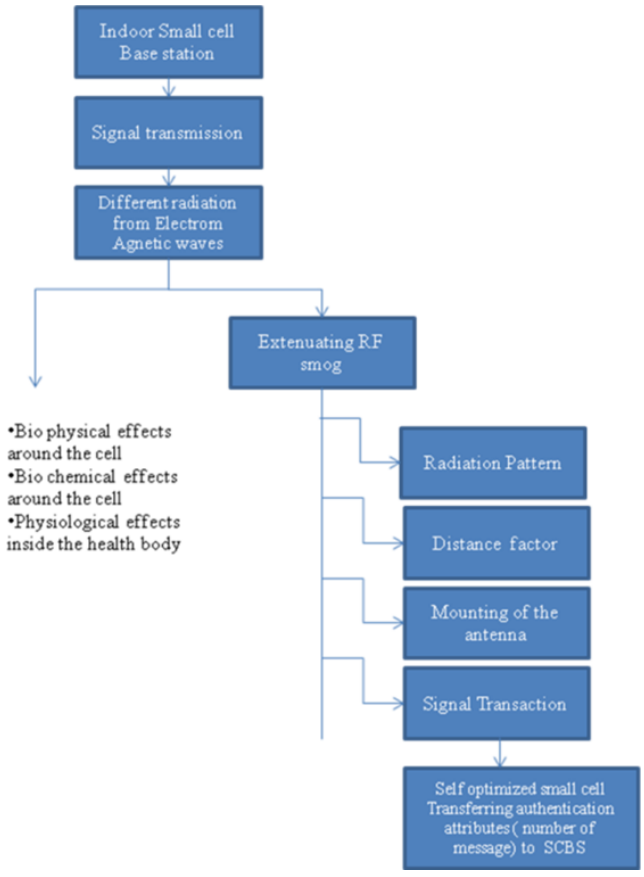

Figure 1. *Reduction of Radio Frequency (RF) impact from signal transmission.*

Radiation Effects and Electromagnetic Field Emissions

Generally, radiation is exhibited by both man-made and natural radiation and they are electromagnetic in nature. In general, there are two categories of electromagnetic radiation which includes the ionizing and non-ionizing radiation. From the research it is evident that the ionizing radiation has a capability to eradicate the electron which is from the atom's orbit of an atom, where it becomes an ionized atom to cause health hazard [6]. For instance, X-rays are perceived as ionized material due to high electromagnetic field frequency [7-9]. However, in the case of non-ionizing radiation it lacks sufficient energy to ionize the atoms. Some of the non-ionizing radiations are microwave radiation visible light and radio wave frequency energy [10-12].

In the current technological world, the society depends on mobile phones for communications purpose at work, school and home. These mobile phones generate the electromagnetic waves like X-ray and visible light. However, the range of electromagnetic radiation falls between non-ionizing and ionizing ranges of frequency, especially for mobile communication can be in the range of 450-2200 MHz but energy is directly proportional to the wave frequency.

Due to absorption of energy, Radio Frequency (RF) fields ranged from at a lower level of 10 GHz to 1 MHz exposed into tissues and give heating. The penetration depth based on the frequency of the field and is greater for lower frequencies. Specific Absorption Rate (SAR) is the quantity used to measure the absorption of Radio Frequency (RF) energy within a given tissue mass and it is expressed in units of watts per kilogram (W/kg or mW/Kg) [13,14]. The quantity of Radio Frequency (RF) fields between about 1 MHz and 10 GHz is measured using specific absorption rate. People who are exposed to Radio Frequency (RF) fields in the specific absorption rate at 4 W/kg, produces several adverse health effects. Similarly, the range at 10 GHz of Radio Frequency (RF) fields are absorbed at the surface of the skin, only few energy enter into the deepen tissues, while the above 10 GHz of Radio Frequency (RF) fields exposed at power densities over 1000 W/m^2 produces severe health effects like skin burns and eye cataracts.

Potential Bio-effects of Exposure to Microwave/ Radio Frequency (RF) Radiation

It deals with the biological entities and electromagnetic fields [6,15,16]. In the human body, more number of molecules weakly interacts with low frequency bands or electromagnetic field in the Radio Frequency (RF). One such interaction is energy absorption from the fields that may cause tissue to high degree of temperature; many intense fields will give higher heating that leads to several biological effects ranging from muscle relaxation (as produced by a diathermy device) to burns. There is a difficulty to prove the electromagnetism direct effects on human health and reported life-threatening interferences from electromagnetic field are limited to medical devices such as electronic implants, pacemakers and others.

