

Tethered Balloon Technology for Green Communication in Smart Cities and Healthy Environment

1st S. H. Alsamhi
Dept. of Electronics Engineering
IBB University, Yemen and Aligarh
Muslim University, India
Ibb, Yemen
s.alsamhi.rs.ece@iitbhu.ac.in

4th Sau Nguyen Van
Biomedical of Information Technology
Shenzhen Insitutes of Advanced
Technology, UCAS
Shenzhen, China
saunv.edu@gmail.com

7th Akram Hatem Saber
Department of Electronics Engineering
Aligarh Muslim University
Aligarh, India
alasmr.2a@gmail.com

10th Hasan Mohsen Aljabali
Department of Electronics Engineering
Aligarh Muslim University
Aligarh, India
hasanaljabali45@gmail.com

2nd Mohd Samar Ansari, IEEE
Senior Member
Software Research Institute
Athlone
Institute of Technology Athlone
Ireland
mdsamar@gmail.com

5th S. K. Gupta
School of Electronics and
Communication Engineering
Shri Mata Vaishno Devi
University
Katra, India
sachin.rs.eee@iitbhu.ac.in

8th Mohammed Y.A.M.Hebah
Department of Electronics
Engineering Aligarh Muslim
University
Aligarh, India
moha.hebah@gmail.com

11th Mohd Najim
Department of Electrical and
Electronics Engineering
University of Jaddah
Jaddah, Saudi Arabia
mohdnajim.iitr@gmail.com

3th Liang Zhao
School of Computer Science
Shenyang Aerospace
university
Shenyang, China
lzhao@sau.edu.cn

6th Amr A. Alammari, IEEE
Member
Department of Electronics
Engineering
Aligarh Muslim University
Aligarh, India
amr.rs@amu.ac.in

9th Marwan Ahmed
Abdullah Alasali
Department of Electrical
Engineering
Aligarh Muslim University
Aligarh, India
ma734608@gmail.com

12th Ashutosh Srivastava
Department of Electrical
Engineering
IIT (BHU)
Varanasi, India
ashutosh.rs.eee@iitbhu.ac.in

Abstract—The development and adopting of advanced communication technologies provide mobile users more convenience to connect any wireless network anytime and anywhere. Therefore, a large number of base stations (BS) are demanded keeping users connectivity, enhancing network capacity, and guarantee a sustained users Quality of Experiences (QoS). However, increasing the number of BS leads to an increase in the ecological ad radiation hazards. In order to green communication, many factors should be taken into consideration, i.e., saving energy, guarantee QoS, and reducing pollution hazards. Therefore, we propose tethered balloon technology that can replace a large number of BS and reduce ecological and radiation hazards due to its high altitude and feasible green and healthy broadband communication. The main contribution of this paper is to deploy tethered balloon technology at different altitude and measure the power density. Furthermore, we evaluate the measurement of power density from different height of tethered balloon comparison with traditional wireless communication technologies. The simulation results showed that tethered balloon technology can deliver green communication effectively and efficiently without any hazardous impacts.

Keywords—Radiation hazard, ecological hazard, green communication, tethered balloon technology, CO₂ emissions.

I. INTRODUCTION

Tremendous growing in wireless communication technologies provide mobile users freedom to inter operate with any existing communication technologies. However, the development of such technologies make people demand for better and high QoS and low cost. To fulfill the mobile users desires, many BS are required to be deployed for ensuring sustainable user Quality of Experience (QoE). Increasing number of BS leads to increase several impacts such as radiation hazards due to the excessive electromagnetic radiation [1], increase the running cost in rural area, and increase the carbon footprint in atmosphere due to the excessive burning of diesel in BS.

Electromagnetic (EM) spectrum has consistently shown the health hazard from the radio frequency range (RFR), which leads to concern [2], DNA damage and so on [3]. Therefore, people who are living more closer to towers are overexposed to EM radiation [3], and females having more complaints than males [2]. So, the location of towers must be far away from human habitats to minimize the effects of EM and RFR. Furthermore, fuel-burning affects the human living environment. In many countries, the cell towers run on diesel,

which leads to an increase in CO₂ emission [2]. CO₂ the emission has estimated around 10000000 tons every year [4]. For more evident, CO₂ emission has reached $1.7 * 10^9$ tone only from Information and communications technologies (ICT) which contributes between 2%-10% of global CO₂ [4]. Reducing carbon by using solar energy is not a solution for the green environment because the effects of radiation still harm

human beings, the environment, and society. Therefore, space technologies play a crucial role in protecting and enhancing our society from wireless communication effects and hazardous. Furthermore, space technology can deliver broadband services to a large coverage area with healthy and green communication. However, delivering communication services is very costly.

