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ASSESSMENT OF ELECTROMAGNETIC FREQUENCIES IN OFFICE SPACES

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ABSTRACT

Recent research in the area of indoor environmental quality, shows that building spaces hosts a plethora of electromagnetic fields and radiation (EMF/R) that are emanated from different electric sources and electronic devices, especially those that operate wirelessly. Studies show that office spaces represent the extreme cases of this phenomenon. This is due to the many different devices and sources utilized in working spaces could generate diverse and multi-level negative impacts on occupants' health and well-being. This paper represents an objective endeavour to further investigate the phenomenon, through quantitative and qualitative assessment techniques, within a specific experimental case study (medium size office). The case study procedures included identification of EMF/R sources, measuring their emitted outflows, and combined effect on different selected locations, as they provide for level of exposure subjected on occupants. Results of the case study have clearly revealed a positive spatial correlation between types, numbers and locations of electronic devices and the levels of EMF/R exposure at occupants seating locations. These results open a window for adequate designing of corresponding measures for mitigation of EMF/R impact, as attuned to location and intensity.

KEYWORDS: Office Spaces, Exposure levels, Electromagnetic Fields/Radiation, Frequencies

تقييم الترددات الكهرومغناطيسية فى فراغات العمل

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الملخص

آخر الدراسات فى مجال البيئة الداخلية للمباني اشارت الى ان الفراغات الداخلية تحتوى على مستويات عالية من الطاقات الكهرومغناطيسية التي تنبعث من أجهزة ومصادر إلكترونية خاصة التى تتحرك من خلال المجال الهوائي (wireless) و ان فراغات العمل الخاصة بالمكاتب هى الأولى فى احتواء اعلى مستويات الطاقة الكهرومغناطيسية مقارنة بأنواع الفراغات الأخرى. هذه الورقة تقدم دراسة تطبيقية لكمية ونوعية الطاقة الكهرومغناطيسية داخل فراغ عمل تم اختياره للتحقيق فى التساؤلات المطروحة. الدراسة اشتملت تحديد كل أنواع المصادر المصدرة للطاقة الكهرومغناطيسية، اماكنها و قياس ترددها فى مختلف أماكن فراغ العمل، و ايضا قياس التردد الذى يحيط كل شخص من أفراد طاقم العمل. الدراسة التطبيقية اوضحت ان يوجد ارتباط وثيق بين كمية و نوعية الأجهزة الإلكترونية و مكانها داخل فراغ العمل و أماكن أفراد طاقم العمل. نتائج الدراسة تفتح المجال لتطوير مناهج تصميم فراغات العمل مما يقلل من التعرض السلبي للطاقات الكهرومغناطيسية المنبعثة.

الكلمات المفتاحية : فراغات العمل، الطاقة الكهرومغناطيسية، ترددات الطاقة الكهرومغناطيسية

1. INTRODUCTION

The demand of fast communication and advanced data transformation have pushed the industry to heavily rely on utilizing electromagnetic technologies [1]. However, the excessive increase of it's use have saturated living and working spaces with immense amount of electromagnetic fields/radiation (EMF/R). The intensity of these energies is another concern as different devices and sources operate at different gadgets [2]. Although There are international standards for the frequency intensity that these sources produce, but their impact on human health remains a debatable topic. There are plenty of studies showing that exposure to EMF/R of our modern technology has many different health problems [3-18]. Although this paper is not investigating the health impact associated with EMF/R intensity, but it is concerned with the exposure levels subjected on the space users, particularly in office spaces. Interestingly, when it comes to the spaces that hosts the highest amount of EMF/R, office spaces comes on the top of the list, followed by medical clinics and schools [19].

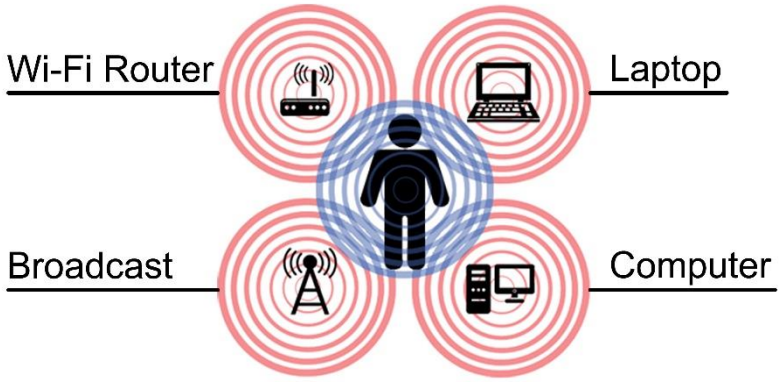


Figure 1: Some sources/devices that emanates EMF/R in Work spaces.

