



**UNIVERSITI PUTRA MALAYSIA**

***THE EFFECTS OF RADIO FREQUENCY (RF) RADIATION FROM  
MOBILE BASE STATION ON DNA DAMAGE AND ITS HEALTH  
EFFECTS AMONG PRIMARY SCHOOL CHILDREN IN SELANGOR***

**NUR AZIRA BINTI BAHARUDDIN**

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**NUR AZIRA BINTI BAHARUDDIN**

**DEPARTMENT OF ENVIRONMENTAL AND OCCUPATIONAL  
HEALTH**

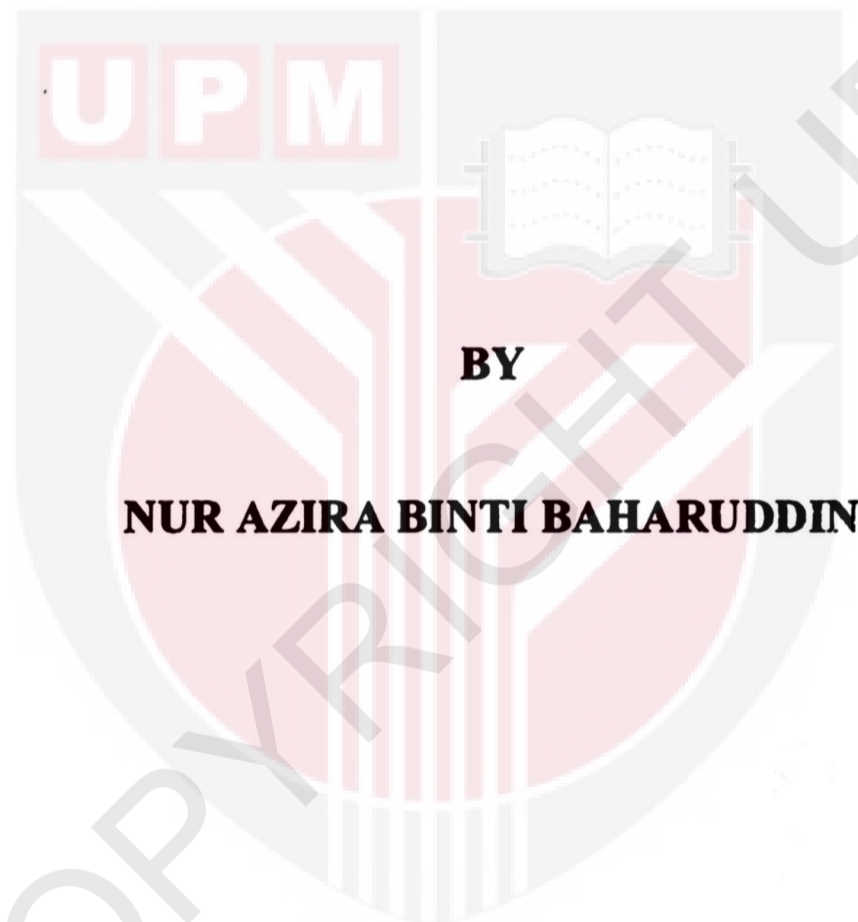
**FACULTY OF MEDICINE AND HEALTH SCIENCES**

**UNIVERSITI PUTRA MALAYSIA**

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EFFECTS AMONG PRIMARY SCHOOL CHILDREN IN SELANGOR**



**BY**

**NUR AZIRA BINTI BAHARUDDIN**

**Thesis submitted in fulfilment of the requirement for the degree of Bachelor  
Science (Environmental and Occupational Health ) from the Faculty of  
Medicine and Health Sciences, Universiti Putra Malaysia**

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## ABSTRAK

### KESAN PENDEDAHAN RADIASI RADIOFREKUENSI DARI MENARA SISTEM TELEKOMUNIKASI KEPADA KEROSAKAN DNA DAN KESAN KEPADA KESIHATAN DALAM KALANGAN KANAK-KANAK SEKOLAH RENDAH DI SELANGOR

NUR AZIRA BINTI BAHARUDDIN

**Pengenalan:** Peningkatan penggunaan dan permintaan telefon bimbit telah meningkatkan pemasangan menara sistem telekomunikasi sebagai pemancar rangkaian telefon bimbit. Walaupun terdapat kebimbangan tentang risiko kesihatan yang mungkin disebabkan oleh tinggal berhampiran menara sistem telekomunikasi. Kesan pelepasan radiasi radiofrekuensi (RF) dari menara sistem telekomunikasi ini masih tidak menentu dan isu yang agak kontroversi. **Objektif:** Tujuan kajian ini adalah untuk mengkaji kesan radiasi radiofrekuensi dari menara sistem telekomunikasi kepada kanak-kanak sekolah dengan menyelidik frekuensi mikronuklei (MN) dalam sel mukosa buccal dan potensi kesan kesihatan di kalangan kanak-kanak sekolah rendah di Selangor. **Kaedah:** Pensampelan rawak berstrata digunakan untuk mengumpul sejumlah 201 kanak-kanak sekolah rendah yang kemudiannya dikumpulkan ke dalam kumpulan terdedah dan tidak terdedah berdasarkan kewujudan menara sistem telekomunikasi yang terdapat di kawasan sekolah mereka. Dalam konteks ini, kumpulan terdedah adalah kanak-kanak sekolah yang sekolahnya terletak di sekitar menara sistem telekomunikasi (<200 meter) dan kumpulan tidak terdedah adalah di kalangan kanak-kanak di mana kawasan sekolah jauh dari menara sistem telekomunikasi (> 200 meter). Pengukuran radiasi diukur pada setiap jarak 10m bermula dari sekolah ke 200m dengan menggunakan *Digital Analyzer RF (Model HF35C)*. Satu set borang soal selidik digunakan untuk mengkaji latar belakang sosio-demografi, sumber lain radiasi tanpa pengionan di rumah dan kesan kesihatan yang dilaporkan sendiri dalam kalangan kanak-kanak sekolah. Sel mukosa buccal dari rongga mulut diambil untuk menilai frekuensi mikronuklei dengan menggunakan *Micronuclei Assay*. **Keputusan:** Nilai radiofrekuensi menunjukkan corak yang berbeza di antara sekolah yang terdedah dan tidak terdedah semasa persampelan pada hujung minggu dan hari persekolahan. Secara keseluruhannya, kumpulan tidak terdedah mempunyai kiraan frekuensi mikronuklei (MN) (11.50) lebih tinggi berbanding dengan kumpulan terdedah (6.50). Tidak ada persamaan penting antara frekuensi MN dan RF dengan perkaitan yang lemah ( $r=0.097$ ) dilaporkan. Latar belakang sosiodemografi, sumber isi rumah radiasi tanpa pengionan dan kawasan kediaman mereka tidak menunjukkan perkaitan yang signifikan dengan frekuensi mikronuklei, bagaimanapun, hubungan yang signifikan antara masalah kehilangan rambut dengan frekuensi mikronuklei dikenalpasti dalam kajian ini. **Kesimpulan:** Perubahan ukuran tahap RF bergantung kepada titik tempat pemasangannya, dan tetapan persekitaran sekitarnya. Sumber RF dari menara sistem telekomunikasi sahaja tidak mencukupi untuk menyimpulkan potensi kerosakan DNA dalam konteks ini, sebenarnya, sumber radiasi lain yang tidak mengion dan faktor penyumbang yang mungkin mempengaruhi frekuensi MN akan diambil kira untuk menilai potensi kepada kesihatan pada masa akan datang.

**Kata kunci :** menara sistem telekomunikasi, radiasi radiofrekuensi, mikronuklei, kanak-kanak

## ABSTRACT

### THE EFFECTS OF RADIOFREQUENCY (RF) RADIATION FROM MOBILE BASE STATION ON DNA DAMAGE AND ITS HEALTH EFFECTS AMONG PRIMARY SCHOOL CHILDREN IN SELANGOR

NUR AZIRA BINTI BAHARUDDIN

**Introduction:** The increase of mobile phone usage and demands has increased the installation of the mobile base station as the cellular phones' network carrier. Even though there is growing concern about the health risks that may be caused by living nearby a mobile base station. The effect of radiofrequency (RF) radiation emission from this mobile base station is still highly uncertain and controversial. **Objective:** The purposes of this study is to examine the effect of (RF) radiation from mobile base station to school children by investigating the micronuclei (MN) frequencies counts in buccal mucosa cells and its potential health effects among primary school children in Selangor. **Method:** Stratified random sampling were used to gather a total of 201 primary school children which were then grouped into exposed and non-exposed groups based on the existence of mobile base station found in their school territory. In this context, exposed group are school children whose school located in the vicinity of mobile base station (<200 metres) and non-exposed group were among school children whose school located distant from the mobile base station (>200 metres). RF measurements were measured at each 10m intervals starting from the school to 200m by using the Digital RF Analyzer (Model HF35C). A set of questionnaires were also used to examine the socio-demographical background, other sources of non-ionizing radiation and self-reported health effects among school children. The buccal mucosa cells from the oral cavity were sampled to evaluate the micronuclei frequencies by using Micronuclei Assay. **Result:** The RF values shows different RF pattern among both exposed and non-exposed school when sampling during weekend and schooling days. Overall, the non-exposed group has a higher median (11.50) of MN frequency count as compared to the exposed group (6.50). There is no significant association between MN frequency and RF level with relatively weak association ( $r=0.097$ ) reported. The socio-demographic backgrounds, household sources of non-ionizing radiations and their residential settings shows no significant association with micronuclei frequency, however, a significant association between hair loss problems with micronuclei frequency were found in this study. **Conclusion:** The fluctuations of RF levels depend on its fixed point of installation, and the surrounding environmental settings. Single source of RF from mobile base station is insufficient to conclude the potential DNA damage in this context, in fact, other sources of non-ionizing radiations and contributing factors that might affect the MN frequency shall be taken into consideration to better estimation of the potential health effects in the future.

**Keywords:** *mobile base station, radiofrequency radiation, micronuclei, children*

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## LIST OF ABBREVIATIONS

RF	Radiofrequency
EMR	Electromagnetic radiation
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
FCC	Federal Communication Commission
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IARC	International Agency for Research on Cancer
IEEE	Institute of Electrical and Electronics Engineers
MWR	Microwave radiation
MN	Micronuclei
HPS	Health Physics Science
GHz	gigahertz
kHz	kilohertz
WHO	World Health Organization
CNS	Central Nervous System

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background**

Malaysia is almost to achieve its goal towards Vision 2020 which will be a new benchmark for Malaysia as a developed country. Obviously, there are many impressive changes from many years ago until now, 2017. Those changes also included the development of the mobile communication technology and led to the substantial growth of the number of mobile base station tower. Users of mobile phones are exposed to radiofrequency (RF) electromagnetic radiation (EMR) which is the transfer of energy by waves. Based on the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (n.d.), RF EMR is emitted at frequency range between 3 kilohertz (kHz) to 300 gigahertz (GHz). Radiofrequency mainly used for telecommunication purposes. Examples of radiofrequency radiation sources are radio and television broadcasting, mobile phones, pagers, cordless phones, microwave ovens and others.

In Malaysia, the antennas of the mobile base station are usually mounted on towers or on the rooftops of buildings. It is expected that numbers of mobile base stations will be erected and the concern of the general public relating to the health effects of exposure to RF radiation will increase since the recent launch of the third generation (3G) system (Man and Radiman, 2005). Furthermore, mobile base

stations also mounted on or near the school area which is considered as restriction area since children can be categorized as susceptible group. According to World Health Organization (WHO), children categorized as susceptible group because they are constantly growing and breathe more air, consume more food and drink more water than adults in proportion of their weight. The children's central nervous, immune, reproductive and digestive systems are still developing and they behave differently from the adults and have different patterns of exposure. They also have little control over their environment. Unlike adults, they may be both unaware of risks and unable to make choices to protect their health.

Therefore, this study aims to identify the possibility of radiofrequency (RF) radiation from mobile base station that can affect the DNA damage and its health effects among primary school children.

## **1.2 Problem Statement**

Users of mobile telephones are exposed to radiofrequency (RF) electromagnetic fields in a daily basis. Although the average exposure levels are lower than the recommended exposure limits as suggested by Federal Communication Commission (FCC) and International Commission on Non-Ionizing Radiation Protection (ICNIRP), the rapid increase of personal telecommunication devices has activated the discussion on the possible health risks especially on the chronic and accumulative low level of RF radiation exposure at the early age among our children.

In view of this, this study targeted the primary school children as the vulnerable group in this context. Children spent more time at school during their

childhood development, therefore, it is presumed that schools which located at the vicinity of mobile base station are exposing their school children to low level and cumulative effects to health. This assumption is supported by consistent epidemiologic evidence which highlighted the existing association between childhood leukaemia when expose to extremely low frequency (ELF) magnetic fields. Even though studies have reported cancer-enhancing effects of RF exposure in transgenic mice but these findings are so far inconclusive, especially since replication studies were not able to confirm these results (Verschaeve, 2005).

To date, alongside with the well-recognized benefits of mobile phones and the emerging needs of installing mobile phone base station, questions have been raised about possible health effects, especially after prolonged exposure. However, study by Kheifets et. al. (2005) suggested his concerns about the potential vulnerability of children to RF fields because of the potentially greater susceptibility of their developing nervous systems, plus, their brain tissue is more conductive, RF penetration is greater relative to head size, and they will have a longer lifetime of exposure than adults.

Therefore, children consider at greater risk since they have longer exposure to carcinogens than adults, since the younger the child, the higher the risk. There are multiple studies showing that children absorb more microwave radiation (MWR) than adults. In 1996, a study reported that the absorbed MWR penetrated proportionally deeper into the brain of children age 5 and 10 compared to adults' brain. Furthermore, in 2010, Christ and team reported children's hippocampus and hypothalamus absorbs 1.6–3.1 times higher and the cerebellum absorbs 2.5 times higher MWR compared to adults', children's bone marrow absorbs 10 times higher

MWR radiation than in adults, and children's eyes absorb higher MWR than adults (Morgan, Kesari, & Davis, 2014).

Having only a few reports of apparent cancer clusters near a mobile base station, it is still difficult to interpret the causal-effect relationship as only small numbers were reported and possible selection and reporting biases were frequently been highlighted (Elliott and Wartenberg, 2004). Also, there is no known radiobiological explanation following these studies (Regel et al., 2006; Elliott et al., 2010). However, the chronic health concerns has continuously highlighted by scientists, until recently, the International Agency for Research on Cancer (IARC) reviewed all relevant scientific literatures on the carcinogenic potential of RF exposure *in vitro* as well as *in vivo* in animals and humans. Based on the limited evidence of an association between mobile phone use and cancer in both human and animal investigations, RF exposure is classified as a possible human carcinogen (class 2B). Following the scientific review, national and international expert groups of scientists have recommended a precautionary approach as well as some further research (Vijayalaxmi, 2016).

This study primarily targeted primary school children as they are among the most vulnerable group of community who spend most time in school, especially when the school sessions is about 7 to 8 hours and some of the children stay back in school for extra-curricular. According to the Education Ministry, at May 31, 2013, there were 1,503 1BRIS (1BestariNet Receiver Integrated System) towers had been built and were in operation, while 281 had been built but not yet operational. As at June 2013, there were increased to 7,139 schools that had already been equipped with 1BestariNet. Most of the mobile base station pole is installed with no buffer

distance consideration, for instance, some were found near to the classroom at the school environment. Environmental activist claimed that the increases of mobile phone base station installation in the country are simply due to the country development needs without proper health risk assessment consideration. Since children are starting to use mobile phones at an early age, the main difference between today's children and adults regarding the use of mobile phones is the longer lifetime exposure of children when they grow older. Due to the competition between network providers, the use of mobile phones is becoming cheaper and cheaper, leading to an increased use of mobile phones not only among the adults, but also children and adolescents (Chiu et. al., 2015).