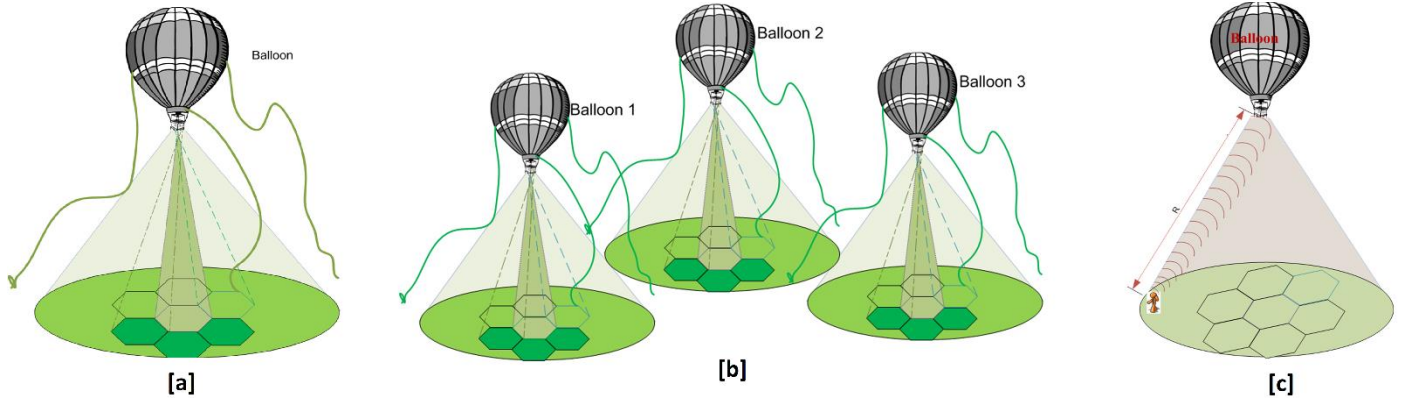


Fig. 1: (a) Single tethered balloon; (b) Multiple tethered balloon; (c) Power density from tethered balloon.

Through the appropriated understanding of the health hazards of radiation, carbon emission, and power consumption demanded, we found tethered balloon technology will represent the critical solution for enhancing the healthy environment and green communication effectively and efficiently. Many existing kinds of research have emerged on tethered balloon technology network architecture, coverage area, and its application for disaster mitigation and recovery [1], [5]–[13], but none of these studies focused on the application of tethered balloon for green communication in smart cities for improving the health quality. These researches are exciting, but they have applied for limited applications. First of all, the authors [8] summarized the enabling technologies for greening Internet of Things (IoT). The authors of [1], [6] discussed tethered balloon network architecture and the coverage for delivering broadband communication services. However, the authors of [7], [9], [13] explored that tethered balloon represented the efficient solution for disaster prevention, mitigation, management and recovery. However, the studies [10], [11] focus on the classification of environments and health hazards while the effects of exposure to EMFs on the body and cells discussed in [11]. Therefore, we propose a tethered balloon as a robust technology that can improve human life quality and make it more comfortable and healthy. The rest of the paper is organized as follows. Section II shows the advantages and applications of tethered balloon technology. The proposed network architecture is presented in Section III. In Section IV, network design is proposed, and performance analysis is discussed in Section V. Finally, results and conclusions are drawn in Sections VI and VII, respectively.

II. TETHERED BALLOON TECHNOLOGY

Tethered balloon is one of the low altitude platform family (LAP), which operates in troposphere 200-440m [6], [10]. Zeppelin launched a craft in 2000, followed by many projects which focused on the design of tethered balloon for various

applications from different altitudes [14]. The authors of [15] discussed machine learning and the optimal propagation models from different altitude. Then, in 2003, CAPANINA project focused on providing broadband services [16]. Internet connectivity via the balloon network was proposed by the Loon project. In 2001, Gawale et al. [17] aimed to develop an airship for various applications such as surveillance, disaster management, and advertisement. Tethered balloon established a long-distance wireless communication link to provide Internet connectivity in rural areas [16]. Furthermore, Chopra et al. [4] attempted to provide telecommunication and broadband services in remote and hilly areas.

Hence, Tethered balloon technology has the capability to overcome the challenges which appear in traditional cellular systems such as high-power consumption, limited coverage area, and lack of line of sight (LoS). Furthermore, it carries the the potential of mitigating the health risk due to radiation exposure and environmental effects that are linked with terrestrial mobile BS. Therefore, tethered balloon technology has several advantages over terrestrial communication such as low cost of launch and operation, rapid deployment, large coverage area, low propagation delay, easily reconfigurable, and LoS [10], [18].