Generally more biological effects of exposure to radio frequency/microwave radiation are related to heating of tissues which is commonly referred as "thermal effects", mainly due to the Radio Frequency (RF) energy ability to heat biological tissue [17-20]. However, the evidence of harmful biological effects is unproven. Non-thermal effects have been proved in animals such as teratogenesis, carcinogenesis etc. but not tested

on humans. Some of the biological effects are tested in humans are burns from contact with spectacles, metal implants Radio Frequency (RF) (induction) burns, formation of cataract (from eye exposure).

The role of long-term revelation to high radio frequency radiation emitted either from mobile phones or from base stations and its relations with human's hormone profiles [21-23]. This radiation effects on pituitary-adrenal axis represented in the reduction of Adrenocorticotropic Hormone (ACTH), cortisol, thyroid hormones, prolactin in young females, and testosterone levels.

Pulsed microwave radiation used in base station of cellular device can non-thermally affect these various biological (electrical) activities and provoke adverse health reactions [24-26]. Weak radiation can entail only correspondingly weak effects, and vice versa. To be more specific it was identified that these radiations cause adverse effect to human brain functioning, especially these affect the electro-chemistry and electrical activities in human body, degrades the immune system and other health reactions [27,28]. Moreover, these effects were experience by extensive mobile phones user and other who are subjected to long-term radiation exposure from black smoke.

Furthermore, the studies have identified that these microwave radiation cause a serious damage to hippocampus region of the brain which results in memory loss related issues and some children had neural problems like epileptic seizures [29,30]. In this technique targeted the photosensitive human sampled where every 15-20 times per second the light was flashed which provoked the seizures in the five percentage minimum of epileptics.

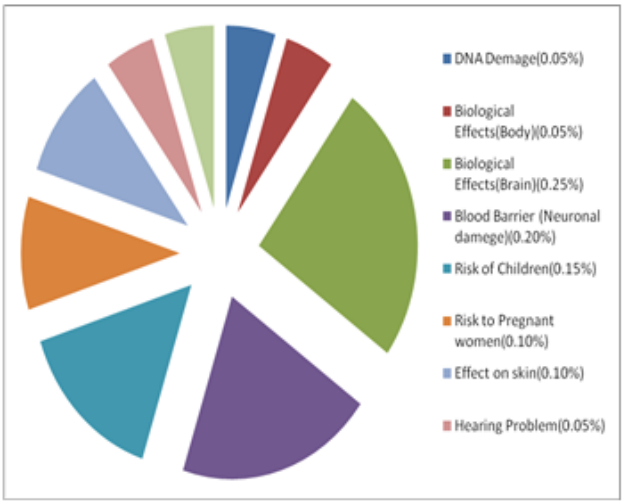

Figure 2. *Human health hazard from Radio Frequency (RF) interference.*

From the Figure 2, it is evidence from both animal and human studies on association between exposure and outcome seems to be insufficient and inconsistent. This is perhaps due to the methodological challenge involved in distinguishing between exposed Radio Frequency (RF) [3] field from base station and characterize the high and low Radio Frequency (RF) signals in the environment [4,17]. Despite the fact that few studies of electromagnetic field research have identified changes in behaviour, cognition and brain wave patterns after exposure to Radio Frequency (RF) fields produced by mobile phones. However, there is lack of convincing evidence about cardiovascular function or altered sleep pattern. Few individuals have felt the non-specific symptoms during the exposure to Radio Frequency (RF) fields produced from electromagnetic field devices, and base stations. In spite of that, there is a necessary to understand the individual's difficulty from these symptoms.