Source: www.iyashisource.com

The EMF/R emanating from different sources end up being consumed by the human body, due to the carrier wave component of these frequencies [20]. Some devices if used by one worker, would typically be used by most of the other workers – mostly associated with desk/working station such as (Computer desktop, DECT Phones, lamp desktop, and electrical cables supplying these devices). Other devices could be used without being associated with the workers count and usually serves the needs of a group or covers a wider area of the office space, such as (WiFi router, servers, and printers) [21,22]. Nonetheless, some particular workers could be using other devices that adds another source of EMF/R to their location, such as wireless (keyboard, mouse, speakers, and headphones). Therefore the personal exposure levels to EMF/R can significantly vary from one worker to another. This paper focuses on the devices sources that is commonly used by most workers in an office space, excluding the exceptional uses of non-typical devices.

There are different tools to measure the EMF/R levels. Some tools are used to measure within a space, and these are called "Electrosmog meters" (Figure 2), which usually measures radio frequencies in volt/meter (V/M), and micro tesla (μT) for magnetic fields, or milli Gauss (mG) [23]. Other tools like "Exposimeters" (Figure 3) are used to track the exposure subjected on a specific user. Usually this meter is accompanied by the monitored user while they are moving from one place to another, so they can determine how much EMF/R his body was exposed to during a certain period of time (hour, day, or longer) [2].

Figure 2: Types of Electrosmog meters.

Source: www.wavecontrol.com / www.helseforhandleren.no

Figure 3: Types of Exposimeters.

Source: www.wavecontrol.com / www.fieldsatwork.ch

While investigating the EMF/R exposure in office spaces, Koppel, Tasa and Tint [2] utilized exposimeters by placing 14 measuring points on the human body covering area from Head, Torso and Limbs. They conducted scanning for different individuals in 69 office spaces with different low, medium and high EMF/R. The study indicated that the exposure levels are directly connected with the type of appliance or electrical device and the intensity of it's EMF/R. The limbs parts of the body had higher exposure levels for electromagnetic fields due to being near to the working desk station power/electric sources, while the head and neck had lower exposure. However, when it comes to measured frequencies and radio waves, the head and neck had higher exposure levels (Figure 4).

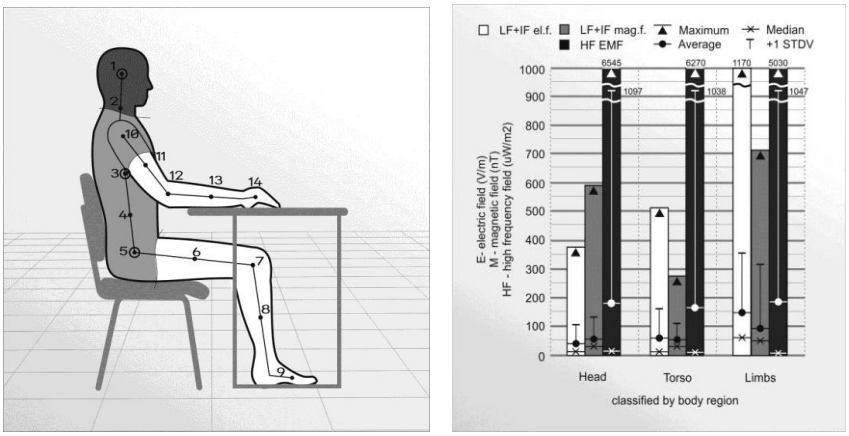


Figure 4. The 14−point measurement system by Koppel. Points are distributed into body regions as characterized by the vulnerability to the EMFs: head, torso, limbs.

Source: [2].

