RESEARCH ARTICLE

The Use of Camouflaged Cell Phone Towers for a Quality Urban Environment: Koya City as Case Study

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ABSTRACT

The widespread use of cell phones has led to cell phone towers being located in many communities. These towers, also called base stations, incorporate electronic equipment and antennas that receive and transmit radiofrequency signals. Along with the towers, used for TV and line of sight microwave communication, the proliferation of these base stations is having a detrimental effect on urban esthetics. It is highly recommended for developing urban areas to consider the problem of these unsightly towers as a form of visual pollution, which increases in parallel with the rise of human population density, and also, the possible electromagnetic field (EMF) hazard due to the existence of the cell phone towers in the residential areas. This paper presents the feasibility of using camouflaged cell phone towers to improve the quality of the urban environment. Cell phone towers disguised as trees might address the visual pollution, while, at the same time, might also mitigate the possible EMF hazard by installing these disguised towers in free spaces, rather than on the roof of buildings, schools, hospitals, etc. The feasibility of implementing such a scenario for a quality urban environment in Koya city is discussed.

Keywords: Base station, Cell phone tower, Cell tower proliferation, Tower disguising, Tree tower, Urban development

1. INTRODUCTION

To communicate through cell phones, receive radio and TV signal, and transmit/receive point-to-point microwave (MW) signals between cities over long distances, it is necessary to use one or multi-antenna mounted on top of a pole or tower. In the case of cellular communication, this tower is also called a cell phone tower or base station. The density of these towers is directly proportional to the human population density. This mathematical principle called "cell tower proliferation" (Wikle, 2002) is a new subject for urban ecologists.

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Since the 1990s, when the digital second generation of cellular communication was launched in Europe as a global system for mobile (GSM) standard and in the USA as a code division multiple access (CDMA) standard, cell phone operators put their cell phone towers everywhere, covering all the residential areas and the places where the human live/work. Although there is no official number of the cell phone towers worldwide, there were more than 307,626 scattered across the United States, in 2018. It is expected that 5G could require cell towers on every street corner.

An area with a radius of about 10 km can be covered by cellular radio frequencies constituting a macrocell, using a base station of latticework structure tower. For a residential area of high population density, such a scenario does not exist due to the limited communication channels/carrier frequencies (users to communicate at the same time) offered by one cellular antenna. Thus, dividing the macrocell into many microcells and picocells is necessary to increase the number of carrier frequencies. Moreover, the latter scenario may not be useful, in the case of very high population density area, where a three 120-degree sector antenna on top of every tower is used instead of 360-degree omnidirectional antenna. This is a way to multiply the number of carrier frequencies offered by the base station tower by three. The proliferation of such unsightly towers and their existence in residential buildings, schools, hospitals, et al., is now considered a big issue for urban ecologists, creating what they term: "Visual pollution" (Nagle, 2009).

Besides the cell phone towers' visual pollution, another concern which should be raised is they are a possible biological effect (health hazard), due to the cellular antenna electromagnetic field (EMF) emission. The possible hazard of cell phones/cellular antennas radiation is due to the thermal effect (Al-Mously, 2010). The telecommunications industry claims cellular antennas are safe because the radiofrequency (RF)/MW radiation they produce is too weak to cause heating. They point to ANSI/IEEE (IEEE Standards Coordinating Committee 28.4, 2006) or ICNIRP (1998) standards to support their claims. However, these standards support the cellular antennas to be installed at a safe distance, far from residential buildings. Some studies revealed that people living in the vicinity of mobile phone base stations had various complaints, such as sleep disturbances, headaches, dizziness, irritability, concentration difficulties, and hypertension (Singh, et al., 2016; Islam, 2014; Levitt and Lai, 2010).

In 1996, a palm tree was introduced to a suburb in Cape Town, South Africa. The tree appeared almost overnight, and it was not an ordinary tree: It was one of the world's first (if not the first) disguised cell phone towers. Rather than have unnatural and unattractive metal towers jutting out of the ground, companies began working to make the towers blend in with the natural environment. This "fake tree" concept soon spread across Cape Town, across South Africa, and finally, across the world (Zhang, 2013). Cell phone trees appear to coexist very well with living trees, although they have a definite competitive advantage. Unlike living trees, cell phone trees do not require water or mineral nutrients. In fact, they do well in just about any type of soil. They even flourish in solid concrete. They do well under a variety of gradients and exposures and may over a good shade.