Small Cell and Interference Mitigation

The term Small Cell (SC) is known as the minimum powered radio access nodes that range from 10 m to 2 km. These access node function both in licensed as well as unlicensed spectrum. Small cells comprises of microcells, picocells and femtocells. The Microcells and Picocells have also in the range of a few hundred meters to kilometers, but they vary from femtocells in that they do not always have self-management and self-organising abilities. These Small Cells (SCs) are small in size when compared to the microcells in mobile phones with a range of ten or more than ten kilometers. Hence, these remains as constraint to the mobile operators as these operators are struggling highly to improve due to the mobile data traffic. Even though these are considered to be ineffective users or the operators still consider the mobile data offloading as the most efficient way of the radio spectrum. However, to some degree these network operators have evaded with an economic growth and encouraged the adoption of Wi-Fi both in office and home, 3G was the redesign of 2G spectrum and in later stage the Long-Term Evolution (LTE) was introduced an additional spectrum. Moreover, these Small Cells (SCs) are considered to be the most important element to 3G data offloading and other researcher consider that these Small Cells (SCs) are important during Long-Term Evolution (LTE) advanced spectrum management most effectively in comparison to other macro cells.

The best approach to using Long-Term Evolution (LTE) networks by operators is Small cells (SCs), especially femtocell. A Long-Term Evolution (LTE) femtocell station is mentioned to as the Home eNode B (HeNB). This is an efficient method to increasing the capacity of the cell and coverage of indoor. The important issue in the present femtocell deployment is the interference of cross-tier between adjacent Home eNode B (HeNB) and users of macrocell. The interface mitigation can be achieved if the base station is designed in such a way that in the network every cell must perform well with a reduced congestion, good signal, or no call drop [31].

Energy Distribution-Base Station

The network operators have turned out to concentrate more on Small Cell Base Station (SCBS), due to the following reasons:

Good energy resource, for the growth of wireless communication. This energy consumption of base-stations will give different opportunities for future heterogeneous networks. Radio equipment dominated the energy consumption of a Future Heterogeneous Base Stations (FHBS).

Hence, to reduce the energy consumption of the radio equipment efficiently, it is essential to quantify the energy consumption over the different radio equipment components and to focus on the main consumers.

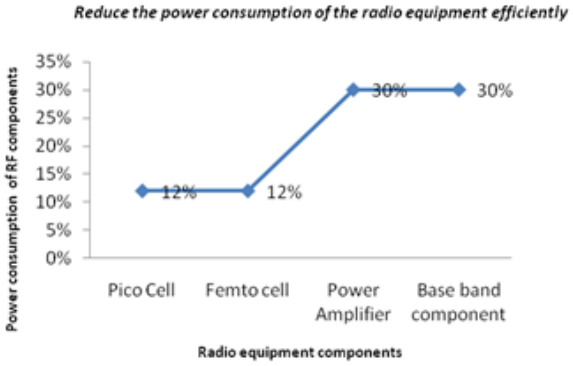

Figure 3. *Reduction of radio equipment efficiency.*

From the Figure 3, normally, base-stations are designed for maximal traffic load and high variations in the power saving parameter. To evaluate the performance of utilizing base station traffic load many parameters were adopted. From the figure, it is illustrated that the variation of base station depends on various aspects like heavy traffic period, medium traffic, heterogeneous interference period and sleep mode period.

Table 1. *Path loss vs. various distances.*

CDMA (850 and 890 MHz)			
RSSI (dBm)	**Path loss (Db)**	**RSSI (dBm)**	**Path loss (Db)**
1.94925	37.05075	1.54983	37.45017
-6.00955	45.0095	-6.40897	45.40897
-11.115	50.115	-11.5144	50.51442
13.6138	52.61378	-14.032	53.0132
-15.552	54.55198	-15.9514	54.9514
GSM 900-900 and 960 (MHz)			
1.45278	37.54672	0.8922	38.1078
-6.50602	45.50602	-7.0666	46-0666
-116115	50.61147	-12.1721	51.17205
-14.1103	53.11025	-14.6708	53.67082
-16.0485	55.04845	-16.609	55.60902
GSM 1800-1800 and 1880 (MHz)			
-4.56782	43.56782	-4.94553	43.94553
-12.5266	51.52662	-12.9043	51.90433
-17.6321	56.63207	-18.0098	57.0097
-20.1309	59.13085	-20.5086	59.50855
-22.0691	61.06905	-22.4468	61.95745
3G (2100 and 2170 MHz)			
-5.90676	44.90676	-6.19157	45.19157
13.8656	52.86556	-14.1504	53.15037
-18.971	57-97101	-19.2558	58.25582
-21.4698	60.46978	-217546	60.75456
-23.4079	62.40798	-23.6928	62.69279

RSSI: Received Signal Strength Indicator; dBm: Decibels; Db: Decibels.