Within this context, the paper is driven by a few questions: Does personal exposure to EMF/R in an office space varies between one location to another? Are all workers exposed equally? Are some devices/sources radiate different frequencies than the other? The paper tries to address these questions by conducting an experimental study in a selected office space. The methodology of this experimental study will include the following phases;

- Devices Survey
- Frequencies Spatial Survey
- Frequencies Selective Survey
- Analysis and Assessment

2. SELECTED CASE STUDY

The selected office space is on the 4th story of a large commercial building with total 6 stories, which occupies many offices and retail spaces. The building is located in Brooklyn Borough, New York City, NY, USA. The selected office space has a total gross area of the space is 1,842 square feet (sq.ft.), and it occupies an architecture design firm (Figure 5). The space boundary walls have a rectangular shape, where there are windows on one side overlooking the street, and on the opposite side wall is shared with the common corridor. The two other walls are shared with adjacent office spaces. The interior layout is divided into three main areas. First is the “Reception” area which is right at the office entry door and it has 2 working desks. Second is the “Private offices” area which includes 2 enclosed offices, each with 1 working desk and one conference room. Third is the “Open Space” area, which includes the open office occupying 20 working desks. The office’s total of 24 working desks.

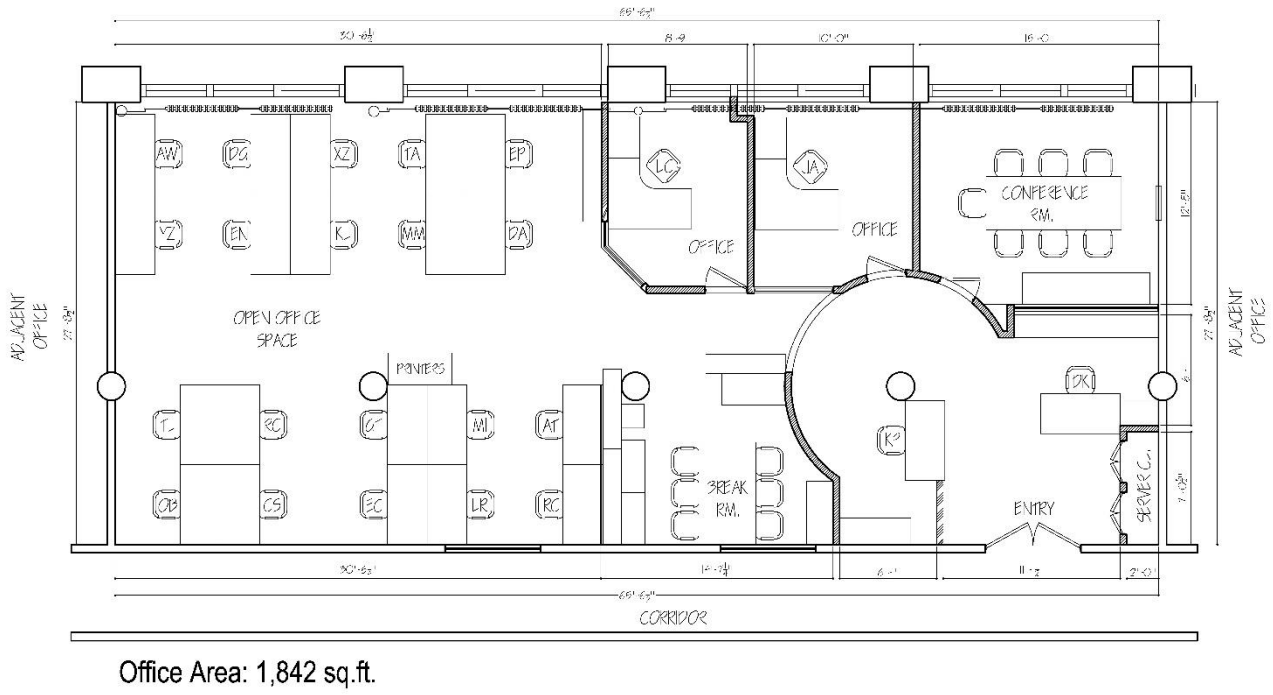


Figure 5: The office space floor plan.