### **1.3 Study Justification**

Previous reports of apparent cancer clusters near mobile phone base stations are difficult to interpret because of small numbers and possible selection and reporting biases. Also, there is no known radiobiological explanation for such cancer excesses. Instead of studying the reported cancer incidence, this study choose to use micronuclei assay as the indicative of early cancer risk of DNA damage by investigating the micronuclei frequency count presented on buccal mucosa cells of our school children. This may avoid cancer clusters' selection biases and reporting biases found at previous studies.

Besides, this study measured the RF level each at 10m starting from one fixed point near to school until it reached 200m distant from school territory. Alongside the RF measurement, the environmental settings and other potential contributing factors which might affect the RF level variation were also observed. The output of

this would help to understand the background of environmental RF exposure and how does this exposure pattern affecting our children health in a long-term basis.

This is by far, the first study in Malaysia which examines the early cancer risk by investigating the MN frequency among school children as an indicator of early DNA damage. In fact, it contribute as the idea or benchmark on “exposure of RF radiation on DNA damage and other self-reported health effects/symptoms” due to chronic exposure to sources of non-ionizing radiation from mobile base station. . The input from this study output will definitely help to provide insight to public about the effects of RF radiation on their children health from long term exposure.

In fact, this study is crucial and necessary as it help to place any future reports of any health effects near mobile phone base stations in a wider environmental health context by examining the suitability of mobile base station installation at any fixed location.

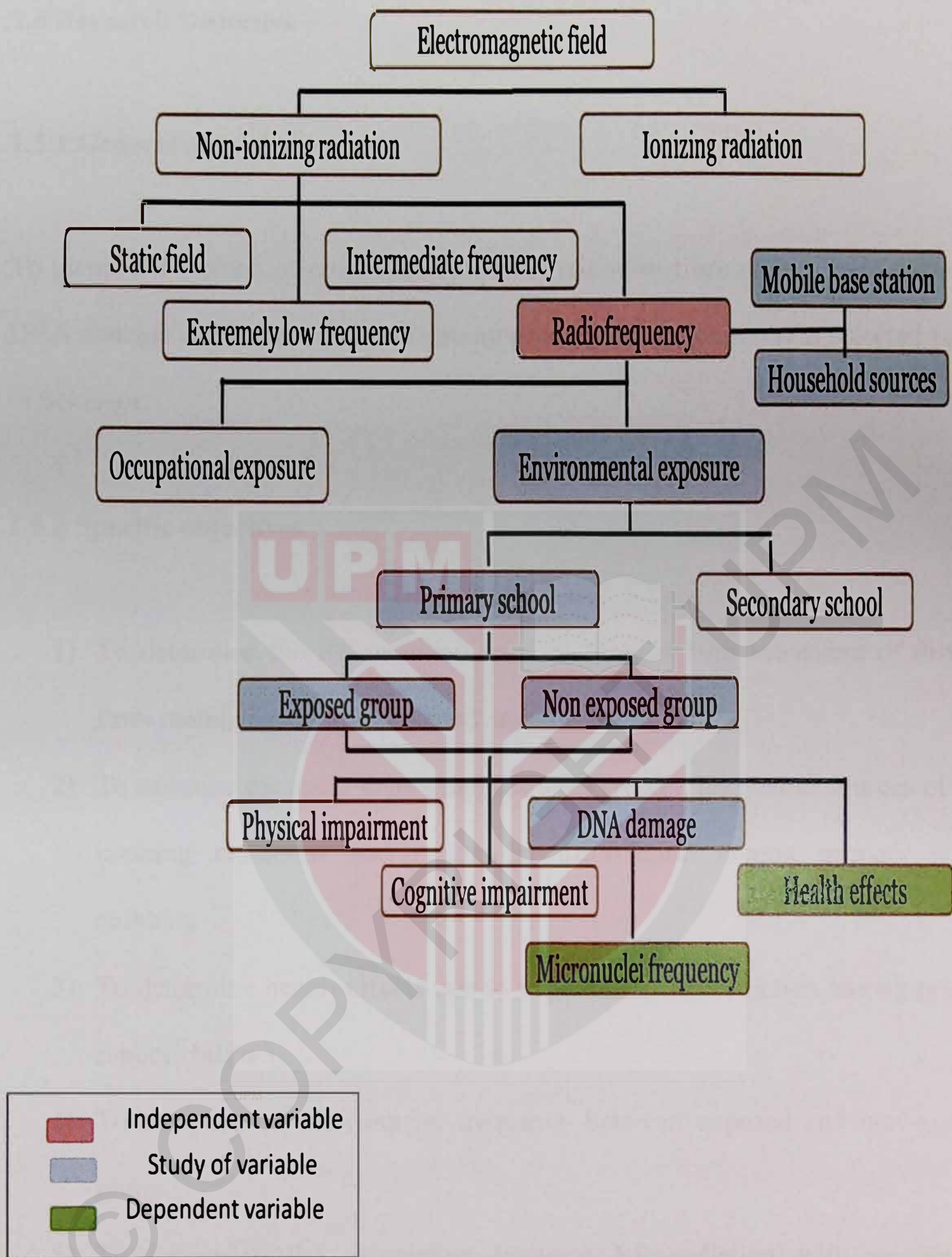
#### **1.4 Conceptual Framework**

Figure 1.1 shows the conceptual framework of this study. This conceptual framework used to assist and guide researcher in conducting this study and answering the objective of this study, i.e. to determine the effects of radiofrequency (RF) radiation on DNA damage and its health effects among primary school children in Selangor.

From the framework, radiofrequency (RF) radiation is emitted from both mobile base station and household sources that can also emit RF radiation. The RF radiation from mobile base station measured by using the RF Analyzer (Model : HF35C). The

environmental exposure focused among primary school children whose school located either in the vicinity of the mobile base station (exposed group) or distant away (or none at all) (non-exposed group) mobile base station located near to their school facility.

In this study, the emission of RF radiation is presumed to contribute adverse health effects to primary school children due to their vulnerability in protecting themselves from exposing to the RF radiation from mobile base station. Therefore, the health effects was also examined by using an adapted questionnaires while the DNA damage were determined by examining the frequency of micronuclei found in the buccal mucosa cell through Micronuclei Assay.



**Figure 1.0 : Conceptual framework of the research**

## **1.5 Research Objective**

### **1.5.1 General objective**

To identify the effect of radiofrequency (RF) radiation from mobile base station on DNA damage and its health effect among primary school children at selected school in Selangor.

### **1.5.2 Specific objectives**

- 1) To determine the RF radiation level at each of 10m increment of distance from mobile base station located near the schools.
- 2) To examine the socio-demographical background, household sources of non-ionizing radiations and residential information among primary school children.
- 3) To determine health effects due to exposure of RF radiation among primary school children.
- 4) To compare the micronuclei frequency between exposed and non-exposed group.
- 5) To determine the association between RF radiation with micronuclei frequency among primary school children.
- 6) To determine the association between health effects with micronuclei frequency among primary school children.
- 7) To determine relationship of RF radiation with socio-demographic background, household sources of non-ionizing radiations and residential information with micronuclei frequency among primary school children.

### 1.5.3 Hypothesis

- 1) There is a significant difference of micronuclei frequency between exposed and non-exposed group.
- 2) There is a significant association between RF radiation with micronuclei frequency among primary school children.
- 3) There is a significant association between health effects with micronuclei frequency among primary school children.
- 4) There is a significant relationship between RF radiation with socio-demographic background, household sources of non-ionizing radiations and residential information with micronuclei frequency among primary school children.

### 1.5.4 Research questions

- 1) What is the RF radiation level at each of 10m increment of distance from mobile base station located near the schools?
- 2) Does the RF radiation emit from mobile base station affect the micronuclei frequency among primary school children?
- 3) What are the common health effects due to the exposure of RF radiation among school children?
- 4) Is there difference of micronuclei frequency and self-reported health effects between exposed and non-exposed group among primary school children?
- 5) What is the association between RF radiation with micronuclei frequency among primary school children?

- 6) What is the association between health effects with micronuclei frequency among primary school children?
- 7) What is the relationship between RF radiation from mobile base station with socio-demographic background, household sources of non-ionizing radiations and residential information on micronuclei frequency presented among primary school children.

## **1.6 Definition of term**

### **1.6.1 Conceptual definition**

#### **i. Radiofrequency radiation**

Mobile telephones, television and radio transmitters and radar produce RF fields. These fields are used to transmit information over long distances and form the basis of telecommunications as well as radio and television broadcasting all over the world. Microwaves are RF fields at high frequencies in the GHz range (WHO, n.d.).

#### **ii. DNA damage**

Damage to DNA can cause genetic alterations, and if genes that control cell growth are involved, these mutations can lead to the development of cancer. DNA damage may also result in cell death which can have serious consequences for the organism of which the cell is a part of it as for example, loss of irreplaceable neurons in the brain (Wiesmuller et al., 2002).

### **iii. Mobile base station**

A base station is the interface between wireless phones and traditional wired phones. The base station is a wireless system which uses microwave radio communication. It is composed of several antennas mounted on a tower and a building with electronics in it at the base (Engineering and Technology History Wiki, 2015).

### **iv. Primary school children**

The admission age to the first year of primary education is seven. Primary schooling is mandatory for all children between the ages of 7 and 12.

## **1.6.2 Operational definition**

### **i. Radiofrequency radiation**

Radiofrequency (RF) electromagnetic radiation (EMR) is the transfer of energy by radio waves and emitted by base station and electronic devices. RF EMR lies in the frequency range between 3 kilohertz (kHz) to 300 gigahertz (GHz). RF EMR is non-ionising radiation, meaning that it has insufficient energy to break chemical bonds or remove electrons (ionisation) (ARPANSA, n.d.).

### **ii. DNA damage**

Micronuclei are characterized in the cells that have some sort of DNA damage. This includes damage caused by radiation, harmful chemicals, and random mutations that occur throughout the genome. Micronuclei are small bodies that can be seen budding off of a newly divided daughter cell. Micronuclei can contain a whole chromosome or part of a chromatid. The increased formation of micronuclei is usually an

indication of increased DNA damage or mutation. It is characteristically found in cancer cells, or cells that have been exposed to increased risk factors.

**iii. Primary school children**

In this study, the primary school children involved are from 10 to 11 years old for both exposed and non-exposed group.

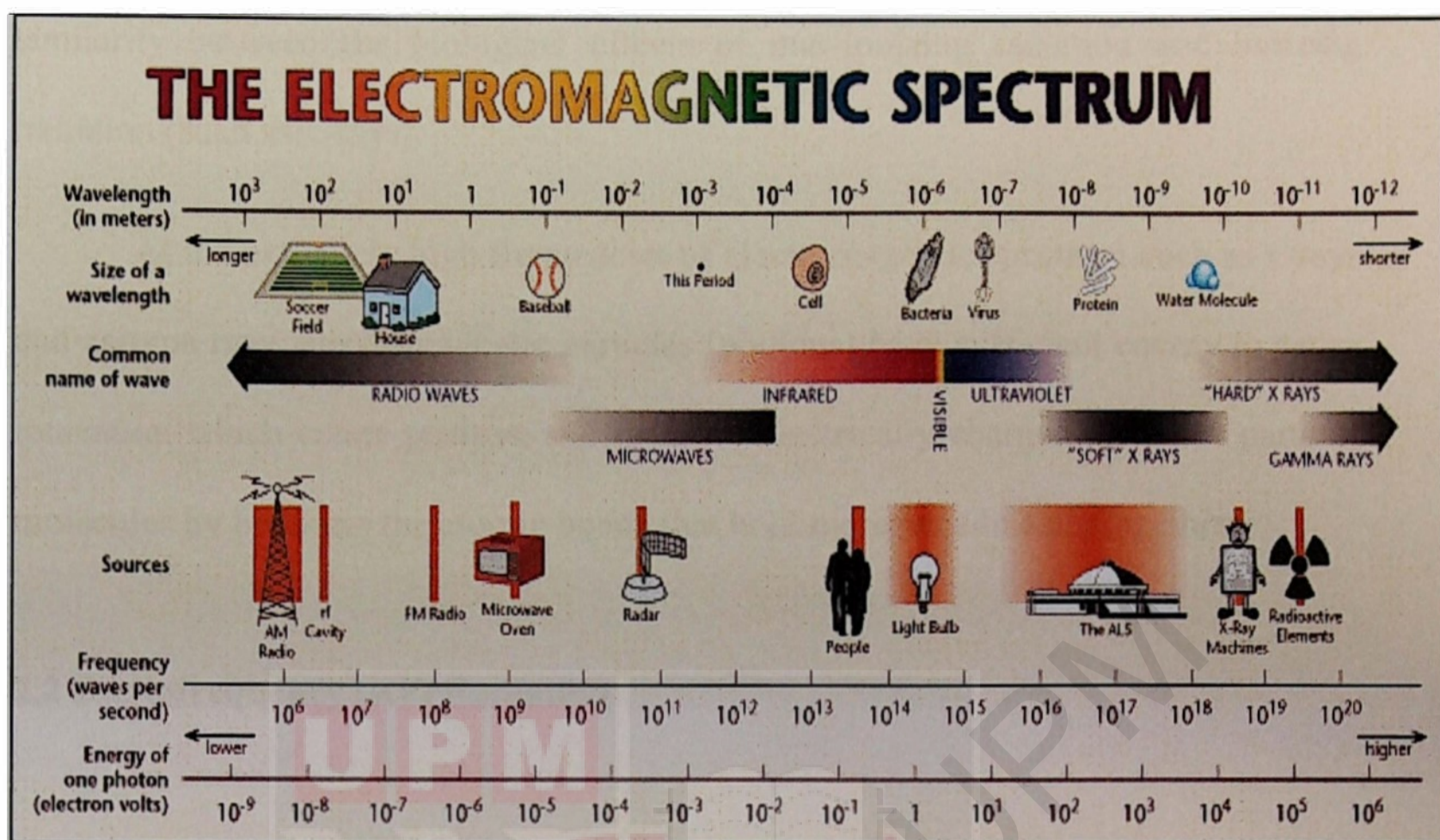


## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Electromagnetic Field**

EMF is often used to indicate the presence of electromagnetic radiation, which consists of waves of electric and magnetic energy moving together through space at the speed of light. Electromagnetic (EM) waves can be characterized by their wavelength, frequency or energy. These three parameters are interrelated. The frequency of electromagnetic waves is the number of oscillations which passes a fixed point per unit time. It is measured in units of Hertz ( $1 \text{ Hz} = 1 \text{ cycle per second}$ ). The wavelength is the distance travelled by the wave in one oscillation (or cycle). EM waves can travel through space while carrying energy at the speed of light. The higher the frequency, the shorter the wavelength.



**Figure 2.0 : Electromagnetic spectrum**

**Source :** <http://www2.lbl.gov/MicroWorlds/ALSTool/EMSpec/EMSpec2.html>

EM waves extend from the lowest frequency to frequencies beyond radio waves, light waves, X-rays and gamma rays. This broad energy range is known as the electromagnetic spectrum (Figure 2.0).

In general, power lines, electrical wiring and electrical equipment produce EMF. There are many other sources of EMF which includes mobile phones and base stations. It is established that energy from radio waves can lead to the heating of the body, but radio waves do not have sufficient energy to damage cell structures. Thus, the radiofrequency energy from the base stations and the mobile phones is considered as "non-ionizing". Non-ionizing radiation (NIR) is a general term for certain parts of the electromagnetic spectrum with energies that are too weak to break atomic bonds. They include extremely low frequency (ELF) fields, radiofrequency and microwave (RF/MW) fields, infrared radiation, visible light and ultraviolet (UV) radiation. As non-ionizing radiation cannot break chemical bonds, there is no

similarity between the biological effects of non-ionizing radiation and ionizing radiation (such as x-rays).