Disguising cell phone towers as trees, to address visual pollution has been common practice in some countries for 20 years. There are an estimated 1000–2000 cell phone tower trees in the United States (Young, 2016). This paper presents the feasibility of using the cell phone towers, not to avoid the visual pollution, only, but to avoid the possible antenna EMF emission hazard, as well. Koya city was examined as a case study.

2. BACKGROUNDS AND RELATED WORKS

2.1. Cellular Communication Frequencies and Generations

The International Telecommunication Union – Radio Sector (ITU-R), described the cellular systems in multiple generations, with the fourth-generation (4G) system, which was first launched by TeliaSonera in 2009, in the city centers of Stockholm and Oslo (Al-Mously, 2009):

1. 1G systems: These are the analog systems, such as advance mobile phone system, that grew rapidly in the 1980s and are still available today. Many metropolitan areas have a mix of 1G and 2G systems, as well as emerging 3G systems. The systems use frequency division multiplexing to divide the bandwidth into specific frequencies that are assigned to individual calls.
2. 2G systems: These second-generation systems are digital, and use either time division multiple access (TDMA) or CDMA methods. The European GSM communications is a 2G digital system with its own TDMA access methods. The 2G digital services began appearing in the late 1980s, providing expanded capacity and unique services such as caller ID, call forwarding, and short messaging. A critical feature was seamless roaming, which let subscribers move across provider boundaries.
3. 3G systems: 3G has become an umbrella term to describe cellular data communications with a target data rate of 2 Mbits/sec. The ITU originally attempted to define 3G in its IMT-2000 specifications, which specified global wireless frequency ranges, data rates, and availability dates.
4. 4G systems: On the horizon is 4G systems that may become available even before 3G matures (3G is a confusing mix of standards). While 3G is important in boosting the number of wireless calls, 4G will offer true high-speed data services. 4G data rates will be in the 2-Mbit/sec to 156-Mbit/sec range, and possibly higher. 4G will also fully support IP.

Cell tower antennas transmit in the frequency range of 869–890 MHz (CDMA), 935–960 MHz (GSM900), 1810–1880 MHz (GSM1800), and 2110–2170 MHz (3G).

2.2. Cell Phone Tower Structure

A cell tower is a tall structure usually made of steel or galvanized steel. The cell tower is typically designed as a latticework structure (usually found in the industrial areas), a monopole structure (usually found in residential and commercial areas), or a tri-pole structure (usually found on building sites as an attempt to blend the structure in as an architectural element). Figure 1 shows two common types of towers that are used for cellular and MW point-to-point.

Most cell towers are between 14.9 m (49 feet) and 35 m (115 feet) in height but can be as high as 45 m (148 feet) to 65 m (213 feet). The height of a tower is dependent on such things as the topography of the area being serviced by the tower's antennas, the height of any trees in the area, the height of buildings (trees and tall buildings can block signals between towers, so the antennas must be higher than these elements), and the number of antennas being placed on the tower. In addition, a line-of-sight is required for any MW dish mounted on the tower – this line-of-sight being from one tower to another so that signals can be passed back and forth between the towers through their MW dishes.

In cellular communication, antennas are placed on a tower in an array or cluster of three, with each antenna covering a sector of 120 degrees, which is one-third of the circumference of a circle (120 × 3=360 degrees or one complete radius/circle around the tower). Each set of antenna arrays requires a separation distance on the tower of at least 1 m (3 feet) so that the antennas do not interfere with or receive interference from the signals being received or sent by other antenna arrays mounted on the same tower. Figure 2 shows three sets of 120-degree sector cellular radio antennae belonging to three operators on top of the tower.

2.3. Cell Phone Tower Coverage Scale

The term macrocell is used to describe the widest range of cell sizes. Macrocells are found in rural areas or along highways. Macrocell sites can cover a radius of 1–10 km, depending on the terrain, where the antenna tower height is >30 m. Over a smaller cell area, a microcell is used in a densely populated urban area. Microcell sites can cover an area with a radius of <1 km, depending on the terrain, where the antenna tower height is about 10 m. Picocells are used for areas even smaller than microcells. An example of usage would be a large office, a mall, or a train station. At present, the smallest area of coverage that can be implemented with a femtocell is a home or small office.