Two phases of the study includes measuring the electromagnetic (EM) frequencies in the office space - conducted using the "Cornet" electrosmog meter (Figure 6). This will be recorded in the unit measure of Volts/Metre (v/m). The cornet is a high efficient device that is light and easy to use while measuring withing an open space walkthrough.

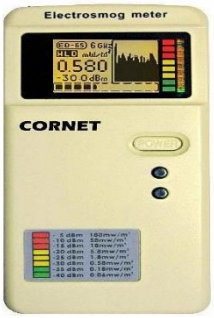


Figure 6: Electrosmog meter Cornet

Source: www.helseforhandleren.no

2.1. Devices Survey

This phase conducted a full survey of the space to determine and locate all devices and sources that produces or emanate electromagnetic fields/radiation (EMF/R). Total of 15 sources were found. 7 sources are related to the electricity supply for the space such as (electric outlets and cables, extension cords, internet outlet and the electrical panel), and 8 sources are stationed devices or fixtures such as (computer monitors and desktop, lamps, WiFi router, server, TV, printer, and microwave). Figure 7 shows their locations on the floor plan and the legend that describes each source. Some additional devices were found like cell phones, but they were excluded from the survey as they are personal items, and does not belong to the office equipment.

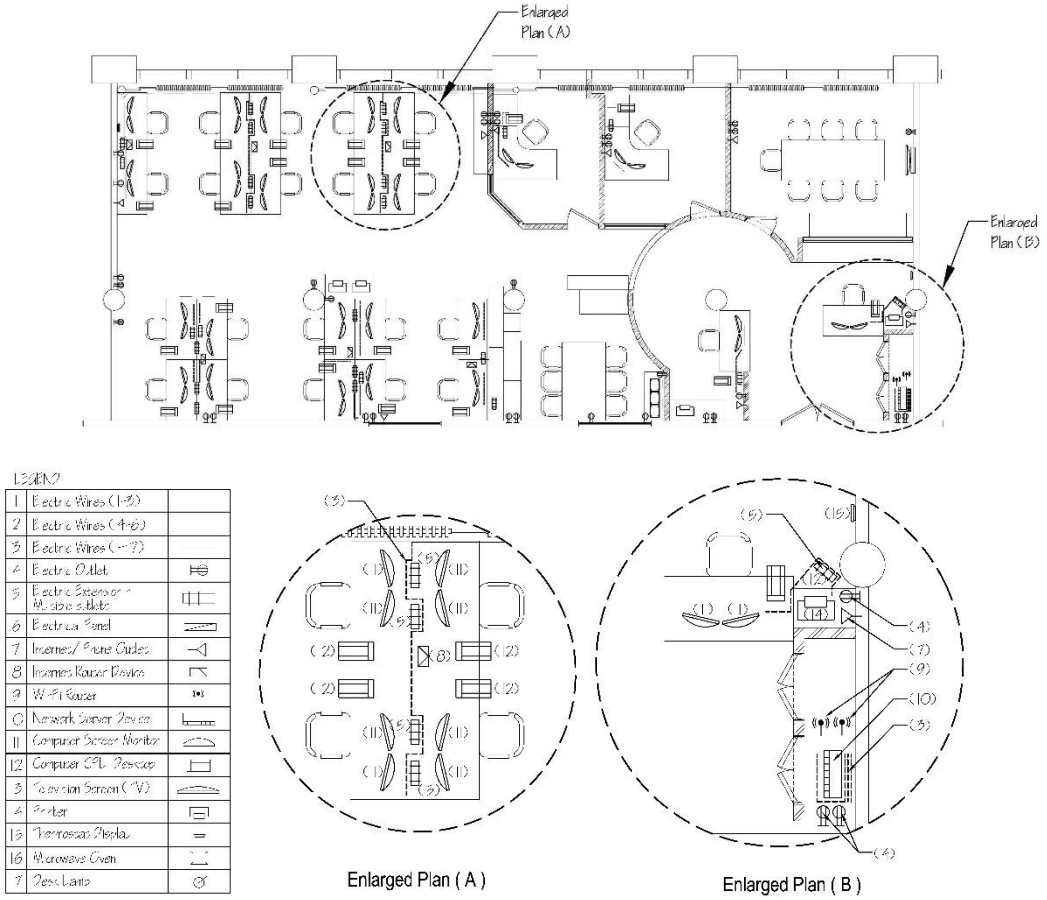


Figure 7: The space floor plan showing sources & devices emanating EMF/R.