At the extremely high frequencies of electromagnetic spectrum such as x-rays and gamma rays, electromagnetic particles (photons) have sufficient energy to cause ionization which create positive and negative electrically charged atoms or parts of molecules by breaking the atomic bonds that hold molecules in cells together.

## **2.2 Radiofrequency (RF) Radiation**

Radiofrequency (RF) radiation which includes radio waves and microwaves is at the low energy at the end of the electromagnetic spectrum. It is a type of non-ionizing radiation. Non-ionizing radiation has enough energy to move atoms in a molecule around or cause them to vibrate but not enough to ionize or remove charged particles such as electrons. RF radiation has lower energy than some other types of non-ionizing radiation, like visible light and infrared but it has higher energy than extremely low-frequency (ELF) radiation (American Cancer Society, 2016).

Most important use for RF energy is in providing telecommunications services. Radio and television broadcasting, cellular telephones, radio communications for police and fire departments, amateur radio, microwave point-to-point links, and satellite communications are just some of the many telecommunications applications. Besides, microwave ovens are a good example of a non-communication that apply the principle of RF energy. Other important non-communication uses of RF energy are radar and for industrial heating and sealing (HPS, n.d.).

International organizations such as the Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Nonionizing Radiation Protection (ICNIRP) have developed safety standards and guidelines to protect occupational exposure as well as general public from potential adverse health effects due to exposure to EMF. In the case of RF, at the frequencies relevant for mobile communications, the absorption of energy is measured or estimated as specific absorption rate (SAR) which is defined as the energy absorbed by the tissue mass contained in a volume of a given density and expressed as W/kg. SAR has been the basic restriction in exposure limits from 100 kHz to 3 (IEEE) or 10 GHz (ICNIRP). Based on the thermal effects leading to an increase in body temperature at 4 W/kg whole body average SAR, the recommendations are 0.4 W/kg and 0.08 W/kg for occupational and general public (10x and 50x lower) respectively.

## **2.3 Mobile Base Station (MBS)**

### **2.3.1 MBS Function**

Mobile base stations (MBS) served as the mobile communication networks which are divided into geographic areas called cells. These base stations transmit vary power levels depend on the required area or 'cell' that they are providing coverage for. From an outdoor base station, the typical transmitted power are in the range from few watts to 100 watts, while the output power of indoor base station is lower. The mobile base station are comprised of several different components including an equipment shelter, a tower or mast which provides the suitable height to give better coverage for the communication network. Besides, the transceivers and antennas which sit at top of the tower or mast while some of them are attached to the

top of buildings, where the building itself provides sufficient height for the coverage. The antennas are about 15-30 cm in width and up to a few metres in length which depend on the frequency of operation. Radiofrequency (RF) electromagnetic energy which is also called as radio waves, have been emitted by those antennas in beams that are consist of vertical and horizontal directions. The RF energy typically very narrow in vertical direction (height), but for horizontal direction (width) are quite broad. Because of this, the RF energy at ground level directly below the antenna is very low. Public exposure is still within established limits since the antennas are elevated and the base stations are considered as restricted area. The restrict access are used with appropriate signage to ensure that only authorized personnel can access around the base station. The RF levels are below international safety limits. ("Mobile Phone Base Stations EMF / Health Fact Pack," n.d.)

### **2.3.2 Type of MBS Structure**

In Malaysia, there are 6 types of base station which are monopole plain, monopole tree, lamp pole, four legged tower, rooftop (tripod) and rapid deployment structure (RDS). All these structure are function as for communication network (Konsortium Jaringan Selangor, 2018).

Mobile phone systems in Malaysia same as the technology used in other countries. The frequency transmitted and received back by mobile base station are within the range which are 900 MHz-19000 MHz and 800 MHz-18000 MHz respectively. While for the transmitted power is within the range of 10 watts. In urban areas, the mobile base station are normally installed on the rooftop of high-rise buildings while in rural areas often sit on top of the towers for coverage. Besides, the

height of the station above the ground are different and depend on the locations. They are installed at height of 15 to 50 metres from the ground on the rooftop of high-rise buildings and 40 to 100 metres sit on top of the towers. (Yusof, et. al., 2003)

#### **2.4 Radiofrequency Radiation and Health Effects**

Potential health effects or possible health effects refers to the possibility of adverse effects which may not be detected at the beginning but may be detected only after a long duration. This is due to the prolonged latency period of many chronic diseases. There may be potential adverse health effects from the prolonged usage of mobile phones which are not fully known at this point in time. Therefore, precautionary approach is to be adopted for mobile phone usage until further research and data are available (Ministry of Health, n.d.)

The development of mobile telecommunication technology has led to substantial growth of the number of mobile phone base station. The main concern on long term effect of EMF exposure is the possibility of inducing cancer. ICNIRP in its guideline (1998) states that there is no convincing evidence that typical exposure levels can lead to an increased cancer risk in exposed individuals. However, there is some evidence that shows the significant effect of radiofrequency (RF) radiation to DNA damage in human. In previous study, they analyzed the peer reviewed papers published between 1982 and 2012 dealing with the association between RF radiation and cancer in both environmental and occupational settings. The studies were found using the Medline and Google scholar search engines or based on previous knowledge. Furthermore, Yakymenko et al. reviewed epidemiological evidence from

radars and mobile communication systems studies. The researchers found that under certain conditions, exposure to long term low intensity RF radiation led to initiation and promotion of cancer. Yakymenko concluded that recent data strongly indicate the need for concern and transparency of the current safety limits for non-ionizing radiation using recently obtained knowledge. Besides, Levitt and Lai (2010) found that broadcast exposures had been found unsafe even at regulated thresholds, noting significant increases for all cancers in both men and women living near broadcast towers and leukaemia clusters in children and adults. In addition to this, studies also found that there were 56 of 56 studies reported biological effects at very low intensities of RF radiation, including DNA damage in human glial and leukaemia cells, effect on the DNA repair mechanism and indication of an increase in glioma cells division (Atzmon, et. al., 2016).

Past study reported by Sweden and Norway stated that people who complained or experienced symptoms are mainly among those who used mobile phones (MP) and working with electromagnetic fields. The symptoms reported were headaches, feeling of discomfort, warmth behind or around or on the ear, and difficulties concentrating but sometimes also a stinging sensation and a feeling of heat in the facial skin (Sandström, 1998). Other studies also reported that chronic exposure to RF EMF through the use of mobile phones or vicinity to their base stations has been linked to headache, fatigue, sleep disturbances, concentration difficulties, alterations in memory, warming of the ear and other symptoms. Also, the prevalence and frequency of some of these symptoms were increasing with increasing duration and number of calls per day or decreasing distance to base stations, which could be considered as signs of dose-response. These symptoms were termed as Non-Specific Health Symptoms in the literature (Durusoy, et. al., 2017)

## **2.5 Radiofrequency Radiation and Children Health Effects**

### **2.5.1 Children as Vulnerable Group**

Children are more vulnerable because of their developing nervous system, greater absorption of energy and a long life exposure. (Behari, 2010). They are known to have smaller heads which are often accompanied by thinner pinnae (and skulls) that leads to a closer placement of the source of RF radiation to the tissues of the head and the brain, hence larger absorption of radiofrequency energy radiated by mobile telephones (Gandhi, 2015).

In fact, past studies had shown that children absorb more MWR than adults. For instance, a study conducted in 1996 reported that the absorbed MWR penetrated proportionally deeper into the brain of children age 5 and 10 compared to adults' brains (Gandhi, 2015). In 2008, a senior researcher for French telecom and Orange reported that the brain tissue of children absorbed about two times more MWR than adults' brain tissue. A 2009 study reported the CNS absorption by children is “significantly larger ( $\sim 2\times$ ) because the RF [MWR] source is closer and skin and bone layers are thinner”, and “bone marrow exposure strongly varies with age and is significantly larger for children ( $\sim 10\times$ )” (Morgan, et. al.,2014).

### **2.5.2 Children and DNA Damage**

Damage to cellular DNA is involved in mutagenesis and the development of cancer. The DNA in a human cell undergoes several thousand to a million damaging

events per day, generated by both external (exogenous) and internal metabolic (endogenous) processes (Sigma Aldrich, n.d.).

RF exposure has possibility to give adverse effect either in children or adults, so, there are some studies that had been conducted that involved children as the subject. Based on previous study, they had reviewed many studies that showed increased risk of developing leukaemia in children near transmitter antennas for radio and television in Hawaii (Eger et. al.,2004).

In fact, based on a study near the transmitter station of Radio Vatican, there were 2.2 times more leukaemia cases in children within a radius of 6 km, as well as an increase in adult mortality from leukaemia (Michelozzi et al., 2002).

### **2.5.3 Micronuclei Mechanism**

The micronucleus (MN) assay in exfoliated buccal cells is a useful and minimally invasive method for monitoring genetic damage in humans. This overview has concluded that although MN assay in buccal cells has been used since the 1980s to demonstrate cytogenetic effects of environmental and occupational exposures, lifestyle factors, dietary deficiencies, and different diseases, important knowledge gaps remain about the characteristics of micronuclei and other nuclear abnormalities, the basic biology explaining the appearance of various cell types in buccal mucosa samples and effects of diverse staining procedures and scoring criteria in laboratories around the world.

In humans, MN can be easily assessed in erythrocytes, lymphocytes, and exfoliated epithelial cells (e.g. oral, urothelial, nasal) to obtain a measure of genome

damage induced in vivo. The MN assay can be performed in buccal and other exfoliated cells originating from rapidly dividing epithelial tissue without the need for ex vivo nuclear division, so that the cell cultures required for cytogenetic assays based on analysis of metaphase chromosomes, such as chromosome aberrations and sister chromatid exchanges, are not needed (Holland et al., 2008).

Micronuclei (MN) originate from chromosome fragments or whole chromosomes that lag behind at anaphase during nuclear division. In mitotic cells, MN could arise from the chromosome breakage and the dysfunction of the mitotic apparatus. It is now well established that micronuclei mainly originate from the acentric chromosome fragment, acentric chromatid fragments or whole chromosome that fail to be included in the daughter nuclei at the completion of telophase during mitosis because they did not attach properly with the spindle during segregation process in anaphase. Bigger micronuclei results from the damage to the spindle apparatus of the cell resulting in the exclusion of whole chromosome (aneugenic effect) whereas smaller MN results from structural aberrations causing fragments of chromosomes (clastogenic effect). It is evident that multiple molecular mechanisms can lead to the formation of micronuclei and other nuclear abnormalities (Agarwal, Sunitha, Geetanshu, & Neelakshi, 2014).

#### **2.5.4 Children and Non-ionizing Health Symptoms**

Even though, WHO IARC had classified RF radiation as Class 2B carcinogen or possible human carcinogen, there is by far limited study to confirm the cancer incident on RF exposure. One of this limited study suggested that children's risk of brain cancer from mobile phone usage and more than 2-fold risk of brain cancer were

found on the side of their head where they held the phone after >2.8 years of use. This had showed the significant trend of increasing risk with year of mobile phone usage. The study also shows that non-ionizing radiation can affect sleep by delayed entrance into deep non-REM sleep and decrease time spent in stage of sleep. The quantity and quality of sleep are known to connect with the learning and memory, which will somehow influence the ability of memory for learning new information (Environmental Health Trust, 2012).

Redmayne et al. (2013) obtained data from 373 children (mean age 12.3 years (10.4 to 13.7 years)) and their parents with respect to cordless and mobile phone use, use of and type of mobile phone headset, cordless phone frequency, and presence of Wi-Fi at home. The authors controlled for the following in their analyses: age, sex, the socioeconomic rating of the school (SES), having recently had a cold or flu, usual bedtime, exercise levels, weekend viewing/electronic gaming hours, having a television in the bedroom, the number of times woken weekly by the cell phone, and cell phone storage and carrying habits. Associations were found between headaches and having long or frequent mobile phone calls (compared to not, or hardly ever using a mobile phone) or using a wireless headset. Associations were also found between tinnitus and having a cordless phone at home with a frequency less than or equal to 900 MHz or 1.8 to 1.9GHz, and using a wired mobile phone headset. Feeling down or depressed was associated with using a wireless headset or having a cordless phone with a frequency of 900MHz or less. Waking in the night was associated with using a wireless headset or not having Wi-Fi at home. Being tired at school was associated with having a digital spread spectrum cordless phone at home. Finally, having a painful texting thumb was associated with making more or longer cordless or mobile phone calls, and sending more texts (Scenihr, 2006).

In term of headaches, there were a research shows children who used cell phones or were exposed prenatally to wireless radiation are at higher risk of developing headaches (Volkow et al., 2012). Plus, in other study, the researchers had found an association between prenatal and postnatal RF exposure from mobile phone usage and migraines and headache related symptoms in children (Sudan, 2012).



## **CHAPTER 3**

### **METHODOLOGY**

#### **3.1 Study Location**

Four primary schools that were selected in this study were based on distance from the mobile base station identified in the vicinity of the school location.

Schools which located within 200m of the identified mobile base station is categorized as exposed school (Figure 3.1 and 3.2), whereas school located outside the 200m with no identified mobile base station (Figure 3.3 and 3.4) were categorized as non-exposed school.

Based on the description above, primary school children from the exposed school were selected as exposed group, conversely, primary school children from the non-exposed school were recruited as non-exposed group. Based on this concept, Sekolah Kebangsaan Serdang and Sekolah Kebangsaan Sri Serdang are as exposed school while Sekolah Kebangsaan Puchong Batu 14 and Sekolah Kebangsaan Sungai Merab Luar are categorized as non-exposed school.

## Exposed schools

### 1) Sekolah Kebangsaan Sri Serdang

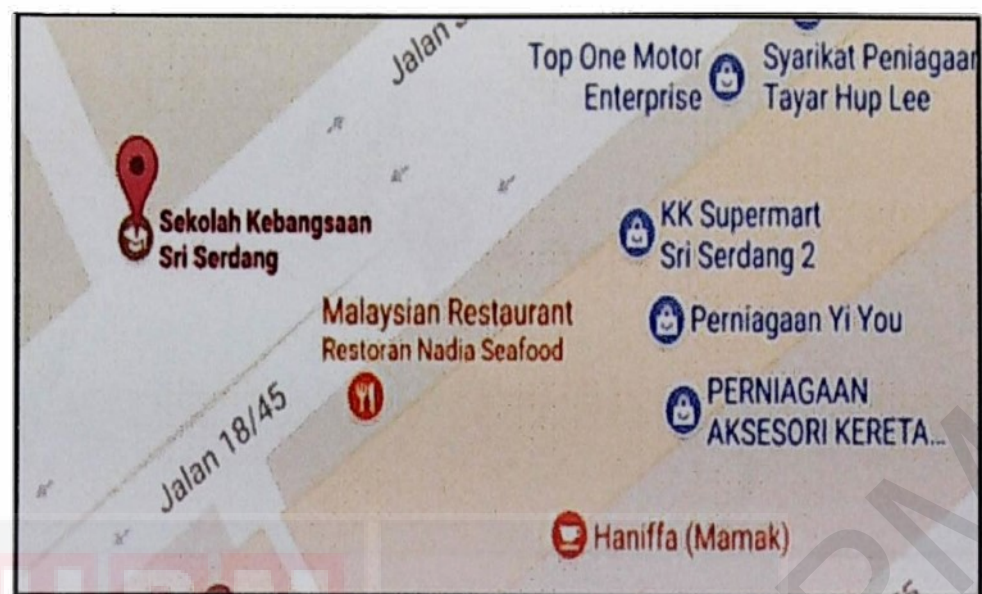


Figure 3.0 : Sekolah Kebangsaan Sri Serdang location

### 2) Sekolah Kebangsaan Serdang



Figure 3.1 : Sekolah Kebangsaan Serdang location

Non-exposed schools:

**3) Sekolah Kebangsaan Puchong Batu 14**



**Figure 3.2 : Sekolah Kebangsaan Puchong Batu 14 location**

**4) Sekolah Kebangsaan Sungai Merab Luar**



**Figure 3.3 : Sekolah Kebangsaan Sungai Merab Luar location**

## **3.2 Study Design**

This is a comparative cross-sectional study. Data collection were carried out from November 2017 to March 2018. Two part of data and sample were collected, (1) questionnaire, (2) buccal mucosa cells for micronuclei assay.