Tethered balloon can be used for different applications such as disaster recovery, observation and meteorological usage for being able to gather data [19], [20], delivering power [21], monitoring civilian activities and delivering wireless telecommunication services efficiently and enables large coverage area as well as support wired and wireless communications in the disaster area and healthy recovery [22].

III. TETHERED BALLOON FOR BROADBAND COMMUNICATION

Tethered balloon can cover a large area and replace a massive number of terrestrial towers in urban areas. The coverage area can be extended via multi-balloons depends on

many parameters such as radiation power, the height of the antenna, environment, and propagation path. The value of allowable LoS is also substituted in Hata model [6], [7] with ‘correction factor’ of a small city taken as:

$$\text{Correct Factor} = (1.1 \log_{10}(f_c) - 0.7)h_{re} - (1.56 \log_{10}(f_c) - 0.8) \quad (1)$$

$$P_l = 69.55 + 26.16 \log_{10}(f_c) - 13.82 \log_{10}(h_{te}) - a(h_{re}) + (44.9 - 6.55 \log_{10}(h_{te})) \log_{10} D \quad (2)$$

The variable D in Hata model equation determines the cell radius of the coverage area (km), and f_c is frequency, h_{re} represents height of the mobile antenna, h_{te} is BS antenna height, $a(h_{re})$ represent the correction factor, P_l is the path loss. A single tethered balloon is envisaged for providing communication services for special events such as disaster recovery, rapid broadband employment over highly populated cited as shown in Fig. 1(a).

A. Coverage Extension Using Multi-Balloon

Multi-balloons constellations can increase the capacity by exploiting the directionality of the fixed user antenna. Configuration of tethered balloon leads to provide resilience and unique diversity to end users receiving antennas for improved service availability. In the case of multi-balloon constellations, they can be interconnected via ground stations or via inner balloon link (IBL), which represents an additional network interface between multi-balloons. IBLs can be radio or optical, thus arbitrarily extending the system coverage. In fact, the coverage area is divided into multiple cells for increasing the capacity. Tethered balloon constellations architecture is depicted in Fig. 1(b). Worldwide interoperability for Microwave Access (WiMAX) BS should be taken into the payload of the balloon to deliver broadband services [23], [24].

IV. HAZARDS

Our society and environment should be given priority during the design of wireless technologies equipment with considering their long-term adverse effects. Threats posed by the introduction of such devices can be classified as environmental hazard and health hazards [10]. Recently, the EM radiations are emitted from phone towers estimated beyond safety levels. Radiation is a form of energy on the move and consists of electric waves and magnetic waves which moving together through space at the speed of light. Various neuro-behavioral changes were observed in the inhabitants living near the towers. Also, diseases had been reported among individuals such as headaches, dizziness, memory changes, sleep disorder.

A. Electromagnetic Radiation Hazards from BS

The electrical and magnetic equipment produce invisible electric and magnetic fields (EMFs) and electromagnetic radiation (EMR) in which continuously attacks the human body affecting its bio-field. EMR is a form of energy emitted which attacks human biology depending on the radiated power density as well as the distance from the transmitter [25]. It is measured by the specific absorption rate (SAR in W/kg) and classified into two forms: non-ionizing radiation and ionizing radiation [26]. Non-ionizing radiations do not have enough

energy to break apart atoms and molecules and turn them into ions. However, electromagnetic radiation could be considered as ionizing, if the energy associated with a photon of radiation has larger energy than ionizing energies of atoms. For example, X-rays and gamma rays are taken to be ionizing. People who are living within 50 to 300 m radius are in the highest radiation zone (dark/blue) and are more prone to ill-effects of electromagnetic radiation, as shown in Fig. 2.

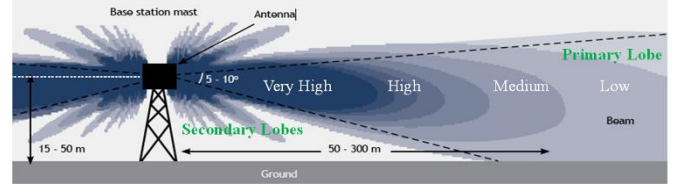


Fig. 2: EMR levels from the BS

B. Biological Effects

Currently, active radiation can induce capable of delivering an electric shock to persons or animals. Non-ionizing radiation is associated with two significant potential hazards: electrical and biological. It does not damage the genetic material (DNA) in molecules, directly. Therefore, it cannot cause cancer or any other illness for humanity. X-ray and gamma rays are forms of ionizing radiation. Mainly, these can increase one's risk of cancer, congenital disabilities, and genetic defects through DNA mutations resulting from the atom and molecule ionization. EMR and EMF create an artificial stress situation in the bio-system, which, in turn, affects the metabolism as well as hormone production.