Electric cables were found in different density. Some were grouped in 3 cables, and some were grouped in 7 or more cables. Since the expected EMF emanations would be higher from multiple grouped cables, then they were classified in the survey into 3 types. The enlarged plan “A” in figure 6 shows that each worker had by their desk the following (2 computer monitors, 1 CPU desktop, cabled router, and an average of 6 electric cables). While the enlarged plan “B” in figure 6 shows that main Wi-Fi router and server are located at one specific place - in a closet by the entry door. Figure 8 shows an image from the office space for both the working desks and Wi-Fi closet. Also the printers were at one specific location. Looking at the conference room, it has less amount of devices - only the TV, and the break room had the least amount of devices - only the microwave, which is used only at specific times during the day.

Figure 8: Each desk has 2 computer monitors, electric cables, and PC desktop. The server and Wi-Fi router are placed in a closet by the office entry door.

2.2. Frequencies Spatial Survey

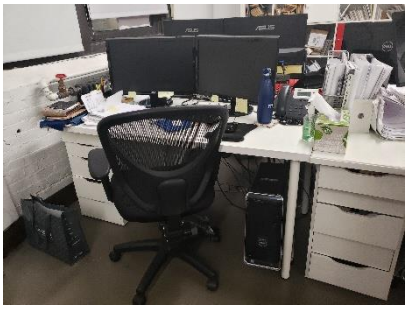
This phase of the study used the electrosmog meter (Cornet) to measure the electromagnetic (EM) frequencies in the office space. The meter was held at 6 feet above the floor level, and measurements were recorded in Volt/Meter (v/m) during a walk through which covered every area in the office space. This was conducted to categorize the office space into zones that could possibly have varying frequency levels. Figure 9 Shows the different ranges of EM frequencies recorded at different areas. This classification shows approximately eighty percent (80%) of the recorded readings ranging between 0.1 v/m to 2.0 v/m, while twenty percent (20%) are above 2.0 v/m and up to 26.0 v/m. It is noticeable that there are some small areas showing high EM frequency compared to the large spans with intermediate range. It is also noticeable that there is a small area at the entry space, close to the closet that occupy high EM frequencies. Measurements were conducted twice at different times of the day to verify that the detected measurements are not significantly interchangeable. In both times there was only a slight difference within a range of 0.1 v/m (+/-).

Figure 9: EM frequency measurements throughout the office space in v/m

Units in V/M
(Volt/Meter)

2.3. Frequencies Selective Survey

Workers are at the office 5 days per week, 7 hours each day, and most of their time is spent seated at their desks. Accordingly, this selective survey was also conducted using an electrosmog meter (Cornet) to measure the EM frequencies, but this time the measurements are taken at each of the worker's seating desk location. Since the frequencies can slightly adjust, the measurements were taken at three different heights from the floor level of the worker's chair, to determine the average frequencies each worker is exposed to. Figure 10 Shows the different heights of each measurements (at 3 feet, 5 feet & 6/7 feet). Figure 11 shows the average of the 3 measurements at each desk's seat.



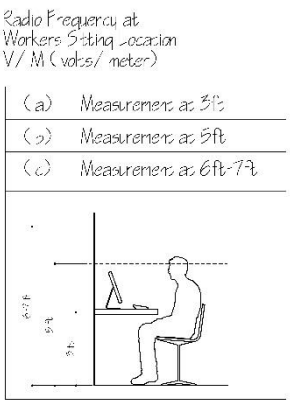


Figure 10: Electromagnetic frequencies measured at the chair location at 3 different