From Table 1 both the transmission and reception power of base station depends on the strength of a Radio Frequency Electromagnetic Field (RF-EMF). Since multiple channels are present in the base station, worse affect the signal transmission, power and frequency of transmission.

Small Cell Base Station Interference Reduction

Small Cells Base Station (SCBS) gives flexibility and improved the capabilities of Quality of Service (QoS) at an attractive cost. The implementation of infrastructure of small cell provides the eco-friendly environment that decreases the cell towers (maybe even eventually eliminate them) and it gives a clean signal with low power. The intensity of Radio Frequency (RF) radiation from the mobile phones is higher than base stations, but less than the local television and radio stations at the ground level.

A typical base station has several transceivers allowing operation in several different frequencies (Ultra High Frequency (UHF)/Very High Frequency (VHF)) and different technologies Code Division Multiple Access (CDMA), Global System for Mobile communication (GSM), 3G, 4G, and futuristic 5G directions of the cell in the system. Finally, another issue to be taken into account is the public opinion worrying about the multiplication of radio transmitters in the neighbourhood and inside living areas. People are more and more complaining about the multiplication of cellular transmitters near their home. In many countries, a mood of suspicion about radio waves is noticeable, and more and more lawsuit is brought against the installation of base station.

Reduction in signalling messages

Several techniques have been adopted for selecting serving base stations for a wireless communication network user. The present review proposed a communication protocol called Extensible Authentication Protocol Method for 3rd Generation-Authentication and Key Agreement (EAP AKA') for a multiple candidate Base Station (BS) for identifying the user, with each user base station being a candidate for selection as the serving base station for the terminal.

From the Figure 4, the main beam the radio frequency field's inner portion much stronger than outside due to the narrow beam pattern a person exposed to radio frequency field experiences the radiation's adverse effect and the degree of exposure is estimated based on the distance and main beam direction. In many base stations, the strength of the signal near the ground level gradually increases with distance from the tower and attains maximum strength between 50-200 meters from the tower bottom, and further reduces at still considerable distances. In all the bottom places, there is a low level of signals in compared to regulatory guidelines.

Population exposure of radiation pattern in small cell base station generally depends on the power, antenna type and distance. In the case of indoor Future Heterogeneous Base Stations (FHBS), special type of antennas are used as its position, angle elevation and the directivities are different from other normal type antennas that leads to low production of radiation energy. In wireless communication various optimal exposure guidelines have been proposed that includes co-channel base station interferences produced a Maximum Permissible Exposure (MPE) limit. Sometimes this limit exceed by uncontrolled access of public due to different antennas are used for distinct services. Therefore, clear safety analyses are necessary to examine the compliance. The important objective of the radio frequency exposure standards is to suppress the exposures on biological effects of electromagnetic fields and also decrease the severe human health hazards. Earlier researches carried out the short term electromagnetic field exposure in animals but sometimes using high power exposure. Even though only few humans and animals studies used the long term exposure of electromagnetic field. Studies reported previously on deleterious effect of radio frequency are mainly due to high level of heating. A different guidelines of exposure included safety factors to maintain the low levels of exposure which caused the hazardous effects to humans.

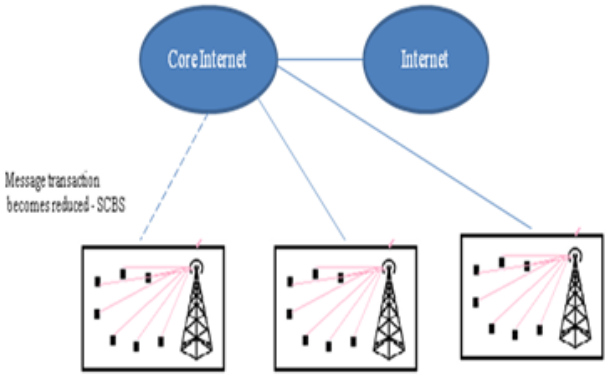

Figure 4. *Message signal reduction.*

Signal Transmission Reduction

To reduce the message transaction between wireless communications, results less interference from radio frequency. There are two types of handovers inter cell and intra cell communication. Once the small cell base station is placed inside the area of the required environment, not required or unused areas are unaffected from the harmfulness. Before data transfer, the small cell access point or Future Heterogeneous Base Stations (FHBS) mutually authenticated from user equipment and the access network. If the authentication message transaction is more, then the radio frequency interference impact is also high in the public areas.