## **3.3 Sampling**

### **3.3.1 Study Population**

The study population corresponds to children at the age of 10-11 years old. The exposed group are children whose school located in the vicinity of mobile phone base stations and the non-exposed group was sampled among children whose school located outside buffer location (>200m) of mobile phone base station.

#### **Inclusive criteria**

- Age (10-11 years old)
- Gender (female and male)
- School children that have their own mobile phones.
- Studied at the current schools since Standard One

#### **Exclusive criteria**

- i. Had history of exposure to cytotoxic therapeutic drugs (e.g. chemotherapy) and radiation

- ii. Had medical condition, e.g. tendency for gum bleeding, malnutrition, anaemia, nephritic problem and hepatic diseases.

### **3.3.2 Sampling Frame**

The information used to identify the study population were determined. Different approaches were performed by the researcher in order to recruit the study population based on the inclusion and exclusive criteria as discussed in Section 3.3.1.

A written permission was obtained from the District Office of Education, Selangor. The list of schools at Selangor was obtained from the District Office of Education, Selangor. Schools were sorted based on their locations which are located in the proximity to the mobile base. Children from the particular school were approached after list of classroom obtain from the school teacher.

### **3.3.3 Sampling Method**

Based on the sample size calculation (Section 3.4), a total of 120 school children were estimated to be recruited to participate in this study. As shown in Figure 3.5 (Example), a list of children from Standard 4 and 5 from both exposed and non-exposed schools will be obtained from the corresponding school's office. After considering the inclusive and exclusive criteria of the students, students were selected by simple random sampling. Only student that returned back written consent from their parents or guardian were allowed to participate in this study.

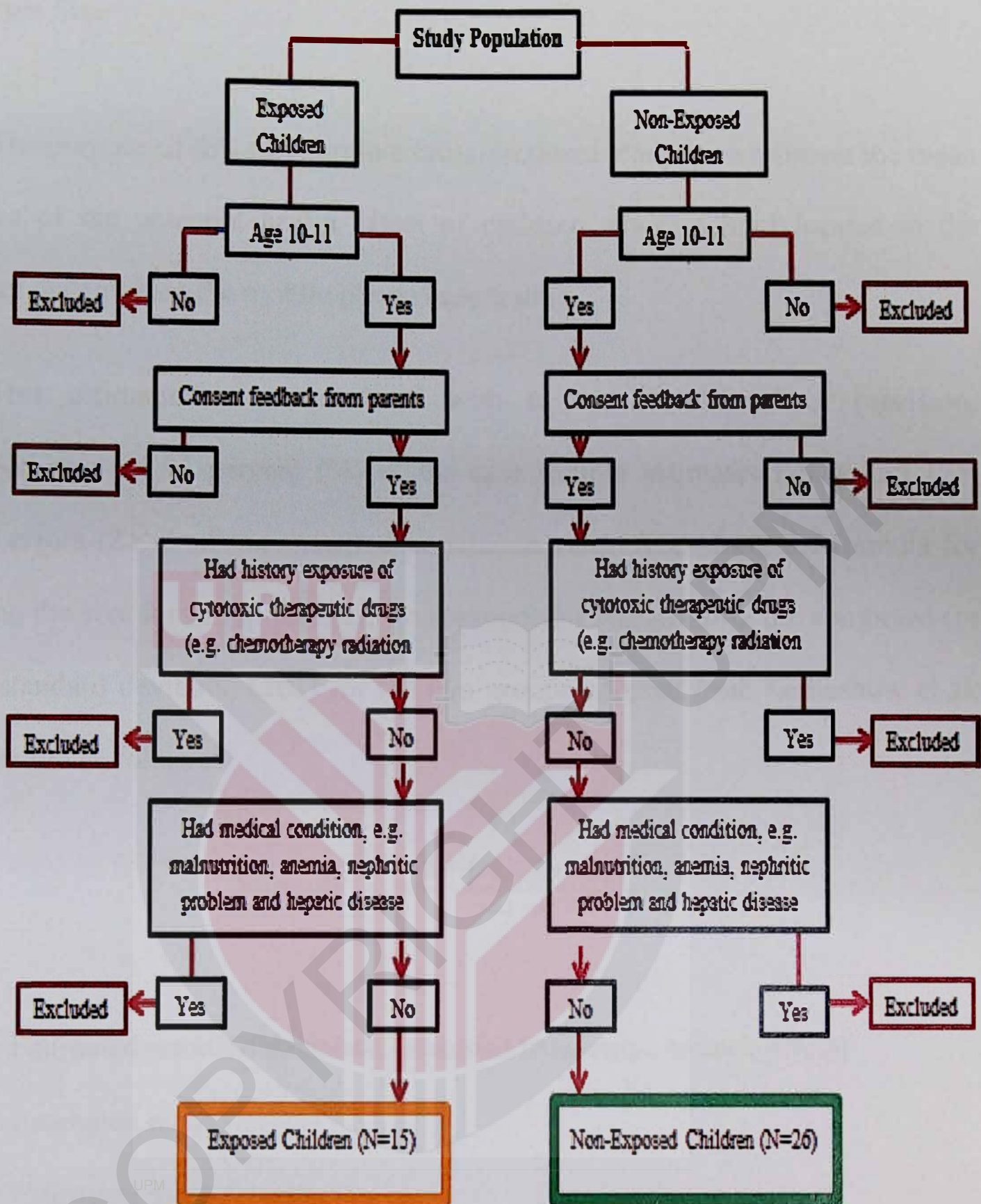


Figure 3.4 : Flow of Recruitment of Study Population

### 3.4 Sample Size

The purpose of this comparative cross-sectional study is to estimate the mean difference of the potential health effect of children whose school located in the vicinity or distant from the mobile phone base station.

This estimation was calculated with a reasonable level of precision, confidence level of 95 percent (%) of the case sample estimates fall within 1.96 standard errors ( $Z_{1-\alpha}$ ) of the specified population value. Therefore, the formula for estimating the size for group-comparison (two-group) design using the combined (or pooled) standard deviation ( $2\sigma^2$ ) for the two groups adopted from Lemeshow et al. (1990) is used as follows:

$$\text{Formula, } n = \frac{2\sigma^2 [Z_{1-\alpha/2} + Z_{1-\beta}]^2}{(\mu_1 - \mu_2)^2}$$

Where,

$\sigma$  = Estimated standard deviation (assumed to be equal to each group)

= Estimated mean (larger)

$\mu^2$  = Estimated mean (smaller)

$Z_{1-\alpha}$  = Standardized value for confidential interval, 95% CI=1.96

$Z_{1-\beta}$  = Standardized value for power, 80% of power =0.84

In order to estimate the minimum number of children to be recruited in this study, the calculation is estimated based on the total micronuclei experienced by exposed and control group of mobile phone users (Yadav and Sharma, 2007).

$$\begin{aligned} n &= \frac{2(6.075)^2 [1.96 + 0.84]^2}{(10.72 - 4.00)^2} \\ &= 12.81 \end{aligned}$$

To increase the power of study, a 20% increased of the estimated sample size will be considered :

$$12.81 \times 20\% + 12.81 = 15.41$$

In other words, at least 15 students will be recruited from each class from each selected schools. Respondents that will be selected for each schools are 30 children. So, total of 60 children will be selected for exposed group which are from two schools located in the vicinity of mobile phone base stations and another 60 children from another two schools located outside buffer location (>200m) of mobile phone base station. Therefore, in this study, as both exposed and non-exposed group are 4 selected schools, the total respondents will be selected are 120 children.

**Table 3.0 : The Distribution of Study Respondents based on Sample Size**

**Calculation**

No.	Type of group	Name of schools	No. of students for each class		No. of students for each schools	Total no. of students
			Standard 4	Standard 5		
1	Exposed group	Sekolah Kebangsaan Serdang	15	15	30	60
2		Sekolah Kebangsaan Sri Serdang	15	15	30	
3	Non-exposed group	Sekolah Kebangsaan Puchong Batu 14	15	15	30	60
4		Sekolah Kebangsaan Sungai Merab Luar	15	15	30	
<b>TOTAL</b>						<b>120</b>

## **3.5 Data Collection**

### **3.5.1 Data Collection Procedures**

This study consists of two (2) sections of data collection and laboratory analysis.

Each section was carried out among exposed and non-exposed children respondents.

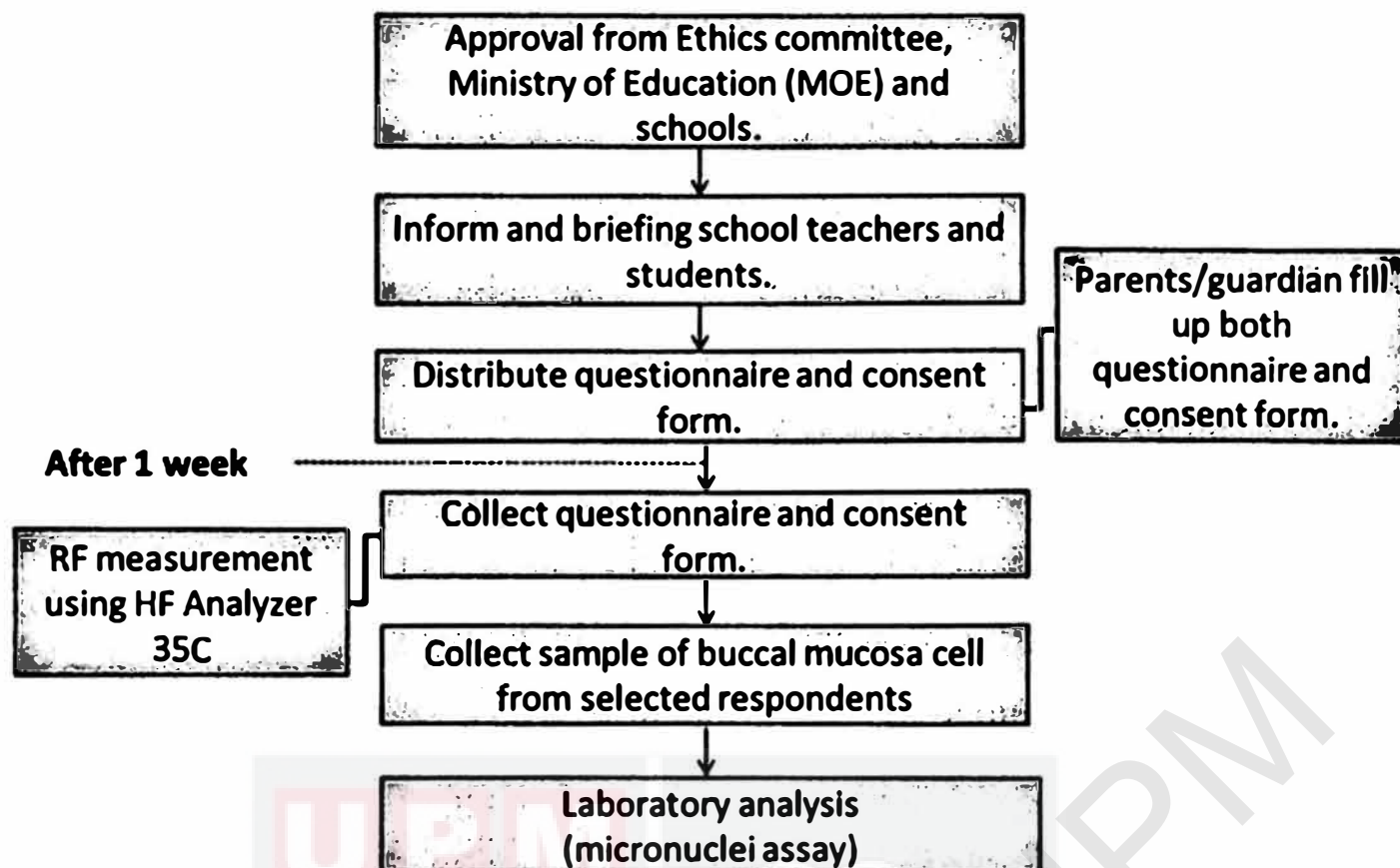
Part A was prepared using descriptive and explanatory closed-end questions to examine socio-demographic and risk factors (health effects) among the study population. The questionnaire consists of:

**PART I : Socio-demographic background**

**PART II : Household sources of radiation**

**PART III : Health status**

Part B was determined by sampling exfoliated buccal mucosa cells from the oral cavity of the study population.



**Figure 3.5 : Procedures of data collection**

Data collection (refer Figure 3.6) starts by informing and briefing school teachers the procedures of this study. Both of the consent letter and questionnaires were distributed to the students to be filled in by their parents or guardian. Then, after one week, both consent letter and questionnaires were collected and only students that approved by their parents or guardian were selected as respondents. At the same time, RF measurement were conducted around the schools by using Digital High Frequency Analyser (Model HF35C) and proceed to collect respondents' buccal mucosa cell (cheek cell). Those buccal mucosa cell were analyzed at the laboratory to observe the micronuclei frequency impairment.

### 3.5.2 General Quality Control

A pre-test study was conducted to test the logistics and identify the potential deficiency in the study design. By recruiting at least 20% of the estimated studied population, a total of 120 children from exposed and non-exposed school are

obtained, coded and analyzed. Research protocol and quality control from each section are identified and analyzed. In order to ensure the reliability and validity of the collected samples throughout the study, the following steps are followed:

**a) Chain-of-custody**

A Chain-of-custody procedure is utilized for the purpose of sample and evidence management. To assure that procedures are being followed, tags or labels, field notes, picture capture and any other recorded information for accuracy is use and follow up by the research team.

**b) Traceability of Sample**

A checklist table was filled by the researcher when relevant samples are collected. This is to ensure that contaminated cotton linens from different body parts, and biological samples, such as blood and buccal cells are made traceable through field records from the researcher who collects the samples or makes the measurement.

**c) Variability and Reproducibility of Samples**

Samples were collected at once at the same time to minimize differences. And samples will duplicated, e.g. replicated samples. For instance, buccal cells collected from inner oral cavity were replicated to two (2) microcentrifuge tube. Variation of biological samples might occur during sampling procedures, therefore duplicated samples are to ensure that the range of obtained results are around the mean values within the population.

#### **d) Sample Collection Precautions**

Precaution steps are emphasized during sample collection to prevent cross-contamination, particularly during biological sample collection. A detailed sample collection precaution which includes sample handling, mixing, preservation, storage and transport are discussed below (Section 3.7).

### **3.6 Quality Control for Questionnaire**

#### **3.6.1 Questionnaire**

A questionnaire is prepared by adapting question items from previous study (Mahthir, 2002) for respondents during the pilot study. A group of research assistants which are PhD students were trained particularly to conduct survey questionnaire among study population. This is to minimize the occurrence of inter-observer variability during a face-to-face interview. Respondents were interviewed by these trained research assistants to ensure the content and validity of the questionnaire. As such, the contents of the item questions had been asked to ensure that it matches the actual situation that was being studied, and its ability to predict a hypothesized outcome. Following the pre-testing assessment, questionnaire items (variables) are selected to test for its reliability and internal consistency.

#### **3.6.2 Face interview**

The guardian consent sheet had been given to their parents or guardian(s) through their children after a briefing session with the corresponding school teachers. Children whose parents agreed and returned with the guardian consent sheet were

recruited to participate in this test. The face-to-face interview method was used to avoid missing information. Structured questionnaires were administered to cover the following sections.