Units in V/M

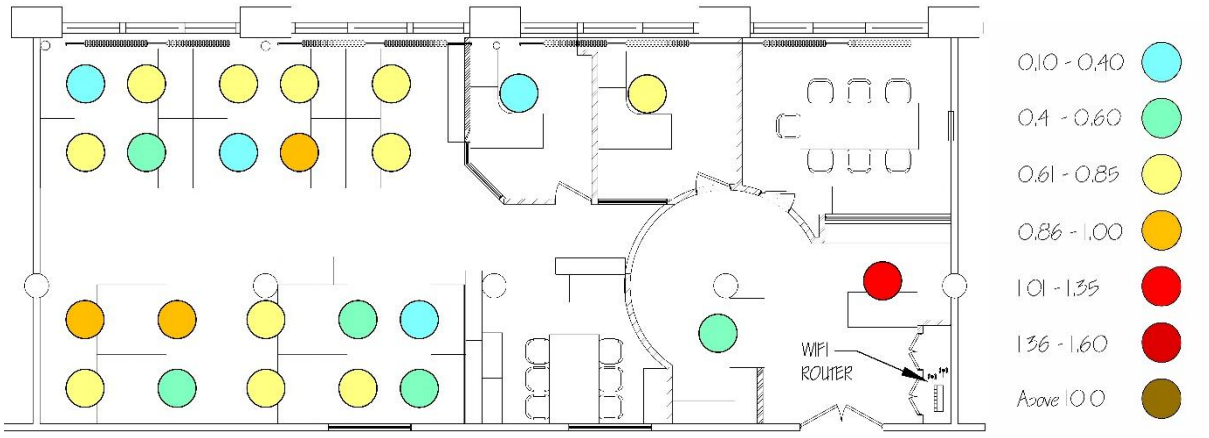


Figure 11: Average radio frequency measured at the chair of each working station.

2.4. Analysis and Assessment

The spatial survey measurements using the electrosmog meter indicates that the EM frequencies were high at the "Reception area", and the highest recorded reading was found close to the Wi-Fi router at 26.0 v/m. Also the intensity of the frequencies increases when moving closer to the Wi-Fi and reduces moving farther away from it. On the other hand, the EM frequencies were low at the "Break Room" area, and the lowest recorded reading was at 0.1 v/m. The rest of the office space showed fluctuating readings between 0.1 v/m and 2.0. When these readings

compared to the location of electronic devices in the space, the Wi-Fi router is the only device type that has a clear and direct relation to the increase of EM around it. But for the other readings, although they fluctuate immensely, but it is hard to find specific relation between one device type and an increase in the frequencies. Accordingly, the intensity of electromagnetic frequencies in the office space can be categorized into 3 zones "Low – Medium – High" (Figure 12).