2.4. Cell Phone Tower EMF Emission

The cellular antenna has a limited number of channels, and in high population density areas, it is necessary to increase the number of channels and fulfill the user's demand. This can be achieved using towers which have three sectors with equal angular coverage of 120 degrees in the horizontal direction and repeating the towers in a way to reduce the coverage areas. This scenario is called cell planning. Consequently, the cellular antenna can be seen everywhere, near and on top of buildings.

With towers that support antennae working for FM radio, TV, and mobile cellular communication bands, the major contribution to the specific absorption rate is from the mobile cellular antenna emissions. The 120-degree sector antenna has the radiation beam pattern as shown in Figure 3 (Ustuner, 2011).

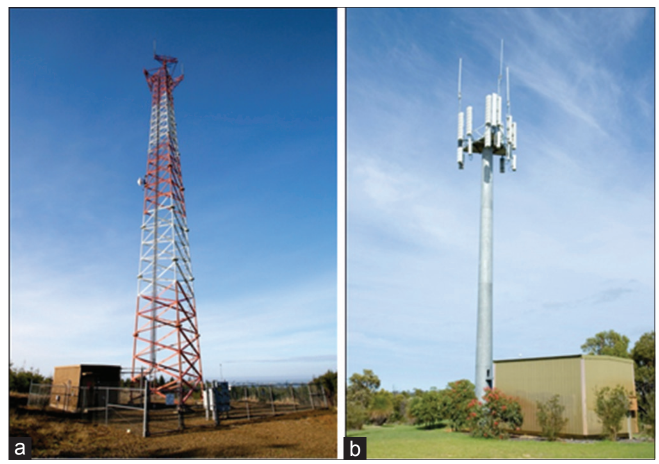

Figure 1. Photo of (a) latticework structure tower, and (b) monopole structure tower Photos are taken from: http://www.fructivore.com/2010/10/look-for-the-right-short-candidates-like-crown-castle/, http://commons.wikimedia.org/wiki/File: Telstra_Mobile_Phone_Tower.jpg.

Figure 2. Top of a cellular radio tower. Nine sector antennae of three operators, three per one operator. http://en.wikipedia.org/wiki/Cellular_network

3. PROBLEM DEFINITION

Although the health limit levels are well established and the cellular base station RF infrastructures are well known, there is still continuing the debate about the radiation hazard level of the base stations. Even though the FCC permits an effective radiated power (ERP) of up to 500 watts per channel (depending on the tower height), the majority of cellular base stations in urban and suburban areas operate at an ERP of 100 watts per channel or less. An ERP of 100 watts corresponds to an actual radiated power of about 5–10 watts, depending on the type of antenna used (ERP is not equivalent to the power that is radiated but, rather, is a quantity that takes into consideration transmitter power and antenna directivity).

The cell phone towers proliferation for mobile communication imposes two issues:

1. Visual pollution.
2. Possible biological effect.

The possibility of the above two issues becomes more obvious in high population density areas. In such areas these two issues are mutual. The mobile phone operators cannot install cell phone towers everywhere due to different reasons, i.e., cost, visual pollution, limited free spaces, and getting license. Thus, the alternative solution is to install the cellular antenna on the roofs of buildings, schools, hospitals, and even houses, Figure 4. Consequently, this increases the visual pollution and the possible biological effect, as well.

A study in India (Kumar, 2010) showed that the majority of cell phone operators use 2–12 carrier frequencies (average maybe around 6) and they transmit 20 W of power per carrier. Hence, one operator may be transmitting nearly 100 W of RF power depending on the number of carriers. There may be 2–3 operators on the same roof-top or tower; thereby total transmitted power may be 200–400 W. In addition, the majority of them use directional antennas of gain=18 dB. Assuming 1 dB cable loss, effective gain=17 dB (numeric value is 50), so effectively, several KW of power may be transmitted in the direction of the main beam. Several KW of EMF emitted by cellular antennas installed in the vicinity of human bodies in buildings, schools, hospitals, et al., makes the possible biological effect a major concern.

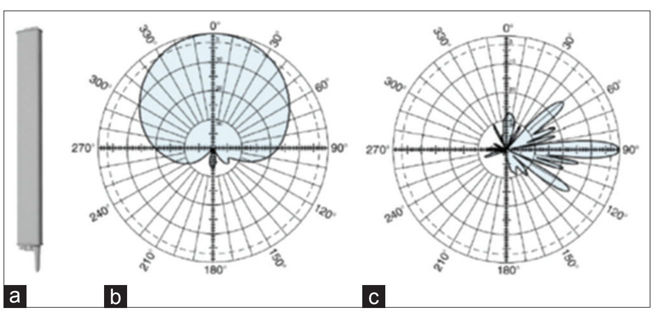

Figure 3. (a) Antenna and (b) its azimuth plane and (c) elevation plane radiation patterns

Figure 4. Photos show two examples of using cellular antennae that do not consider the safety guidelines (IEEE, 2006; FCC, 1997; ICNIRP, 1998) and distort the landscape.