The biological effects of EMR, severe consequences on the health such as DNA damage, increased risk of cancer, breaching of Blood-Brain Barrier, irreversible infertility, effects on the eye, ear, skin, sleeping disorders [27]. Power radiation is defined as the amount of power per unit area in the radiated electromagnetic field at any distance from the antenna. It has uniform power density in a specific direction. Near-field is a region of the electromagnetic field close to the antenna, which lies between the reactive field and far-field [28].

$$n_f = 2L^2/\lambda \quad (3)$$

where n_f is near field, L is the dimension of antenna and λ is wavelength. The power density value is calculated within the range of near field, substituting the distance value between two antennas (transmit and receive antenna) in the power density equation which given in [28].

$$P_d = \frac{P_t G_t}{4\pi R^2} \quad (4)$$

where P_d is power density, P_t is transmitted power, and G_t is transmitted antenna gain. In the case of terrestrial wireless communication, for $P_t = 20W$; $G_t = 17dB$; P_d is given for various distance R as Table. I.

TABLE I: Variation of Power Density with Distance

Distance R (m)	Power density P_d ($\frac{W}{m^2}$)
10	0.796
100	0.008
500	0.000318

On the other hand, P_d from tethered balloon is calculated by using (4), and R is considered as the square root of tethered balloon altitude plus the distance in the near field as shown below.

$$R = \sqrt{a_t^2 + d_{nf}^2} \quad (5)$$

where a_t is the altitude of tethered balloon and d_{nf} is the near field distance. Increasing the distance between the radio station, and the receiver leads to decrease power density. Therefore, radiation power from tethered balloon will not harm or cause hazard to our environment and society in the particular coverage area, as shown in Fig. 1(c). On the other hand, decreasing the distance between the tethered balloon and user on the ground will lead to harm but it does not affect that much as in the traditional wireless communication. Therefore, power density is calculated by using (6), where R represents the distance between tethered balloon and users on the ground.

$$P_d = \frac{P_t G_t}{4\pi R^2} \quad (6)$$

Also, the rms value of the E-field can be calculated as:

$$E = \frac{\sqrt{30 P_t G_t}}{R} \quad (7)$$

The received power at the particular point is:

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi R)^2} \quad (8)$$

C. Thermal Effects of EMF

The radiation effects are divided into thermal and nonthermal effects. Many studies have been reported that nonthermal effects are more harmful than thermal effects by 3 to 4 times [29]. The adverse health effects are associated with RF energy exposure in the frequency range from 100 kHz to 300 GHz, which is related to the thermal effects.

The harmful effects of radio BS become evident. EMF above 100 KHz can lead to significant absorption of energy and increasing the temperature [5] and it is called thermal effects of EMF. Hence, the effects of exposure to EMFs on the body and cells depend on the EMF frequency and strength [11]. Subsequently, organizations such as WHO, IEEE, and ICNIRP, has been taken into account the risk of thermal effects of high energy radiation, determined a threshold exposure level basis of a health risk assessment of the scientific data below health hazards have been found.

D. Ecological Hazards

Huawei has reported that carbon emissions of telecommunication equipment is mainly from BSs [30]. According to the international energy agency (IEA), carbon emissions have increased by about 80%. The solution is to have more numbers of cell towers with lesser transmitted power. Lesser transmitted power leads to reduce the heating

effects. However, the reduction in the transmitted power for the above solutions will increase the installation and maintenance cost. The operators all over the world are claiming that there are no radiation health hazards. It results in complaining the subscribers of network problems. To avoid these problems solar panels can be used. So, high power diesel generators will not be required. It will reduce carbon emission. Solar systems have a tremendous contribution to reducing CO₂ emission as it does not consume fuel. Furthermore, another advantage is a lower cost of operation and maintenance when compared with a diesel system, for the same power delivery.

V. PROPOSED TECHNOLOGY

Traditional wireless communication technologies have several impacts on our life style and environments. Environment impacts are including increasing the CO₂ emission of atmosphere, generators pollution and water resource pollution the result from powering the radio BS and using a diesel generator. Moreover, we have to be aware of the hazards of such advancement and take control before its too late. Therefore, we propose new logistic technology to save energy, avoid EMR eliminates carbon emission and power consumption. For improving the life quality in the smart city, tethered balloon technology can play a vital role in solving hazardous challenges of radio BS via mitigation biological, heating, and effects of ecological hazardous. Tethered balloon technology can play a vital solution to reduce health hazard and environmental hazards through energy-efficient radio equipment and solar system. It is the promise and emergent technology for green communication and could improve human life quality and make it more comfortable. Hence, it becomes possible solution to reduce the ill effects of cell tower radiation.