Section I : Socio-demographic background

Section II : Household sources

Section III : Health status

### 3.7 Measurement of RF/MW radiation level

Measurements were carried out by using a digital RF Analyzer (HF35C). This instrument measures RF exposure between 800 MHz and 2.5 GHz.



**Figure 3.6 : RF Analyzer (Model: HF35C)**

The frequency range of this RF analyzer covers cellular phone frequencies and frequencies from the antennas of mobile phone base stations. Measurements were conducted during daytime following the phone calls peak times set by most of the phone company, i.e. 8am – 7 pm.

The measurements were repeated three times to consider the average radiation levels throughout the peak hours of phone used by consumers. Measurements were performed starting at the foot of the base station, in the direction of the main beam of the antennas. Measurement then repeated at increments of 10m distance in each measurement. All measurements were performed when people around are not using mobile phones or not engage in any activities involving the emission of RF radiation. The measurements were recorded with the receiving antenna at height of approximately 1.5 meters from the ground, which correspond to head position of average adult.

### **3.7.1 Procedure**

#### **Connecting the Antenna**

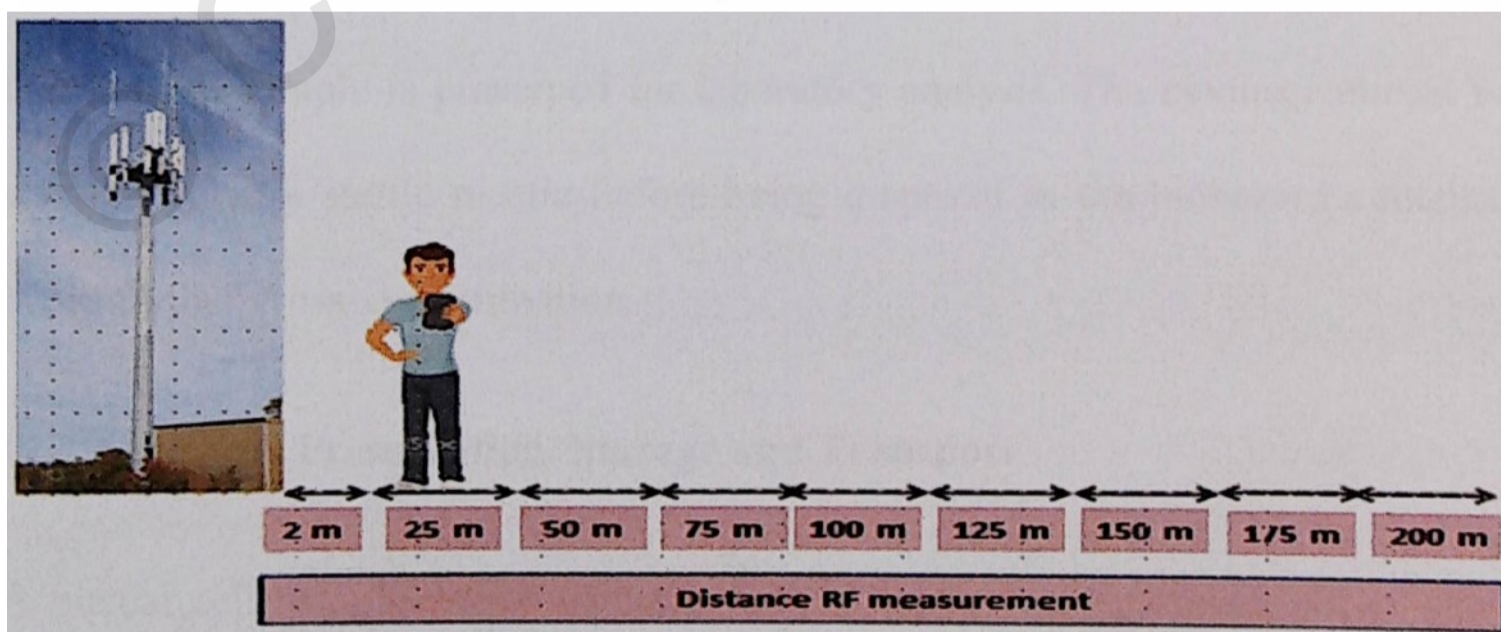
- 1) Screw the angle connector of the antenna connection into the uppermost right socket of the HF analyzer. It is sufficient to tighten the connection with your fingers. (Do not use a wrench or other tools because over tightening may damage the threads.)
- 2) Slide the antenna into the vertical / cross shaped slot at the rounded top end of the HF analyzer. Make sure the antenna cable has no tension and lies below the instrument
- 3) The antenna can be used by attaching it to the top end of the HF analyzer or holding it in your hand.
- 4) For a precision measurement, the antenna should not be held with your fingers, but be attached to the designated slot at the top end of the HF analyzer.

### Setting of HF Analyzer

- 1) Set " On/Off" switch ("Mode" to, and turn down the audio analysis knob to low).
- 2) Set the measurement range ("Range Selection") switch to "1999 $\mu$ W/m<sup>2</sup>" (coarse). Only if the displayed measurement values are persistently below ca. 10  $\mu$ W/m<sup>2</sup>, change to the measurement range "199.9 $\mu$ W/m<sup>2</sup>" (fine).
- 3) Set the "Signal Evaluation" switch to "Peak".
- 4) HF radiation exposure can differ at each point and from all directions.

### 3.7.2 Minimum Distance

In order to measure the quantity of HF radiation in the common unit "power density" (W/m<sup>2</sup>), a certain distance has to be kept from the HF source. It is important to keep a minimum distance of one to two meters between the HF35C and the source of radiation.



**Figure 3.7 : RF measurement distance from mobile base station**

## **3.8 Micronuclei Assay**

### **3.8.1 Quality Control for Exfoliated Buccal Mucosa Cells Collection**

#### **i. Sample Collection Precautions**

Few precautionary steps were followed to ensure the biological integrity of samples, such as excluding respondents who had oral ulcer and avoid them to touch or rub the brush hand. In addition, respondents were discouraged to eat, drink or smoke 30 minutes before sample collection.

#### **ii. Sample Handling and Mixing**

Standard operating procedure (SOP) on “Buccal sample collection” from Centers of Disease Control and Prevention (CDC) (2006) will be followed. Before sampling, a clean pair of new, non-powdered and disposable latex gloves were prepared.

A microcentrifuge tube was prepared by filling with phosphate buffer solution (PBS) and normal saline in the laboratory before sending to the field. The buccal cytology brush had been rinsed few times with the solution in microcentrifuge tube to ensure that the cell sample is preserved for laboratory analysis. The cytology buccal brush was placed in a sterile plastic before being disposed in the biohazard container to avoid further cross-contamination.

#### **iii. Sample Preservation, Storage and Transport**

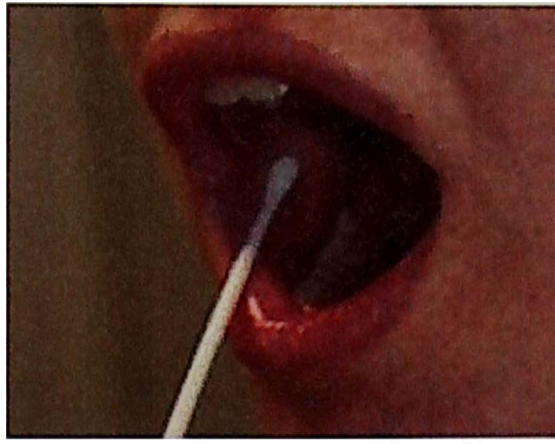
A buccal cell sample which contains normal saline and phosphate buffer solution (PBS) will keep at microcentrifuge tubes. The tube was kept upright at room temperature in a sealed container. Extra care was given throughout the storage and

transportation process to ensure that buccal samples were protected from strong light at all time until they reached the laboratory. The sample with proper preservation can preserve up to 1-3 months.

### **3.8.2 Exfoliated Buccal Mucosa Cells Collection**

In this study, exfoliated buccal mucosa is collected to ensure biological samples collected in a much convenient and less invasive manner. It provides a sensitive biomarker of genotoxic damage in target tissues (Szeto et al., 2005; Paz-y-Mino et al., 2004).

Respondent had been instructed to rinse their mouth with water before the sampling began. A sterile cytology brush (Gentra Puregene Buccal Cell Kit, Qiagen Ltd, Venlo, Limburg) had been used to collect exfoliated buccal mucosa cell from respondents. The sterile cytology brush is safe to be used on human for the buccal mucosa cell collection as the specification of the brush is cotton swab brush. Respondents were instructed to rub the brush firmly up and down along the inside of the cheek 30 times. Next, the cytology brush was washed with phosphate buffered saline (PBS) and normal saline in the different 1.5ml microcentrifuge tube. The specimens were stored in a sealed container before being transferred to the laboratory for laboratory analysis.



**Figure 3.8 : Scraping the Inner Part of the Cheeks (Oral Cavity) with Sterile Cytology Brush**

### **3.8.3 Laboratory Analysis (Micronuclei Assay)**

Micronuclei (MN) assay is a suitable internal dosimeter used to monitor the presence of MN in tissue-specific cell by estimating the possibility of early cancer risk experienced by study population. This assay was conducted based on the standard protocol as discussed by Thomas and Fenech (2008). The specimens were analyzed in Environmental Health Laboratory (Faculty of Medicine and Health Sciences, Universiti Putra Malaysia); microscope slide were examined by using a light microscope (LEICA, Germany) in Chemical Pathology Laboratory (Faculty of Medicine and Health Sciences, Universiti Putra Malaysia).

1. The microcentrifuge tube with normal saline will first centrifuged at 1500 rpm to wash the cells in the buffer solution (80% methanol, absolute ethanol).
2. The supernatant must be discarded, and the leftover cells were smeared on slide by using pulling technique. This slide was kept to dry up to one-day.
3. After one-day, the cells were fixed with cold methanol: acetic acid (3:1) solution in a 0.1% phosphate buffer (pH 7.5) for 20 minutes.

4. Next, the slide was stained by Feulgen reaction. It is to wash the slide with 5M Hydrochloride acid (HCl) for 30 minutes and then to be rinsed in running tap water for 3minutes.

5. After that, the slide was drained in room temperature with Schiff's reagent for 60 minutes in the dark. It is followed by counterstaining the slide with 0.1% of fast green for 20-40 seconds and was rinsed well with deionized water (dH<sub>2</sub>O).

6. Following all these chemicals treatment, the slide was placed face-down in Whatman No.1 filter paper to blot away any residual moisture. The slide was then placed on slide tray and allowed to dry for about 10-15 minutes. Slides were analyzed under light microscope with 1000x magnification. A total of minimum 1000 cells per individual were scored for analysis of micronuclei.

The end point is to measure the cells with the presence of MN (s), which is scored based on the cells presented with a main nucleus and smaller nuclei called MN. The MN is either round or oval in shape and their diameter range between 1/3 to 1/10 the diameter of the main nucleus.

For each individual, 2,000 binucleated cells were analysed for the presence of MN, NPBs and NBUDs in accordance with previously established criteria (Fenech et al. 2003). The frequency of each biomarker was calculated by using the following formula, (Montero et. al. 2006) :

$$MN \text{ per } 1000 \text{ cells} = \frac{\text{Total number of MN in each cell}}{2000} \times 1000$$

### 3.9 Statistical Analysis

The data had been analyzed by using some statistical analysis tests based on the study objectives which are as the following :

<b>Objectives</b>	<b>Statistical analysis</b>
To determine the exposure of radiofrequency (RF) radiation on DNA damage among primary school children at selected school.	Descriptive analysis
To determine the radiofrequency (RF) radiation level at each of 10m increment of distance from mobile base station located near the schools.	Descriptive analysis
To determine health effects due to exposure of radiofrequency (RF) radiation among primary school children.	Descriptive analysis
To compare the micronuclei frequency between exposed and non-exposed group.	Mann-Whitney U test

<p>To determine the association between radiofrequency (RF) radiation with micronuclei frequency among primary school children.</p>	<p>Spearman rank correlation</p>
<p>To determine the association between health effects with micronuclei frequency among primary school children.</p>	<p>Chi-square test</p>
<p>To determine relationship of radiofrequency (RF) radiation and self- reporting household sources with micronuclei frequency among primary school children.</p>	<p>Multiple linear regression</p>

## CHAPTER 4

### RESULT

The aim of this study is to determine the effect of radiofrequency (RF) radiation on mobile base station to DNA damage and its health effects among primary school children in Selangor. A total of 201 children respondents from primary schools were selected to participate in this study.

#### 4.1 Socio-demographic background of respondents

The socio-demographic background of the respondents are summarized as shown in Table 4.0, which includes age, gender, ethnicity, body temperature and body mass index (BMI). The total 201 children respondents who participated in this study were categorized into two groups based on their school location. Exposed group are used to indicate children whose school located in the vicinity of mobile base station (<200 metres) whereas, non-exposed group are used to indicate children whose school located distant from the mobile base station (>200 metres). In this study, a total of 110 respondents and 91 respondents were recruited into exposed and non-exposed group, respectively. Our study, respondents are made up of children at age of 10 and 11 years old which included both male and female gender. For the ethnicity, most of the respondents are Malay respondents with total of 195 respondents, followed by Indian with total of 4 respondents and the rest of respondents were from other ethnic.

Body mass index (BMI) and body temperature (BT) are among the two main health indicators which might influence one's health status during sample collection. In this study, most respondents from exposed and non-exposed groups show a normal body temperature at range of 35.66°C – 35.74°C. Only two respondents from the non-exposed group reported with body temperature more than 37.5°C. As for BMI, 55.5% of exposed and 58.2% of non-exposed respondents are, categorized as underweight. Other respondents were categorized as obese were the least which 0.9% and 4.4% for each group.

**Table 4.0 : Socio-demographic information of respondents (N=201)**

Variables	N (%)		Mean ± SD	
	Exposed (N=110)	Non-exposed (N=91)	Exposed (N=110)	Non-exposed (N=91)
<b>Age</b>				
10	53 (48.2)	52 (57.1)	-	-
11	57 (51.8)	39 (42.9)		
<b>Gender</b>				
Male	47 (42.7)	41 (45.1)	-	-
Female	63 (57.3)	50 (54.9)		
<b>Ethnicity</b>				
Malay	106 (96.4)	89 (97.8)		
Indian	4 (3.6)	-	-	-
Others	-	2 (2.2)		
<b>Body temperature</b>				
Normal	110 (100.0)	89 (97.8)	35.66 (0.81)	35.74
>37.5	-	2 (2.2)		(0.81)
<b>BMI</b>				
Underweight	61 (55.5)	53 (58.2)		
Normal	40 (36.4)	27 (29.7)	18.43 (4.68)	18.76
Overweight	8 (7.3)	7 (7.7)		(4.90)
Obese	1 (0.9)	4 (4.4)		

## **4.2 Parents' Information**

This section is to gather the background information from our study respondent's parents. Based on the Table 4.1, the variables included duration of living, relationship with the respondents, smoking status, level of education, job status, type of houses and residential area. In this study, most of the parents claimed that they had been living at their current living area for more than 11 years old which for exposed and non-exposed were 73.6% and 65% respectively. Most of the respondents stayed at terrace types of houses, followed by double storey terrace and condominium/fat/apartment/quarter. Survey result shows that both exposed and unexposed group show the similar house types. In addition to this, 20% of parents from exposed group's children claimed that their residential are surrounded with construction site, 40.9% claimed that near to main road, 24.5% reported that in the vicinity of industry area and all of exposed children living near to quarry industry. Besides, only 12.1% of parents from unexposed group's children claimed that their residential are surrounded with construction site, 42.9% claimed that near to main road, about 15.4% reported that in the vicinity of industry area and none of them living near to quarry industry.