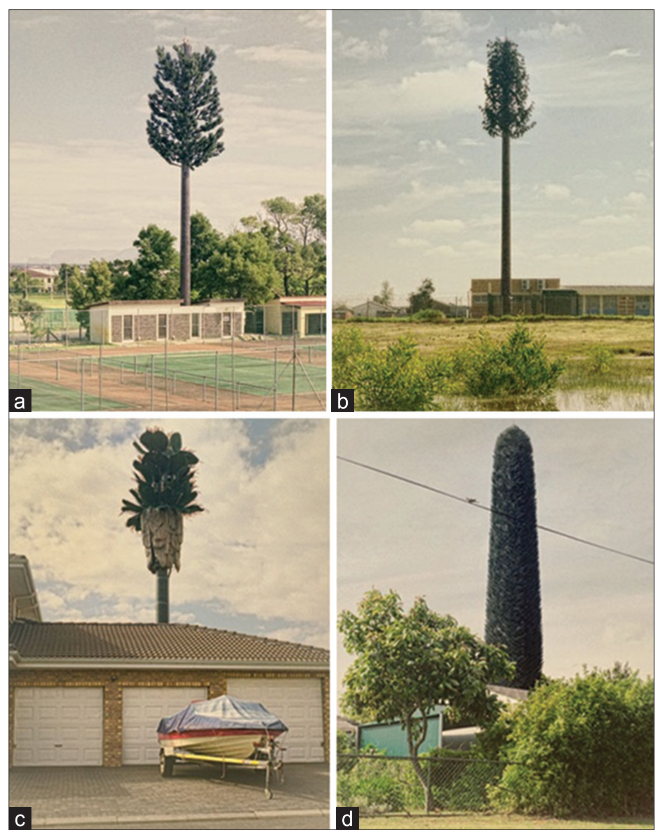

Figure 5. Photos of different applicable shapes of tree cell phone towers, photographer Dillon Marsh, 2009. http://petapixel.com/2013/06/06/photos-of-cell-phone-towers-disguised-as-fake-trees

Figure 6. Google map of Koya city; (a) plain map, (b) Terrain map showing the residential and business areas. Captured on April 17, 2019

4. THE PROPOSED SCENARIO FOR KOYA CITY

The proposed scenario focuses on:

1. Disguising cell phone towers as trees to avoid visual pollution.
2. Installing the cell phone towers away (safe distance) from the buildings, schools, hospitals, et al. This is possible whenever the visual pollution is avoided.
3. Urging the Iraqi Communication and Media Commission to improve the standards or adopting one of the international standards for the cell phone towers safety limits, regarding the power, and distance.

Various disguised cell phone towers are used today among them:

1. Phoenix dactylifera palm pole tower.
2. Cocos plumosa palm pole tower.
3. Foxtail palm pole tower.
4. Phoenix reclinata palm pole tower.
5. Yellow wood tree pole tower.
6. Pine tree pole tower.
7. Cypress tree pole tower.
8. Lighthouse tower.
9. Greek island windmill tower.
10. Signage towers.

Usually, the cell tower trees are made from non-reflecting materials, for example, wood or plastic. Figure 5 shows photo of different disguised cell phone towers using different tree forms.

The type of communication cells, i.e., macro-, micro, pico-, and femtocells, and the volume of population density area is important factors to decide whether using disguised cell phone towers are feasible, or not. Disguised cell phone towers as trees are applicable in macro- and micro-cells more than in pico- and femto-cells.

Taking Koya city (Koy sinjaq, 36°04'59"N 44°37'47"E) as an example, three mobile operators are working in the city, i.e., Korek Telecom, Asiacell, and Zain. The population is between 50,000 and 100,000, according to Wikipedia. Figure 6 shows the Google plain and terrain maps of the city. It is obvious the maximum dimension of Koya city is less than 6 km, and that less than 30% of the city area is populated by humans. Besides its mountain nature, the city is of a horizontal expansion with low-density population, where no vertical expansion is seen. Although the cost of cell phone tower disguised as a tree is about 1.6 times the cost of undisguised cell phone tower (Young, 2016), which is a big concern for the mobile phone operator, the above-mentioned terrain nature and population density make the use of cell phone towers disguised as trees in Koya city feasible. Actually, it needs macro- and micro-cells more than pico- and femto-cells for mobile cellular communications.