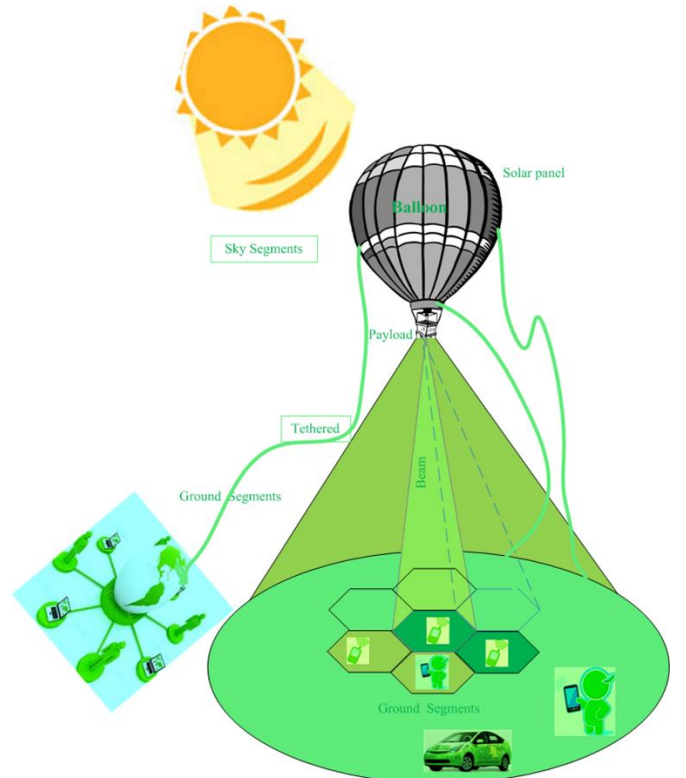


Fig. 3: Tethered balloon technology for green communication

The proposed network architecture is shown in Fig. 3. It consists of space and ground segments. Space segments include the payload, balloon, solar energy, and tether. The payload comprises remote radio unit (RRU) and antennas for mobile wireless communications. The proposed green broadband communication is anticipated to provide access capacity in the range of the underlying wireless access technology capacities WiMAX. Also, a global positioning system (GPS) can be used for measuring the balloon height as well as it can be deployed to monitor the status of the floating platform Fig. 3. Tethered balloon technology plays a vital role in improving life quality due to improving green communication and reducing the impacts of traditional communication technologies. The most important of tethered balloon is the capability of delivering better broadband communication service, low cost, easy to deploy, could be lunched to different altitudes. Tether is the connecting link between the balloon and other networks on the ground. Fiber should be used inside the tether to connect the payload to the ground terminals for delivering broadband services in high capacity and very high speed. Furthermore, Balloon is restrained by the tether to maintain the balloon stable in position. On the other hand, the ground segment includes main unit (MU) of BS, sub-network, and mobile user. Briefly, tethered is used for several function i.e., delivering broadband services, restrict balloon to the ground and make it stable, and recharge the payload devices by energy in the case of solar panel is failed. MU is the system, which interfaces for 2 Mbps transmission links to the existing core network in public switched telephone networks (PSTN). The ground station acts as a hub for the network and provides service to customers within the cell radius. Furthermore, designing the space of balloon with solar panel will play vital role in reducing the energy used from ground to supply the payload.

VI. RESULT AND DISCUSSIONS

The harmful of EMR to the human body is depending on the radiated power density and the distance from the transmitter. The first scenario, the distance of near field is considered 25m from the launch point of a tethered balloon. The balloon heights are 150m and 200m, as shown in Fig. 4 and Fig. 5. The power