Proposed Communication Protocol Description

The nature of the self-optimized, cooperative ability of small cell base station gets the acknowledgement from core network Home Subscriber Server (HSS) and User Equipment (UE). After the mutual authentication signal International Mobile Subscriber Identity (IMSI) of the User Equipment (UE) is transferred to Small Cell Base Station (SCBS). Computational algorithm with key, cryptographic hash generation and verification were done in the base station itself. Consequently the numbers of messages during authentication were reduced, thereby reducing signal transmission and radio frequency exposure.

Formal verification of authentication protocol will use Arduino tool to verify the authentication protocol signalling flow. It is a tool for routinely analysing the authentication protocol and running on a quad co-processor 4 GB memory computing device.

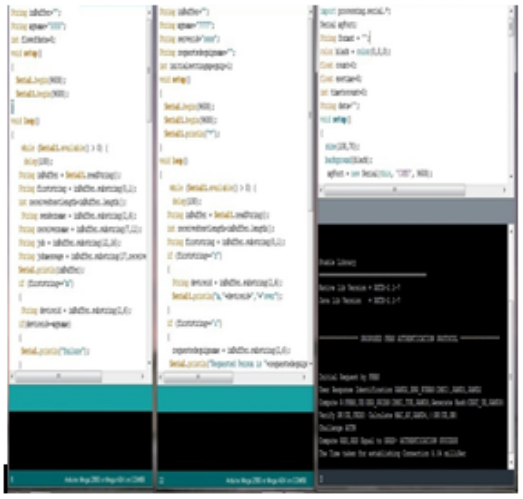

Figure 5. *Verification of authentication protocol between UE, BS and home network-authentication success.*

From the Figure 5, it clearly visualized that the signal transmission between Future Heterogeneous Base Stations (FHBS), user equipment and home network. Authentication signal flow would negotiate key generation computation of hash algorithm. It reduces the delay on the link and reducing transmission time interval compared to other networks.

The authentication protocol between Small Cell Base Station (SCBS) and User equipment (UE) allows rapid re-transmissions of received data, reducing the number of radio link messages and the associated delay. This can lower the number of electromagnetic field interferences the health hazard

from radio link messages, thus increasing the efficiency of the network as a whole.

It is observed that the proposed method reduces signal transaction between Authentication, Authorization, and Accounting (AAA) server and base station with respect to data rates and corresponding messages. Using automatic data configuration and intelligent algorithm, the centralized network management system in small cell bass station, provides reauthentication without the intervention of home server.

Conclusion

It is concluded that authentication protocol used in Future Heterogeneous Base Stations (FHBS) reduces the human health hazard from radio frequency interference aspects.

This paper dealt the thorough analysis of energy requirement (Received Signal Strength Indicator (RSSI)) and path loss characteristics of heterogeneous networks. The performance characteristics of Future Heterogeneous Base Stations (FHBS) transmission density have much influence on throughput and energy efficiency of the network. Future studies need to be accomplished to prove this empirically.

It is assumed that the proposed authentication signal flow would reduce the signal transmission; thereby the radio frequency exposure between base station and home server is reduced significantly. However, future studies need to be conducted to prove this empirically.

Summarizing the above points, it can be affirmed that the developed mechanism can provide a high level of security guarantee in the interworking networks concerning the human health hazard as well. In addition this proposed algorithm is simple and robust.

It also offers effective security with minimal changes implemented compared to the existing infrastructure to achieve healthy measures in heterogeneous networks.