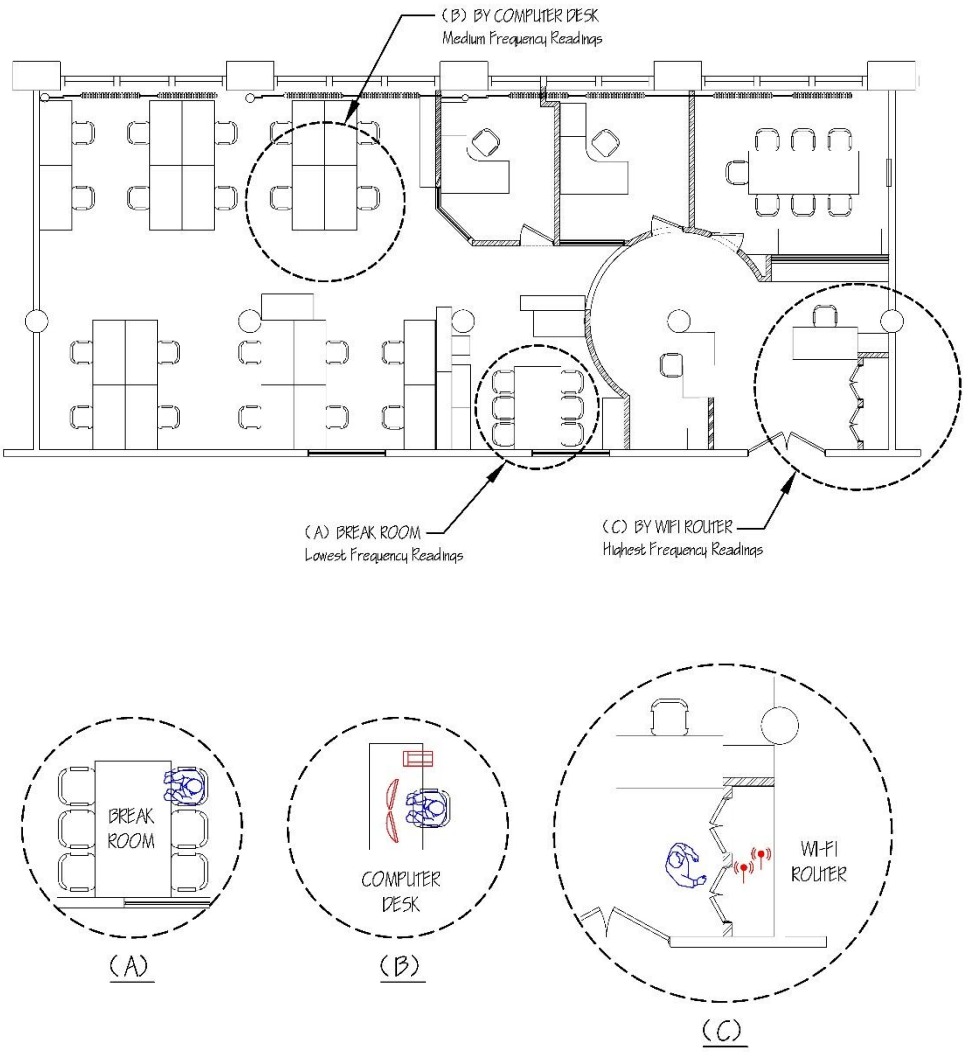


Figure 12: Identified zones with 3 different EM ranges (Low, Medium & High)

In addition, there were few areas that showed significant increase in the EM frequencies that was not associated with a specific device or source. This indicates that there is interference of other EM frequencies. It can possibly be caused by EM devices that are in the office space but operates wirelessely, or Wi-Fi EM frequencies that are coming from other adjacent office spaces - like in a floor below or above, or right or left – considering that they also host Wi-Fi routers. Figure 13 shows a building section illustrating how this interreference can happen from Wi-Fi routers located in adjacent office spaces. Also another indicator of the interreference, is due to visibility of other Wi-Fi networks on electronic devices while being at the office space of study.

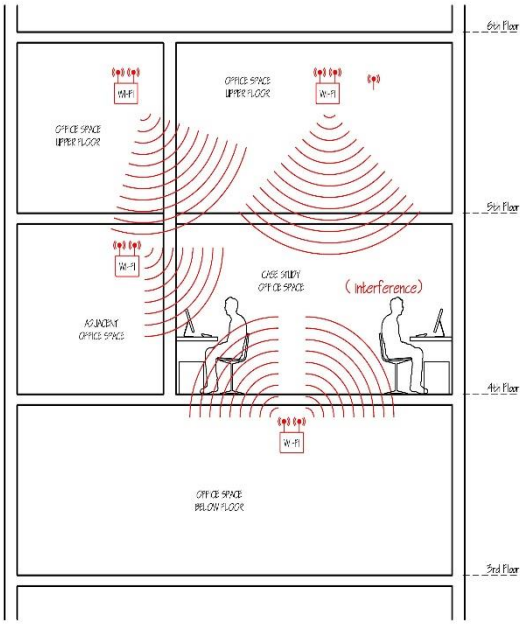


Figure 13: EM frequencies from other adjacent office spaces interfering and increasing exposure levels.

The selective survey which measured the location of each worker's desk, particularly at the chair location, indicates that workers are exposed to a varying EM frequencies as follows;

- Range of 0.1 v/m to 0.4 v/m……..4 workers (17%)
- Range of 0.41 v/m to 0.6 v/m……5 workers (20%)
- Range of 0.61 v/m to 0.85 v/m……11 workers (46%)
- Range of 0.86 v/m to 1.0 v/m……..…….3 workers (13%)
- 10 v/m or more……1 worker (4%)

SUMMARY AND CONCLUSIONS

This paper presented an experimental study and outlined a methodology for testing the electromagnetic frequencies levels in a selected office space. From the survey and data collected, 15 different sources emanating electromagnetic fields/radiation (EMF/R) were detected. The spatial measurements using an electrosmog meter showed different ranges of EM frequencies in the office space, where the "Break room" area occupied the lowest levels due to

lower amount of electronic devices, and the entry/reception area occupied the highest levels due having the Wi-Fi router close by, while the remaining areas in the office occupied a medium range levels – typically hosting working computers and cables for electric supply (Figure 8). Some intermediate areas showed significant increase in EM frequencies, which can possibly be associated with waves "Interference", involving both wireless devices in the selected office space and adjacent offices (Figure 13).