When asking about the smoking status, only 37.3% and 46.2% fathers of study respondents from both exposed and unexposed group claimed that they are smokers, in addition to 18.2% and 30.8% of other family members smoked in the house from both exposed and unexposed group. Conversely, all the mothers claim that they are non-smokers. Survey report also show that most of the parents are literate and educated and only 7.3% of parents from exposed and 8.8% of unexposed groups reported that they are currently unemployed.

**Table 4.1 : Parents' information**

Variables	N (%)	
	Exposed (N=110)	Non-Exposed (N=91)
<b>Duration of living</b>		
< 1 Year	1 (0.9)	1 (1.1)
1-5 Years	2 (1.8)	6 (6.6)
6-11 Years	26 (23.6)	19 (20.9)
>11 Years	81 (73.6)	65 (71.4)
<b>Relationship</b>		
Father	50 (45.5)	50 (54.9)
Mother	60 (54.5)	41 (45.1)
<b>Smoking Status</b>		
<b><u>Father</u></b>		
Yes	41 (37.3)	42 (46.2)
No	69 (62.7)	49 (53.8)
<b><u>Mother</u></b>		
Yes	-	-
No	110 (100.0)	91 (100.0)
<b><u>Other family member (s)</u></b>		
Yes	20 (18.2)	28(30.8)
No	90 (81.8)	63(69.2)
<b>Level of Education</b>		
PMR	3 (2.7)	6 (6.6)
SPM	28 (25.5)	45 (49.5)
Certificate	4 (3.6)	4 (4.4)
Diploma	26 (23.6)	22 (24.2)
Degree	30 (27.3)	12 (13.2)
Master	15 (13.6)	1 (1.1)

PhD	4 (3.6)	1 (1.1)
<b>Job Status</b>		
Unemployed/Housewife	8 (7.3)	8 (8.8)
Businessman/Self-work	10 (9.1)	17 (18.7)
Pensioner	2 (1.8)	2 (2.2)
Clerk	7 (6.4)	5 (5.5)
Teacher/Lecturer	11 (10.0)	7 (7.7)
Policeman/Guard	5 (4.5)	2 (2.2)
Engineer/Technician	6 (5.5)	6 (6.6)
Doctor/Nurse	4 (3.6)	4 (4.4)
Consultant	4 (3.6)	1 (1.1)
Driver	5 (4.5)	6 (6.6)
Accountant/Assistant	6 (5.5)	-
Private Agency	12 (10.9)	28 (30.8)
Government Agency	30 (27.3)	5 (5.5)
<b>Types of House</b>		
Terrace	58(52.7)	36(39.6)
Double-storey Terrace	23(20.9)	14(15.4)
Condominium/Flat/ Apartment/Quarter	23(20.9)	20(22.0)
Semi-D House	2(1.8)	-
Village/Town House	3(2.7)	3(3.3)
Others	1(0.9)	7(7.7)
<b>Residential surrounding</b>		
<b><u>Construction site</u></b>		
Yes	22 (20.0)	11 (12.1)
No	88 (80.0)	80 (87.9)
<b><u>Main road</u></b>		
Yes	45 (40.9)	39 (42.9)
No	65 (59.1)	52 (57.1)

<b><u>Industrial area</u></b>		
Yes	27 (24.5)	14 (15.4)
No	83 (75.5)	77 (84.6)
<b><u>Quarry</u></b>		
Yes	-	1 (1.1)
No	110 (100.0)	90 (98.9)

#### **4.3 Radiofrequency (RF) radiation level within 200m of school location**

This section is to summarize the RF radiation level by considering each of the 10 meter(m) increment of distance within 200 m of school location. In this context, SK Puchong and SK Sungai Merab were treated as non-exposed school due to the non-existing of mobile base station within 200 m of school vicinity. On the other hand, SK Sri Serdang and SK Serdang were treated as exposed school due to the existing of mobile base station within 200 m of school vicinity. Both the RF radiation measurement started from school and increment at each 10m distance until it reached 200 m.

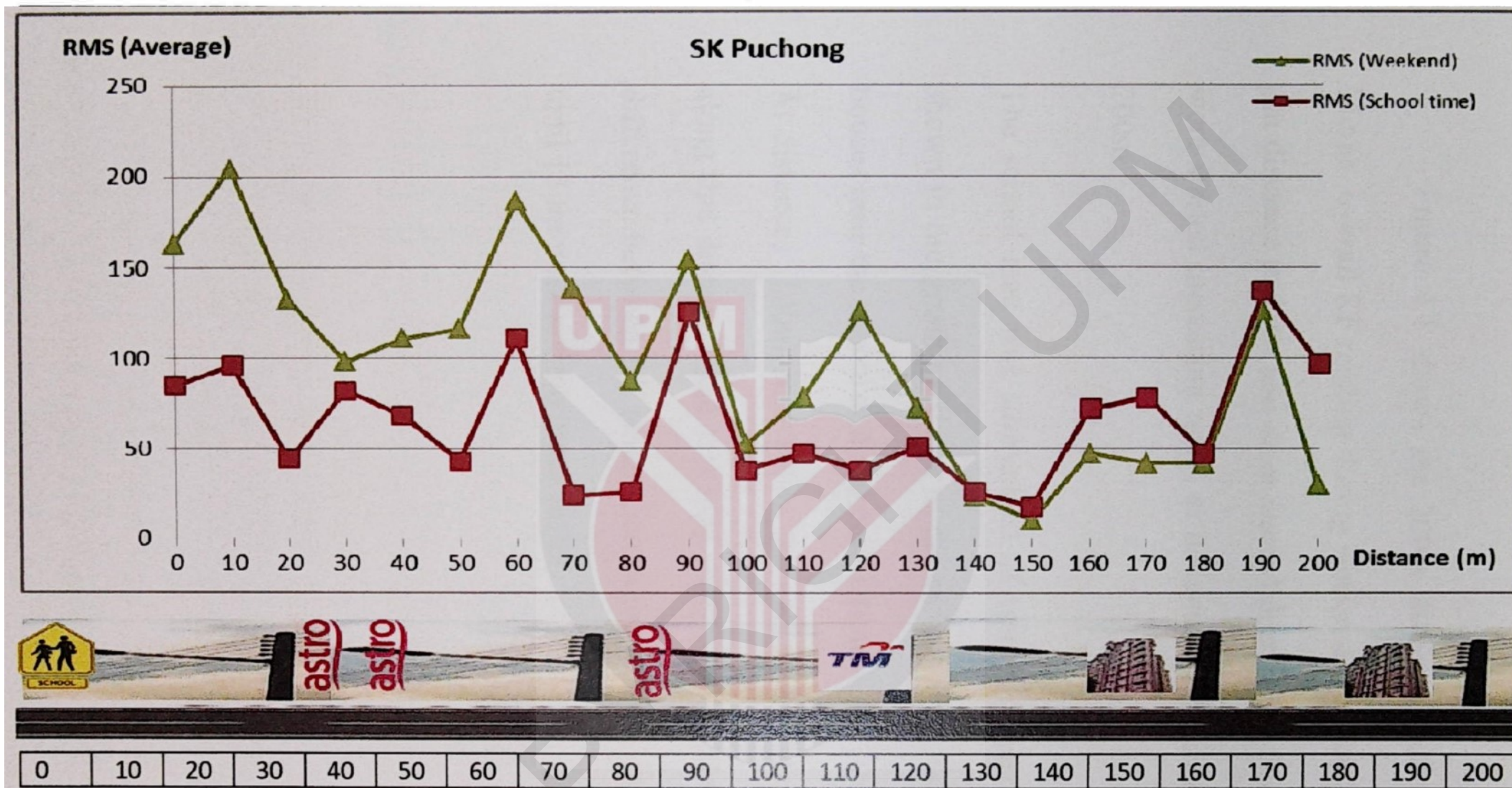
##### **4.3.1 Sekolah Kebangsaan (SK) Puchong**

Figure 4.0 shows the 200 m distance radius of RF reading at SK Puchong, overall RF reading during weekend were higher than during school time from 0m distance until 130m. The reading were started decreasing from 140m until 200m.

The fluctuation RF reading shown in the graph may due to the existence of Astro antenna on the roof of some houses near the school at distance 40m, 50m and 90m. A TM cable box was observed at distance 120m which is used to support communication network for the residential area, causing the changes of RF readings

during weekday and weekend depends on the usage demands. On the other hand, student hostel were observed at 150m and 190m distant from school which is presumed different sources of non-ionizing radiation used at hostel contribute to the changes of RF level from the sources of non-ionizing radiation electrical devices used at the hostel.



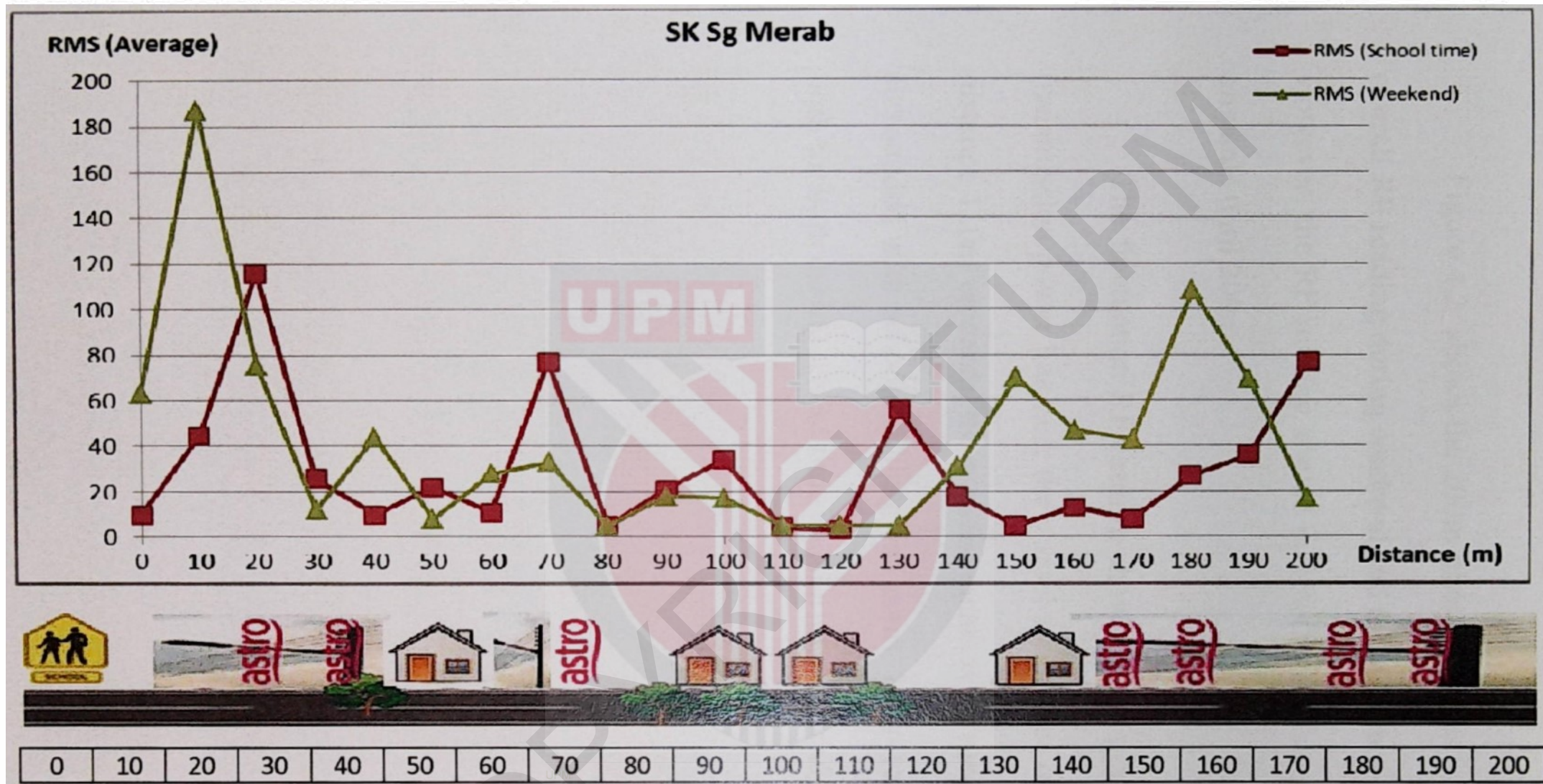


**Figure 4.0 : RF reading for SK Puchong Batu 14**

### **4.3.2 Sekolah Kebangsaan (SK) Sungai Merab Luar**

Figure 4.1 shows the 200m distance radius of RF reading at SK Sungai Merab, overall RF reading during weekend were higher than during school time from 0m distance to 10m and were started decreasing from 20m until 130m. The reading were started increasing again at distance 140m until 190m and dropped at distance 200m.

The school area was surrounded of residential areas. The fluctuation RF reading shown in the graph may due to the existence of Astro antenna on the roof of some houses near the school at distances of 30m, 40m, 70m, 150m, 160m, 180m and 190m. At distances 140m until 190m, the existence of Astro antenna were quite crowded along that distances and this may contributed to the increasing of RF reading. The difference between RF reading on both weekend and during school time from 30m until 130m were not too much differ.

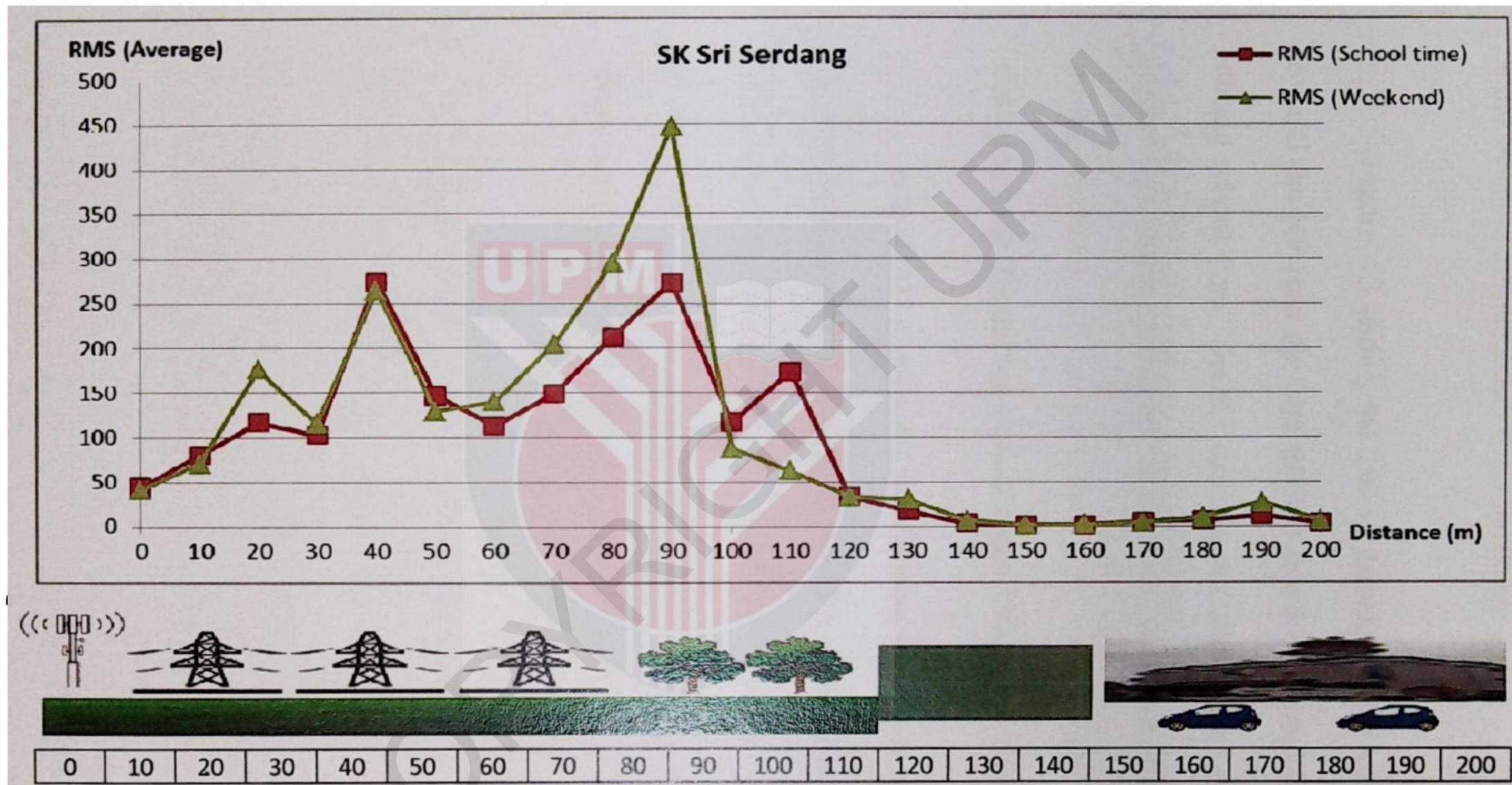


**Figure 4.1 : RF reading for SK Sungai Merab Luar**

### **4.3.3 Sekolah Kebangsaan (SK) Seri Serdang**

Figure 4.2 shows the 200m distance radius of RF reading at SK Sri Serdang, overall RF reading during weekend and during school time were not too much differ. However, the RF reading started increasing at distance 60m until 90m and dropped onwards until 200m.