References

1. Gavan J, Tapuchi S. Mitigation techniques for enhancing mobile radio EMC performances. IEEE Trans URSI 2011; 1-4.
2. Hyland GJ. Potential adverse health impacts of mobile technology. Uni Warwick Int Inst Biophys 2000.
3. Luiis GN, Newry RJ, King BV, John AR. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. PLoS One 2009; 4: 6440-6446.
4. Mousa A. Electromagnetic radiation measurements and safety issues of some cellular base stations in Nablus. J Eng Sci Technol 2011; 4: 35-42.
5. Mobile phones-safety problems, Physicians and scientists for responsible application of science and technology. PSRAST 2014.
6. Rubin GJ, Nieto-Hernandez R, Wessely S. Idiopathic environmental intolerance attributed to electromagnetic fields (formerly electromagnetic hypersensitivity): An updated systematic review of provocation studies. Bioelectromagn 2009; 31: 1-11.
7. Cuadras A, Gasulla M, Ferrari V. Thermal energy harvesting through pyroelectricity, sensors and actuators. Phys J 2010; 158: 2010.
8. Atli E, Unlu H. The effects of microwave frequency electromagnetic fields on the development of Drosophila melanogaster. Int J Radiat Biol 2006; 82: 435-441.
9. Balmori A. Possible effects of electromagnetic fields from phone masts on a population of White Stork. Electromagn Biol Med 2005; 24: 109-119.
10. Beason RC, Semm P. Responses of neurons to amplitude modulated microwave stimulus. Neurosci Lett 2002; 333: 175-178.
11. Belyaev IY. Nonthermal biological effects of microwaves-current knowledge, further perspective and urgent needs. Electromagn Biol Med 2005; 24: 375-403.
12. Bernhardt JH. Non-ionizing radiation safety: Radiofrequency radiation, electric and magnetic fields. Phys Med Biol 1992; 37: 807-844.
13. Roosli M, Hug K. Wireless communication fields and non-specific symptoms of ill health: a literature review. Wien Med Wochenschr 2011; 161: 240-250.
14. World Health Organization (WHO). What are the health risks associated with mobilephones and their base stations? 2005; 12-15.
15. Roosli M, Frei P, Mohler E, Hug K. Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phone base stations. Bull World Health Organ 2010; 88: 887-896.
16. Salford L, Henrietta N, Arne B, Gustav G. The mammalian brain in the electro- magnetic fields designed by man with special reference to blood brain barrier function, neuronal damage and possible physical mechanisms. Prog Theor Phys Suppl 2008; 173: 283-309.
17. TarusawaY, Ohshita K, Suzuki Y, Nojima T. Experimental estimation of EMI from cellular base-station antennas on implantable cardiac pacemakers. IEEE Trans Electromagn Comp 2005; 47: 938-950.
18. Albert EN. Light and electron microscopic observations on the blood-brain barrier after microwave irradiation. HEW Publ 1977; 294-304.
19. Armstrong B. Association between exposure to pulsed electromagnetic fields and cancer in electric utility workers in Quebec, Canada and France. Am J Epidemiol 1994; 140: 805-820.
20. Balcer-Kubiczek EK, Harrison GH. Neoplastic transformation of C3H/10T½ cells following exposure to 120 Hz modulated 2.45 GHz microwaves and phorbol ester tumour promoter. Radiat Res 1991; 126: 65-72.
21. Bawin SM, Kaczmarek LK, Adey WR. Effects of modulated VHF fields on the central nervous system. Ann NY Acad Sci 1975; 247: 74-81.
22. Blackman CF. Genetics and mutagenesis. US Env Protect Ag Res NC 1984; 94-105.

23. Bortkiewicz A, Zmyalony M, Gadzicka E, Paaczyaski C, Szmigielski S. Ambulatory ECG monitoring in workers exposed to electromagnetic fields. J Med Eng Technol 1997; 21: 41-46.
24. Bradley RP. Toronto Public Health Ordinance on the protection against non-ionizing radiation (DRB) Explanatory-report. Swiss Ag Env Forest Landsc 1999.
25. Berncal EPA. Technical support document for the determination of non-cancer chronic reference exposure levels. California Environmental Protection Agency Office of Environmental Health Hazard Assessment, Berkeley 1997.
26. Hasan Z, Boostanimehr H, Bhargava VK. Green cellular networks: A survey, some research issues and challenges. IEEE Commun Surv Tutor 2011; 13: 524-540.
27. Mikeka C, Arai H. Design issues in radio frequency energy harvesting system, sustainable energy harvesting technologies-past, present and future. Inteceph 2011; 236-256.
28. Visser HJ, Vullers RJ. Rf energy harvesting and transport for wireless sensor network applications-principles and requirements. Proc IEEE 2013; 101: 1410-1423.
29. Abdel-Rassoul G, El-Fateh OA, Salem MA, Michael A, Farahat F. Neurobehavioral effects among inhabitants around mobile phone base stations. Neurotoxicology 2007; 28: 434-440.
30. Adey WR. Tissue interactions with nonionizing electromagnetic fields. Physiol Rev 1981; 61: 435-514.
31. Narmadha R, Malarkkan S. Authentication key management analysis for heterogeneous networks. I-manag J Wireless Commun Netw 2013; 2.

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