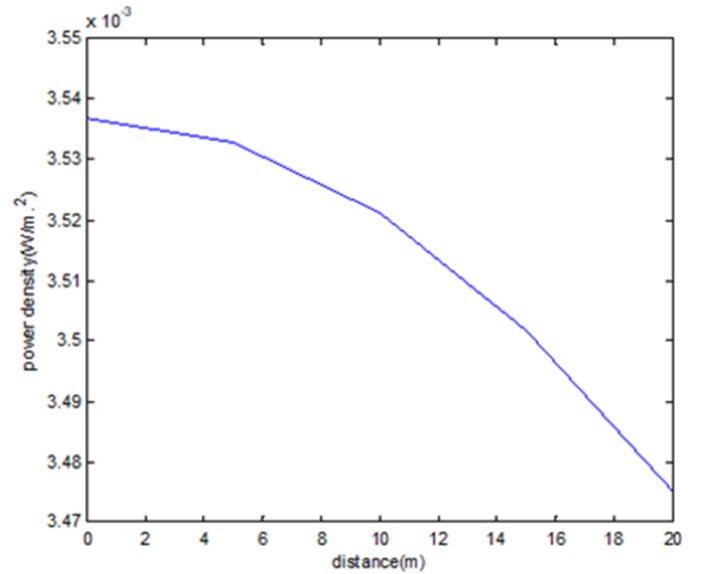


Fig. 4: Power density at the height of 150m

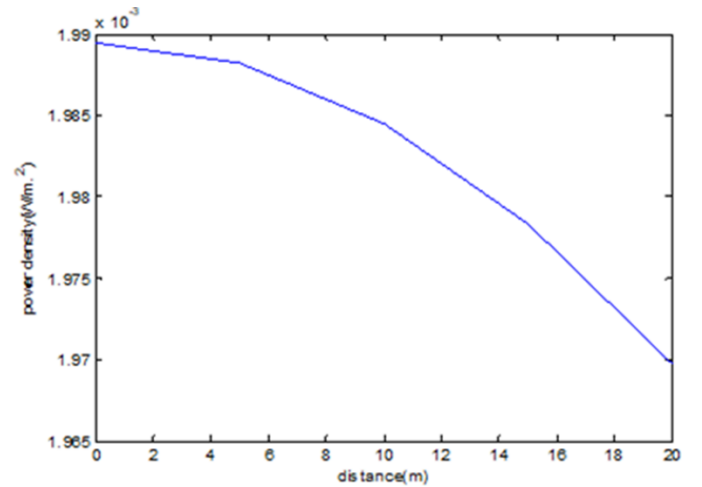


Fig. 5: Power density at the height of 200m

density from Balloon at these heights are shown in the maximum power density $1.98 \times 10^{-3} \text{ W/m}^2$ when the height of the tethered balloon is 200m. Also, the maximum power density is $3.537 \times 10^{-3} \text{ W/m}^2$ when the height of tethered balloon is 150m. Therefore, the power density decreased when the height increased, and vice versa.

In the second scenario, the distance from the tethered balloon to the user at the ground is considered with a different altitude from 200m to 400m. The results show that the distance from the balloon to the user increase by increasing the balloon height. Therefore, increasing the distance leads to decrease the power density gradually from maximum 2.5 nW/m^2 , when the user at the center coverage area of the tethered balloon as shown in Fig. 6. Furthermore, the radiation power also decreases with increases the distance from the balloon as shown in Fig. 7. The received power at the destination is shown also in Fig. 8.