The fluctuation RF reading shown in the graph may due to the existence of transmission power line near the school at distance of 10m until 70m. In addition, at distance 110m onwards, the measurements were measured in the school area which surrounded with school building and court. However, the RF reading were not too high for both during school time and during weekend.

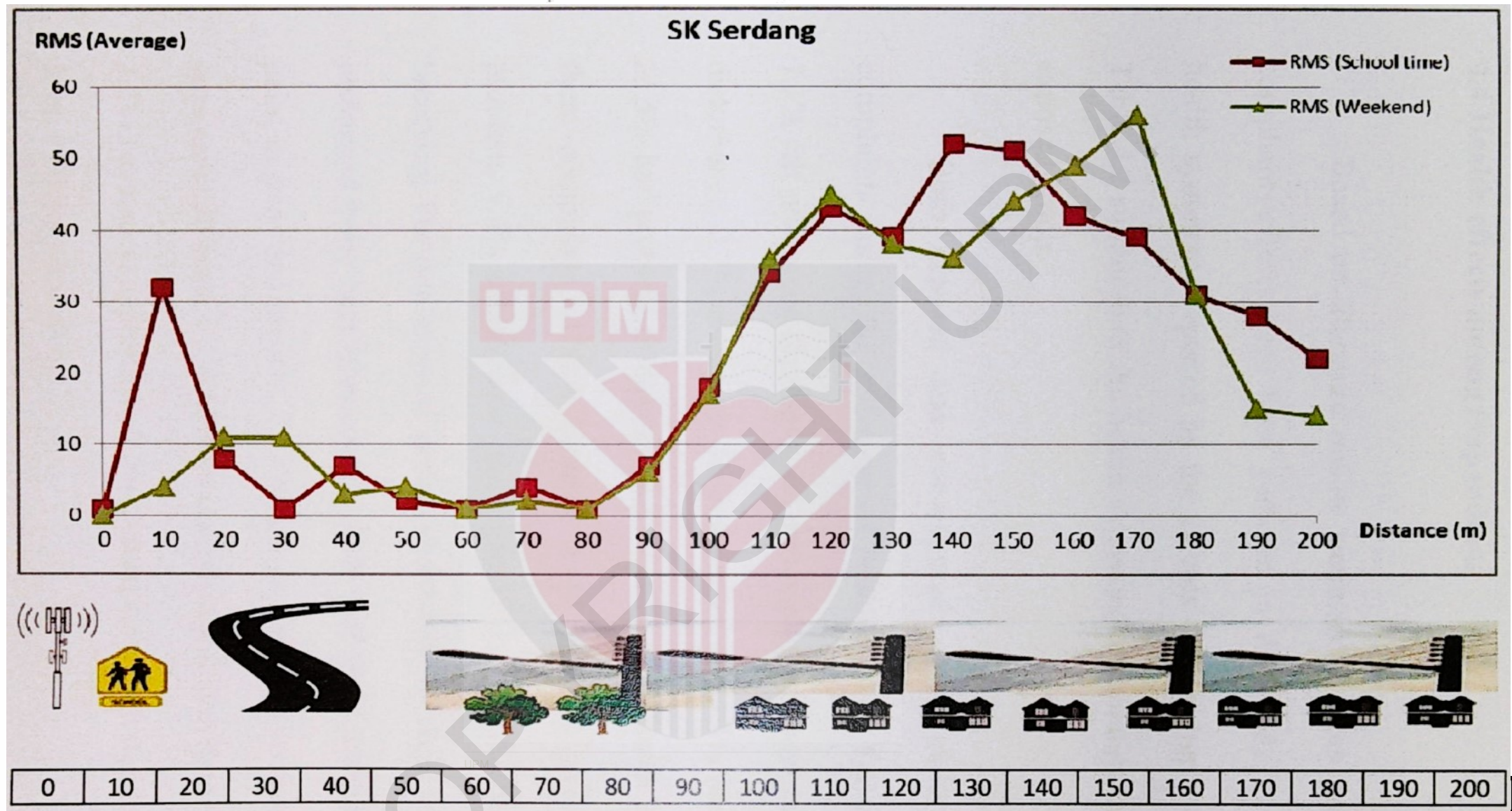


**Figure 4.2 : RF reading for SK Sri Serdang**

#### **4.3.4 Sekolah Kebangsaan (SK) Serdang**

Figure 4.3 shows the 200 m distance radius of RF reading at SK Serdang, overall the RF reading were not too much difference between during weekend and during school time. The RF reading at distance 10m during school time was quite higher than during weekend. at distance 20m until 130m, the RF reading between during weekend and during school time were slightly difference and the reading started to keep fluctuating from distance 140m until 200m.

school RF reading for both during school time and on weekend were only slightly difference at distance 40m until 130m. At distance 100m onwards, the point of measurements were at Department of Horticulture area which is located opposite of the school. The fluctuation RF reading shown in the graph may due to the existence of different sources of non-ionizing radiation used at the department.



**Figure 4.3 : RF reading for SK Serdang**

#### **4.4 Health effects among respondents**

Based on literature review summarized from past studies, different health complaints/effects have been gathered in this study to examine the self-reported health symptoms reported by the parents' of children respondents. In this context, Table 4.2 summarizes the health symptoms/complaints from both exposed and non-exposed group.

Both exposed and non-exposed group children reported little health complaints during the self-reported health survey. For exposed group, 12.7% and 7.3% felt prolonged dizziness and prolonged body heat respectively, 1.8% had sleep disturbance, 2.7% constantly feeling nausea and 6.4% felt pain in joint and muscle, 25.5% had problem of distraction to focus and 1.8% felt anxious at all time, 2.7% of them complaints of skin hotness, 6.4% has eye problems, 0.9% has hair loss problem, 9.4% experienced prolonged fatigue, and 2.7% suffering from difficulty breathing. For non-exposed group, about 4.4% of them felt prolonged dizziness and prolonged body heat respectively, 1.1% had sleep disturbance, 6.4% constantly felt pain in joint and muscle, 23.1% had problem of distraction to focus and 1.1% felt anxious at all time, 1.1% of them complaints of skin hotness, 6.6% has eye problems, 3.3% has hair loss problem, 2.2% experienced prolonged fatigue, and 2.2% suffering from difficulty breathing.

**Table 4.2 : Health effects reported among respondents**

Variables	N (%)	
	Exposed (N=110)	Non-exposed (N=91)
<b>Prolonged dizziness</b>		
Yes	14 (12.7)	4 (4.4)
No	96 (87.3)	87 (95.6)
<b>Prolonged body heat</b>		
Yes	8 (7.3)	4 (4.4)
No	102 (92.7)	87 (95.6)
<b>Sleep disturbance</b>		
Yes	2 (1.8)	1 (1.1)
No	108 (98.2)	90 (98.9)
<b>Nausea</b>		
Yes	3 (2.7)	
No	107 (97.3)	91 (100.0)
<b>Pain in joint and muscle</b>		
Yes	7 (6.4)	3 (3.3)
No	103 (93.6)	88 (96.7)
<b>Distraction of focus</b>		
Yes	28 (25.5)	21 (23.1)
No	82 (74.5)	70 (76.9)
<b>Anxious</b>		
Yes	2 (1.8)	1 (1.1)
No	108 (98.2)	90 (98.9)
<b>Skin hotness</b>		
Yes	3 (2.7)	1 (1.1)
No	107 (97.3)	90 (98.9)
<b>Eyes problem</b>		
Yes	7 (6.4)	6 (6.6)
No	103 (93.6)	85 (93.4)
<b>Hair loss problems</b>		
Yes	1 (0.9)	2 (2.2)
No	109 (99.1)	89 (97.8)
<b>Prolonged fatigue</b>		
Yes	10 (9.1)	3 (3.3)
No	100 (90.9)	88 (96.7)

<b>Difficulty breathing</b>		
Yes	3 (2.7)	2 (2.2)
No	107 (97.3)	89 (97.8)
<b>Serious illness (others)</b>		
Yes	3 (2.7)	2 (2.2)
No	107 (97.3)	89 (97.8)

#### 4.5 Comparison of micronuclei (MN) frequency between exposed and non-exposed group

Table 4.3 shows the comparison of micronuclei frequency between exposed and non-exposed group. Based on the result, there is statistically significant different between micronuclei (MN) frequency of respondents between exposed and non-exposed group, with non-exposed group has higher median (11.50) of MN frequency count in each 1000 cells as compared to exposed group (6.50).

**Table 4.3 : Micronuclei frequency for both exposed and non-exposed group**

	<b>Median (IQR)</b>		<b>Z-statistic</b>	<b>p-value*</b>
	<b>Exposed</b>	<b>Non-exposed</b>		
<b>Micronuclei frequency (per 1000 cells)</b>	6.50 (10.00)	11.50 (8.50)	-3.99	<0.001

<sup>a</sup>Mann-Whitney test

\*p-value is significant at level 0.05

#### 4.6 Association between radiofrequency (RF) radiation with micronuclei frequency

The association between RF value and micronuclei frequency is evaluated as shown in Table 4.4. Result shows that there is no significant ( $p=0.173$ ) association

between MN frequency and RF level, and the association is relatively weak ( $r=0.097$ ) between both variables.

**Table 4.4 : Association between radiofrequency (RF) value with micronuclei frequency**

	RF Value	
	Coefficient (r) <sup>a</sup>	p-value*
<b>Micronuclei frequency (per 1000 cells)</b>	0.097	0.173

<sup>a</sup>Spearman's rank correlation coefficient

\*p-value is significant at 0.05 level

#### **4.7 Association between health effects with micronuclei frequency among respondents**

As discussed in Section 4.4, the self-reported health symptoms is examined to outline the potential health effects experienced by study respondents. This section is to associate the health effects with MN frequency count among study respondents. The association between health effects and micronuclei frequency were analysed by using Chi square test. Table 4.5 shows the association of reported health effects with micronuclei frequency.

Based on the mean value of MN frequency, the MN frequency is then categorized into two groups, In this study, the micronuclei frequency is categorized into two groups which are low (0-11.2 MN per 1000 cells) and high (more than 11.2 MN per 1000 cells). Overall, there is no significance association between self-reported health effects with MN frequency counts, however, the null hypothesis was accepted for hair loss problems since there was a significant association between hair loss problems with micronuclei frequency.

**Table 4.5 : Association between health effects with micronuclei frequency**

Health effects	Micronuclei frequency			X <sup>2</sup>	p
	Low	High	Overall		
<b>Prolonged dizziness</b>					
Yes	8 (44.4)	10 (55.6)	18 (100.0)	2.048	0.152
No	113 (61.7)	70 (38.3)	183 (100.0)		
<b>Prolonged body heat</b>					
Yes	6 (50.0)	115 (60.8)	12 (100.0)	0.554	0.457
No	6 (50.0)	74 (39.2)	189 (100.0)		
<b>Sleep disturbance</b>					
Yes	2 (66.7)	1 (33.3)	3 (100.0)	0.053	0.818
No	119 (60.1)	79 (39.9)	198 (100.0)		
<b>Nausea</b>					
Yes	1 (33.3)	2 (66.7)	3 (100.0)	0.917	0.338
No	120 (60.6)	78 (39.4)	198 (100.0)		
<b>Pain in joint and muscle</b>					
Yes	7 (70.0)	3 (30.0)	10 (100.0)	0.422	0.516
No	114 (59.7)	77 (40.3)	191 (100.0)		
<b>Distraction of focus</b>					
Yes	30 (61.2)	19 (38.8)	49 (100.0)	0.028	0.866
No	91 (59.9)	62 (40.1)	152 (100.0)		
<b>Anxious</b>					
Yes	1 (33.3)	2 (66.7)	3 (100.0)	0.917	0.338
No	120 (60.6)	78 (39.4)	198 (100.0)		
<b>Skin hotness</b>					
Yes	1 (25.0)	3 (75.0)	4 (100.0)	2.110	0.146
No	120 (60.9)	77 (39.1)	197 (100.0)		
<b>Eyes problem</b>					
Yes	6 (46.2)	7 (53.8)	13 (100.0)	1.144	0.285
No	115 (61.2)	73 (38.8)	188 (100.0)		

<b>Hair loss problems</b>	0 (0.0)	3 (100.0)	3 (100.0)	4.606	0.032
Yes	121 (61.1)	77 (38.9)	198 (100.0)		
No					
<b>Prolonged fatigue</b>					
Yes	8 (61.5)	5 (38.5)	13 (100.0)	0.010	0.919
No	113 (60.1)	75 (39.9)	188 (100.0)		
<b>Difficulty breathing</b>					
Yes	4 (80.0)	1 (20.0)	5 (100.0)	0.839	0.360
No	117 (59.7)	79 (40.3)	196 (100.0)		
<b>Serious illness (others)</b>					
Yes	4 (80.0)	1 (20.0)	5 (100.0)	0.839	0.360
No	117 (59.7)	79 (40.3)	196 (100.0)		

Chi-square test  
\*significant at  $p < 0.05$

#### 4.8 Selected variables that influenced micronuclei frequency among respondents

The last objective in this study was to determine relationship of radiofrequency (RF) radiation and self-reporting household sources with micronuclei frequency. The independent variables were chosen based on the assumption supports by past studies which highlight the possibility of these contributing factor(s) affecting the MN frequency counts in our study respondents. In this context, simple linear regression were first be done to account for the relationship of various variables, followed by analysing with multiple linear regression to identify the most influenced independent variables that could possibly affects the micronuclei frequency counts among study respondents.

#### **4.8.1 The risk factors related to micronuclei frequency due to exposure of radiofrequency (RF) radiation among respondents**

The dependent variable is micronuclei frequency, while the predictor factors as independent variables include, BMI, body temperature, electronic devices usage, household sources, radiofrequency (RF) value and existence of mobile base station at their residential surrounding.

Based on Table 4.6 and 4.7, the multiple linear regression is used to determine which predictor factors possible to influence the dependent variable. Overall, there is no significant difference between those independent variables with micronuclei frequency.