It is possible to cover the cell phone communication of Koya entire area with a one or two macrocell base station towers, but the macrocell communication service is not available, only for few tens of users, at the same time. Accordingly, to give the cell phone communication services to hundreds and thousands of users at the same time, microcell coverage becomes essential. If not, picocells may be needed in very limited areas in the city. Moreover, the mountain nature of Koya city and its terrain makes the macrocell Inapplicable.

5. CONCLUSION

While moving toward a ubiquitous society where anyone can get information from anywhere at any time, cell phone towers have proliferated dramatically. By disguising cell phone towers as trees, we can achieve two goals. First, it will address visual pollution, thereby improving the esthetic quality of the urban environment. Second, it will help avoid the possible biological effect of the EMF emission of the cellular antenna on the human body. This paper showed the feasibility of using the camouflaged cell phone towers in the cities which need the macrocells and microcells for cellular communications more than the need of picocells and femtocells. Koya city, located in the northeast of Iraq having mountain nature and low population density, was considered as a case study.

REFERENCES

Al-Mously, S. I. (2010). *Computation of the Temperature-rise in the Human Head Due to Different Mobile Phone Models*. Guzelyurt: Conference 2010 10th Mediterranean Microwave Symposium, pp. 370-373.

Evaluating Compliance with FCC. (1997). *Guidelines for Human Exposure to Radio Frequency Electromagnetic Field, Supplement C to OET Bulletin 65 (edition 9701), Federal Communications Commission (FCC)*. Washington, DC, USA: FCC.

ICNIRP. (1998). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). *Health Physics*, 74(4), 494-522.

IEEE Standards Coordinating Committee. (2006). *Standard for Safety Levels with Respect to Human Exposure to Radiofrequency Electromagnetic Fields, 3 kHz to 300 GHz*. Piscataway, NJ: American National Standards Institute/Institute of Electrical and Electronics Engineers, Inc.

Islam, S. M. (2014). Awareness and self-reported health hazards of electromagnetic waves from mobile phone towers in Dhaka, Bangladesh: A pilot study. *Advances in Public Health*, 2014, 1-7.

Kumar, G. (2010). Cell Tower Radiation. Report Submitted to Secretary. New Delhi: DOT. Available from: https://www.ee.iitb.ac.in/~mwave/GK-cell-tower-rad-report-DOT-Dec2010.pdf. [Last accessed on 2019 Feb 01].

Levitt, B. B. & Lai, H. (2010). Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. *Environmental Reviews*, 18, 369-395.

Nagle, J. C. (2009). In: Dame, J. L. N, editor. Cell Phone Towers as Visual Pollution, Ethics and Pub. Pol'y 537. Switzerland, Geneva: International Telecommunication Union. Available from: http://www.scholarship.law.nd.edu/ndjlepp/vol23/iss2/7; Available from: http://www.itu.int. [Last accessed on 2018 Feb 01].

Singh, K., Nagaraj, A., Yousuf, A., Ganta, S., Pareek, S. & Vishnani, P. (2016). Effect of electromagnetic radiations from mobile phone base stations on general health and salivary function. *Journal of International Society of Preventive and Community Dentistry*, 6(1), 54-59.

Ustuner, F. (2011). Three dimensional safety distance analysis around a cellular base station. *PIERS*, 7(3), 117-128.

Wikle, T. A. (2002). Cellular tower prolifiration in the United States. *The Geographical Review*, 92(1), 45-62.

Young, L. (2016). Take a Look at America's Least Convincing Cell Phone Tower Trees. Tree Week. Available from: https://www.atlasobscura.com/articles/take-a-look-at-americas-least-convincing-cell-phone-tower-trees. [Last accessed on 2019 Apr 17].

Zhang, M.M. (2013). Photos of Cell Phone Towers Disguised as Fake Trees. Available from: http://www.petapixel.csom/2013/06/06/photos-of-cell-phone-towers-disguised-as-fake-trees. [Last accessed on 2018 Feb 01].