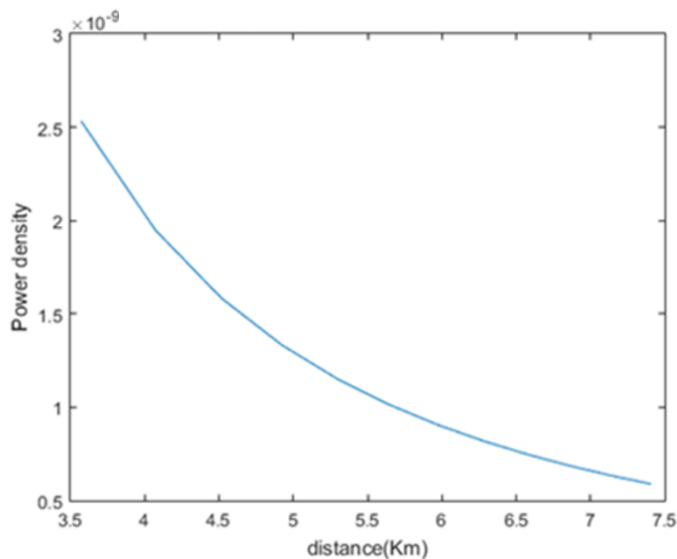


Fig. 6: Power density from balloon of different altitude

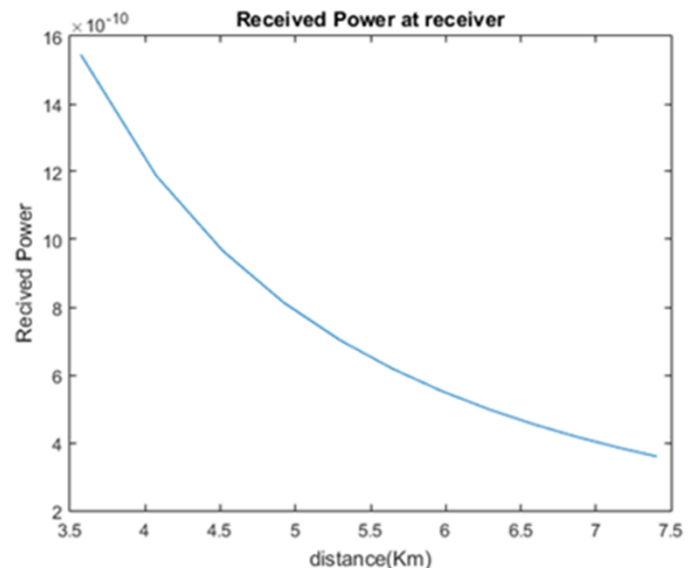


Fig. 8: Received power from Balloon in different heights

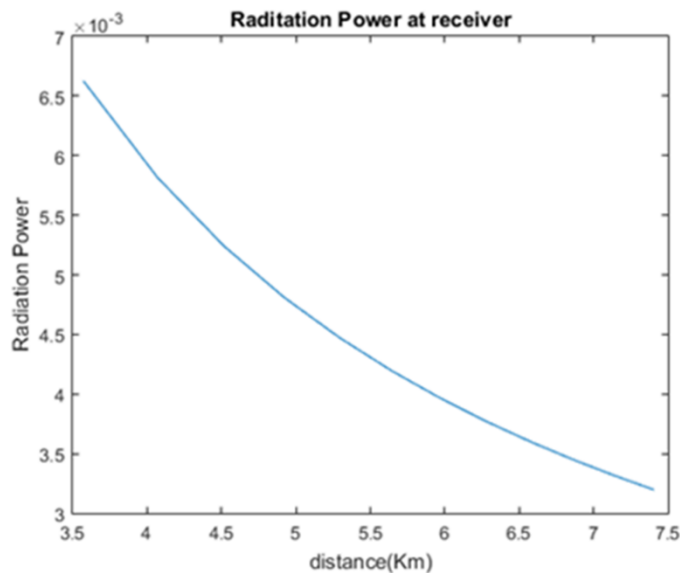


Fig. 7: Radiation Power from different distance

VII. CONCLUSION

Tethered balloon is the newest and promising technology which can be used efficiently for green communication and healthy environments. Tethered balloon can carry the BS in its payload instead of increasing the height of BS over the house, which will affect the health of people who are living in the same house or nearest to BS. Power density values from a different height of tethered balloon are observed. Increasing the distance between radio BS and receiver leads to a decrease the values of power density at near field. The power density, radiation power, and received power are measured with different distances from Balloon at different altitudes. Using the proposed technique leads to an increase in the coverage area, avoid intense EMR even if there are many operators, reduce CO₂ emission as this system could be a solarpowered system. The results are shown that tethered balloon is efficient and optimal broadband communication without harming human life quality and society even if more than one operator shares the same tethered balloon. Thus, tethered balloon plays a vital solution to protect us from the harmful effects of the intense exposure to EMF, carbon emission, and environmental hazards. In the future, the tethered balloon may use for greening IoT for being considered as fog computing for improving energy efficiency and real-time service delivery.

REFERENCES

- [1] Saeed Hamood Alsamhi, Sachin Kumar Gupta, and NS Rajput. Performanceevaluation of broadband service delivery via tethered balloon technology. In Industrial and Information Systems (ICIIS), 2016 11th International Conference on, pages 133–138. IEEE, 2016.
- [2] Lalrinthara Pachuau and Zaithanzauva Pachuau. Study of cell tower radiation and its health hazards on human body. IOSR Journal of Applied Physics (IOSR-JAP), e-ISSN, pages 2278–4861, 2014.
- [3] Dariusz Leszczynski and Zhengping Xu. Mobile phone radiation health risk controversy: the reliability and sufficiency of science behind the safety standards. Health research policy and systems, 8(1):2, 2010.
- [4] PK Chopra, R Manchanda, R Mehrotra, and S Jain. A new topology for telecom and broad band services in spars, remote and hilly areas. WSEAS TRANSACTIONS on COMMUNICATIONS, 10(9):273–286, 2011.