The study finds that Given that the radiation impact reduces when moving away from the router, therefore the farther being located from the router, the less exposure is subjected. It is recommended that the minimum distance in an office space between any worker and the Wi-Fi router to be not less that 22 feet (Figure 14). This distance is based on the electromog meter readings, which was at reasonable levels at 22 feet clearance.

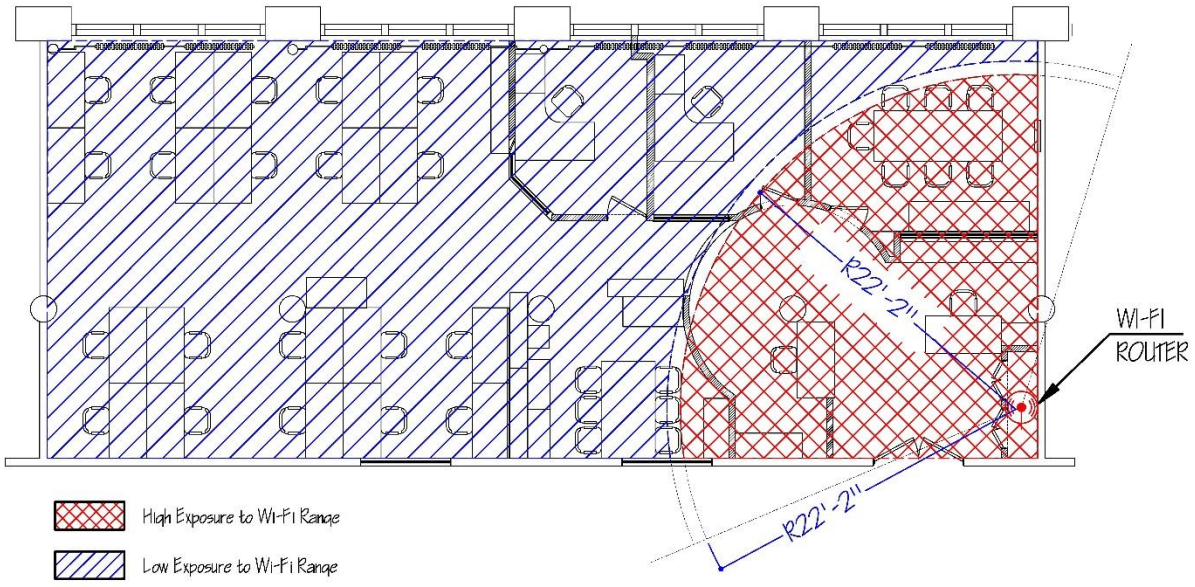


Figure 14: Recommended minimum distance of working desks from Wi-Fi routers.

The paper summarizes the study's analysis and addresses the paper's queries with the following conclusions.

1. All workers in the office space are exposed to a certain amount of electromagnetic fields/radiation (EMF/R).
2. The EMF/R intensity is the lowest at the Break Room, and highest by the Wi-Fi closet, and medium by the Computer desk station.

3. Worker located closer to the Wi-Fi router had the highest exposure levels to of EMF/R in the office space.
4. Electronic devices in the office space emanate different levels of EM frequencies, and the Wi-Fi router emanates the highest and strongest amount of EM frequencies.
5. Personal exposure to EMF/R in an office space do vary from one location to another, therefore workers are not equally exposed to the same amount of electromagnetic EMF/R.
6. Detected EM frequencies are caused by both devices within the office space, as well as devices that are in adjacent office spaces.

Recommendations

- To avoid locating workers' desks close to the Wi-Fi's router. The farther the better. Recommended minimum distance of 22 feet.
- Developing guidelines for designing office spaces to reduce workers exposure to EMF/R.
- Conduct health assessment measures for workers to identify the health impact of EMF/R in office spaces.
- Find new mitigation methods to reduce the negative impact of EMF/R exposure in office spaces.

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