- [5] Gary W Arendash. Review of the evidence that transcranial electromagnetic treatment will be a safe and effective therapeutic against alzheimer's disease. *J. of Alzheimer's Disease*, 53(3):753–771, 2016.
- [6] SA Khaleefa, SH Alsamhi, and NS Rajput. Tethered balloon technology for telecommunication, coverage and path loss. In *Electrical, Electronics and Computer Science (SCEECS), 2014 IEEE Students' Conference on*, pages 1–4. IEEE, 2014.
- [7] Saeed Hamood Alsamhi, Mohd Samar Ansari, Ou Ma, Faris Almalki, and Sachin Kumar Gupta. Tethered balloon technology in design solutions for rescue and relief team emergency communication services. *Disaster medicine and public health preparedness*, pages 1–8, 2018.
- [8] SH Alsamhi, Ou Ma, M Samar Ansari, and Qingliang Meng. Greening internet of things for smart everything with a green-environment life: A survey and future prospects. *arXiv preprint arXiv:1805.00844*, 2018.
- [9] Saeed H Alsamhi, Mohd Samar Ansari, and Navin S Rajput. Disaster coverage predication for the emerging tethered balloon technology: capability for preparedness, detection, mitigation, and response. *Disaster medicine and public health preparedness*, 12(2):222–231, 2018.
- [10] Saeed H Alsamhi and NS Rajput. An intelligent HAP for broadband wireless communications: developments, qos and applications. *Int. J. of Electronics and Electrical Engineering*, 3(2):134–143, 2015.
- [11] Bruce Fife. *Health Hazards of Electromagnetic Radiation*. Piccadilly Books, Ltd., 2017.
- [12] AB Ericsson. Sustainable energy use in mobile communications. White paper, EAB-07: 021801 Uen Rev C, 2007.
- [13] SH Alsamhi, FA Almalki, Ou Ma, MS Ansari, and MC Angelides. Performance optimization of tethered balloon technology for public safety and emergency communications. *Telecommunication Systems*, pages 1–10, 2019.
- [14] T C Tozer and David Grace. High-altitude platforms for wireless communications. *Electronics & communication engineering journal*, 13(3):127–137, 2001.
- [15] MC Angelides and FA Almalki. A machine learning approach to evolving an optimal propagation model for last mile connectivity using low altitude platforms. 2019.
- [16] AARA Gawale, AA Raina, RS Pant, and YP Jahagirdar. Design fabrication and operation of low cost remotely controlled airships in india. In *Proceedings of AIAA's 8th Aviation Technology Integration and Operations (ATIO) Conference*, number 2008-8853, 2008.
- [17] David Grace, Mihael Mohorcic, Masayuki Oodo, MH Capstick, M Bobbio Pallavicini, and M Lalovic. Capanina—communications from aerial platform networks delivering broadband information for all. *Proceedings of the 14th IST Mobile and Wireless and Communications Summit*, 2005.
- [18] P Bilaye, VN Gawande, UB Desai, AA Raina, and RS Pant. Low cost wireless internet access for rural areas using tethered aerostats. In *Industrial and Information Systems, 2008. ICIIS 2008. IEEE Region 10 and the Third international Conference on*, pages 1–5. IEEE, 2008.
- [19] P Sankar and Suresh R Norman. Embedded system for monitoring atmospheric weather conditions using weather balloon. In *Control, Automation, Communication and Energy Conservation, 2009. INCACEC 2009. 2009 International Conference on*, pages 1–4. IEEE, 2009.
- [20] Mingjun Liu, Guozhong Su, and Zongjian Lin. The application of combined camera in low altitude remote sensing with unmanned airship. In *2013 the International Conference on Remote Sensing, Environment and Transportation Engineering (RSETE 2013)*. Atlantis Press, 2013.
- [21] Rajkumar Pant, Narayanan Komerath, and Aravinda Kar. Application of lighter-than-air platforms for power beaming, generation and communications. In *2011 International Symposium on Electronic System Design*, pages 242–247. IEEE, 2011.
- [22] Hadi Hariyanto, Hariyo Santoso, and Anggoro K Widiawan. Emergency broadband access network using low altitude platform. In *Instrumentation, Communications, Information Technology, and Biomedical Engineering (ICICI-BME), 2009 Int. Conf. on*, pages 1–6. IEEE, 2009.
- [23] Zhe Yang, Abbas Mohammed, and Tommy Hult. Performance evaluation of wimax broadband from high altitude platform cellular system and terrestrial coexistence capability. *EURASIP Journal on Wireless Communications and Networking*, 2008:4, 2008.
- [24] SH Alsamhi and NS Rajput. Neural network in a joint haps and terrestrial fixed broadband system. *International Journal of Technological Exploration and Learning (IJTEL)*, 3:344–348, 2014.
- [25] Opara K Felix, Adigwe U Gabriel, and Agbaraji C Emmanuel. Investigation and analysis on electromagnetic radiation from cellular base station transmitters and the implications to human body. *Journal of Environment and Ecology*, 5(1):46–60, 2014.
- [26] Asma Almontasser, SH Alsamhi, and Yas Alhadithi. Study and analysis growing of e. coil bacteria and effected of hene laser.
- [27] Girish Kumar. Cell tower radiation. Mumbai, December, 2010.
- [28] Alejandro Aragon-Zavala. *Antennas and propagation for wireless communication systems*. John Wiley & Sons, 2008.
- [29] Antonio de la Hoz, Angel Diaz-Ortiz, and Andres Moreno. Microwaves in organic synthesis. thermal and non-thermal microwave effects. *Chemical Society Reviews*, 34(2):164–178, 2005.
- [30] Huawei Technologies Co. Save energy and reduce emissions to achieve sustainable development and improve corporate competitiveness. Technical report, Huawei Technologies Co., China, 2012.