**Table 4.6 : The relationship between risk factors and micronuclei frequency among exposed respondents**

Variables	SLR <sup>a</sup>		MLR <sup>b</sup>		
	b (95% CI)	p value	Adjusted b (95% CI)	t	p value
<b>BMI</b>	-0.096 (-0.367, 0.174)	0.482	-	-	-
<b>Body temperature</b>	1.474 (-0.071, 3.020)	0.061	-	-	-
<b>Electronic devices usage</b>	-0.127 (-0.870, 0.615)	0.734	-	-	-
<b>Household sources</b>	0.095 (-0.181, 0.371)	0.498	-	-	-
<b>RF value</b>	0.029 (-0.008, 0.066)	0.122	-	-	-
<b>Second-hand smoker</b>	-0.619 (-3.144, 1.907)	0.628	-	-	-
<b>Residential area</b>					
<b>Main road</b>	-1.421 (-3.974, 1.131)	0.272			
<b>Construction area</b>	-0.403 (-3.558, 2.751)	0.800	-	-	-
<b>Industrial area</b>	-2.188 (-5.091, 0.715)	0.138			

\*p-value significant at 0.05 level

<sup>a</sup>Simple Linear Regression, <sup>b</sup>Multiple Linear Regression

**Table 4.7 : The relationship between risk factors and micronuclei frequency among non-exposed respondents**

Variables	SLR <sup>a</sup>		MLR <sup>b</sup>		
	b (95% CI)	p value	Adjusted b (95% CI)	t	p value
<b>BMI</b>	-0.461 (-1.121, 0.200)	0.169	-	-	-
<b>Body temperature</b>	-1.532 (-5.552, 2.487)	0.451	-	-	-
<b>Electronic devices usage</b>	-0.895 (-3.239, 1.364)	0.400	-	-	-
<b>Household sources</b>	0.147 (-0.607, 0.901)	0.699	-	-	-
<b>RF value</b>	0.055 (-0.059, 0.169)	0.342	-	-	-
<b>Second-hand smoker</b>	-0.635 (-7.608, 6.339)	0.857	-	-	-
<b>Residential area</b>					
<b>Main road</b>	3.522 (-3.003, 10.047)	0.286			
<b>Construction area</b>	4.053 (-13.986, 5.880)	0.420	-	-	-
<b>Industrial area</b>	6.149 (-2.764, 15.063)	0.174			

\*p-value significant at 0.05 level

<sup>a</sup>Simple Linear Regression, <sup>b</sup>Multiple Linear Regression

## **CHAPTER 5**

### **DISCUSSION, CONCLUSION AND RECOMMENDATION**

#### **5.1 Socio-demographic data of respondents**

There were 201 respondents from all four primary schools involved in this study. The age respondents that involved were 10 and 11 years old which included male and female gender. Most of the respondents involved were Malay and Indian students as they are majority races in those primary schools.

#### **5.2 Radiofrequency (RF) radiation level for each school within 200m of school location**

This section summarized radiofrequency (RF) reading for each school considered 10m distance increment within 200m distance from school location. The RF reading were measured by using Digital RF Analyzer (HF35C) which included during school time and during weekend.

SK Puchong and SK Sungai Merab were categorized as exposed group, while SK Sri Serdang and SK Serdang as non-exposed group. Exposed group measurements were started from the nearest mobile base station. While for non-exposed group, the measurements were started from the school. Overall, the RF reading were not exceed the limit based on the international standard which are FCC and ICNIRP that had been enforced in Malaysia.

This can be explained by many factors that can contribute to the RF reading for each school location. Based on the literature review, the presence of the radiofrequency (RF) and microwave radiation in public accessible areas around the mobile base station was very low compared to the radiation levels away from the mobile base station (Yusof, et. al.,2003). The fluctuation of RF level is depending on a variety of factors such as the proximity to the antenna and the surrounding environment.

Environmental settings for exposed group and non-exposed group were in different surrounding environment. The RF value for SK Serdang and SK Sungai Merab were quite low compared to other school. In addition, these two schools were considered as rural area. Those schools were surrounded with residential area and green plants. This is supported by previous study (Ali, Belangi, & Ray, 2016) which measured the RF exposure level for occupational and general public inside a Money plant model and showed that tree can provide us shielding by absorption the RF power.

As for SK Sri Serdang and SK Puchong Batu 14, the RF values were higher as compared to others. This may due to the fact that these schools were located at the urban areas and surrounded by crowed population and high rise building, industrial area, commercial area and main road. In fact, other study also stated that materials of building such as tin roof, copper plated walls etc., can contribute as reflector of RF radiation (Koppel, et. al., 2017).

In general, the RF radiation distribution not only based on the vicinity of mobile base station from the user, but, the environmental settings also contributed for the fluctuation of RF value for each exposed and non-exposed group.

### **5.3 Health effects among respondents**

Table 4.2 summarizes the health symptoms/complaints from both exposed and non-exposed group. In summary, most of the respondents from both exposed and non-exposed group were reported that they were not experienced any health symptoms affected by the RF exposure. In view of this, studies (Regel et al., 2006) showed that children who exposed to low-level non-ionizing radiation rarely developed prominent health symptoms until its reach the critical stages of health effects. Other study suggested that recall and information bias are amongst the most difficult issues to resolve when it involved self-reported health symptoms that needs one to undergo self-declaration of its health conditions (Elliott et al., 2010 ).

### **5.4 Comparison of micronuclei (MN) frequency between exposed and non-exposed group**

According to Table 4.3, the median (IQR) reading for micronuclei frequency counts among non-exposed group was higher 11.50 (8.50) than the median (IQR) reading for micronuclei frequency counts among exposed group 6.50 (10.00).

The fourth objective of this study is to compare the micronuclei frequency counts between exposed and non-exposed group. Statistical analysis shows that there was a significant difference in micronuclei frequency counts between both of the

group. This can be explained by many factors that can contribute to the RF reading for each school location. Based on the literature review, the presence of the RF and microwave radiation in public accessible areas around the mobile base station was very low compared to the radiation levels away from the mobile base station (Yusof, et. al., 2003). Study also show that the non-exposed group has an increased number of MN frequency count as compared to exposed group, this may due to the fact that, by increasing the number of base stations and locating them near where people use mobile phones actually reduces EMF levels. This is because the mobile phones only need to transmit over a short distance to the nearest base station using less power, and the network is also operating more efficiently only needing to communicate with nearby users (MCMC, n.d.)

#### **5.5 Association between radiofrequency (RF) value with micronuclei (MN) frequency**

In term of association between the RF value with MN frequency, (Table 4.4) the result of this study show that there is no significant association between RF value and MN frequency among both exposed and non-exposed group. The findings of this study is consistent with past study conducted by F.M. de Oliveira et al., (2009) stated that RF-EMF at their observed exposure levels did not induce the formation of MN in exfoliated buccal mucosa cells. Other previous study by Hintzsche and Stopper (2010) also stated that there was no significant change in micronuclei frequency with mobile phone usage which is one of the non-ionizing radiation as the RF exposure.

## **5.6 Association between health effects with micronuclei frequency among respondents**

Overall, there is no significance association between self-reported health effects with MN frequency counts, however, there was a significant association between hair loss problems with micronuclei frequency. In previous study, Rajput (2016) had some reviewed of literature regarding the hair loss problems due to radiofrequency radiation from overuse mobile phone. The study found that DNA breakage and generation of Reactive Oxygen Species (ROS) had slowing down the hair growth and lead to hair loss due to exposure of RF radiation.

## **5.7 The risk factors related to micronuclei frequency due to exposure of radiofrequency (RF) radiation among respondents**

Based on the multiple regression analysis (Table 4.6 and 4.7), there are no significant relationship between those predictor factors with dependent variable for both exposed and non-exposed group. In previous study, for BMI, in the comparison between obese subjects in three categories of classes I (BMI, 30.00–34.99), class II (BMI, 35.00–39.99) and class III (BMI,  $\geq 40.00$ ), the frequencies of MN, NPB, NBUD, apoptotic cells and necrotic cells in metaphase and plasma 8-OHdG concentrations had showed no statistically significant differences (Donmez-Altuntas et al., 2014).

In term of body temperature and MN frequency, there were many scientists and engineers believed that electromagnetic fields of low frequency could not cause alterations in human cells. So, a hypothesis was concluded based on the idea that

EMF could not generate a sufficient amount of heat to increase the body temperature, not causing damage at the DNA level (Carbonari et al., 2005). Besides, most of the genotoxicity studies had showed negative effects, however, exposure to RF fields with an extremely high SAR that results in a thermal effect showed different result. (Miyakoshi, 2013).

Plus, electronic devices usage and household sources are show no significant differences with MN frequency. Based on previous study, Lakshmi et. al., (2010) also showed no significant differences with DNA damage and micronuclei frequency with some exposure characteristics, such as total duration working (years) and frequency of use of computer (minutes/day).

In addition of, no previous study was associated with assessing the smoking status and MN frequency. However, there was previous study had stated that there was no correlation between smoking status and sacroiliac joint (SIJ) pathology (Irwin et. al., 2007). For air pollution, previous study had claimed that there was no significant associations were found for MN frequency and traffic exposure variables in any of the participants neither children nor their mothers (Mørck et al., 2016).

## **5.8 Recommendation**

- The government should enforce specific regulation regarding safe exposure of RF radiation to public users.
- The enforcement of safe distance of installation of mobile base station in specific area such as school and residential area.
- Parents should monitor the usage of electronic devices that emit RF radiation among their children.

- Enhance the awareness regarding the RF radiation exposure with health issue among public.

## **5.9 Conclusion**

The fluctuations of RF levels depend on its fixed point of installation, and the surrounding environmental settings. Besides, this study show there is no significant association between RF exposure with other health effects except for hair loss problems. Even though, the micronuclei frequency and RF level has weak association, there is a significant difference between micronuclei (MN) frequency between exposed and non-exposed group. Single source of RF from mobile base station is insufficient to conclude the potential DNA damage in this context, in fact, other sources of non-ionizing radiations and contributing factors that might affect the MN frequency shall be taken into consideration to better estimation of the potential health effects in the future. (Lakshmi, Tiwari, Bhargava, & Ahuja, 2010).

## **6.0 Limitation of the study**

The limitation of this study were the procedure for conducting this study were quite complicated as an approval from many authorities such as Ethics Committee, UPM, Ministry of Education, Department of Education of Selangor and school management must be needed. These approvals must be approved by following the highest to lowest hierarchy of system.

Besides, the cooperation from the school management was one of the limitations in this study as the management need to arrange the school activities and

meetings to give some time for researcher to conduct this study. The session for this study was divided to two session which are briefing and demonstration session and sampling session. There were some lack of information as the details regarding the mobile base station (MBS) in this country from legal authority and telecommunication companies are private and confidential.



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**APPENDIX**

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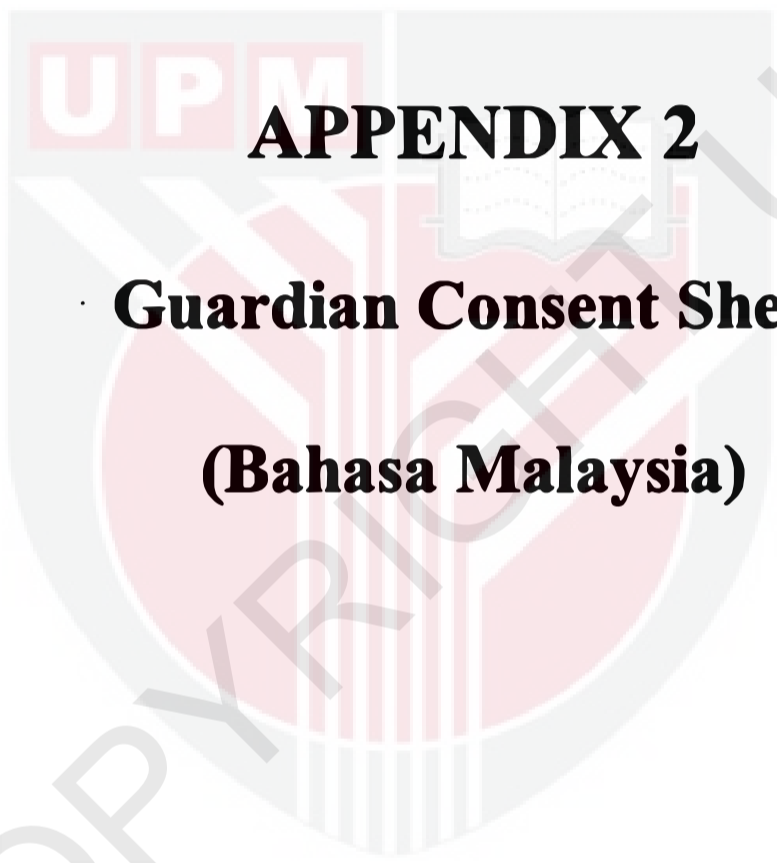
## **APPENDIX 1**

### **Gantt Chart**

**(The planning of study by month)**

UPM

Activities	2017 (months)				2018 (months)				
	9	10	11	12	1	2	3	4	5
Update research proposal									
Review research proposal by supervisor and correction									
Submit proposal to ethical committee									
Correction proposal for ethical approval									
Do pre-test questionnaire									
Update questionnaire									
Data collection									
Data analysis									
Thesis writing									
Thesis review by supervisor and correction									
Viva									



## **APPENDIX 2**

### **Guardian Consent Sheet**

**(Bahasa Malaysia)**

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**JAWATANKUASA ETIKA UNIVERSITI UNTUK  
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)  
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,  
SELANGOR, MALAYSIA**

## **BORANG 2.5 PENERANGAN DAN PERSETUJUAN IBUBAPA/PENJAGA RESPONDEN**

Sila baca maklumat berikut dengan teliti. Sekiranya anda mempunyai sebarang pertanyaan, sila kemukakan kepada penyelidik.

### **1.TAJUK KAJIAN**

Penilaian Kesan Radiofrekuensi Sistem Menara Telekomunikasi kepada Kerosakan Dna dan Kesan kepada Kesihatan dalam Kalangan Pelajar Sekolah Rendah di Selangor.

### **2. PENGENALAN**

Terdapat banyak perubahan yang mengagumkan dari bertahun-tahun yang lalu sehingga sekarang, 2017. Perubahan tersebut juga termasuk pembangunan dalam teknologi komunikasi mudah alih dan membawa kepada pertumbuhan besar bilangan menara stesen pangkalan mudah alih. Pengguna telefon bimbit terdedah kepada sinaran elektromagnet radiofrekuensi (RF) (EMR) yang merupakan pemindahan tenaga melalui gelombang.

Radiofrekuensi selalunya digunakan untuk tujuan telekomunikasi. Contoh sumber sinaran wayar, ketuhar gelombang mikro dan lain-lain.

Kepentingan kajian ini berdasarkan beberapa kajian terdahulu dan kajian ini juga akan menjalankan penyelidikan mengenai kesan radiofrekuensi stesen pangkalan mudah alih terhadap kerosakan DNA dan kesan kesihatan mereka terhadap kanak-aknak sekolah rendah. Kajian ini akan dijalankan pada bulan Januari 2018 dan anggaran responden adalah kira-kira 30 pelajar untuk setiap sekolah.

### **3. APAKAH YANG PERLU ANDA LAKUKAN?**

Penjaga/ibubapa hanya perlu menandatangani borang persetujuan bagi pihak kanak-kanak untuk terlibat dalam kajian ini. Hanya kanak-kanak yang telah disepertujui oleh penjaga/ibubapa sahaja akan diambil sebagai responden dalam kajian ini. Responden dikehendaki untuk melengkapkan setiap ujian di bawah mengikut arahan penyelidik :

- i. Borang soal selidik
- ii. Pengumpulan sel pipi

Prosedur pengumpulan sel pipi adalah seperti berikut :

- 1) Responden akan terlebih dahulu diarahkan untuk membilas mulut mereka dengan air sebelum persampelan bermula.
- 2) Berus sitologi steril akan digunakan untuk mengumpul sel pipi yang terkelupas dari responden.
- 3) Responden akan mengarahkan untuk menggosokkan berus pada bahagian dalam pipi ke atas dan ke bawah di sepanjang pipi 30 kali.
- 4) Berus sitologi akan dibasuh dengan saline buffer fosfat (PBS) dan saline normal dalam tiub mikrosentrifuge 1.5ml yang berbeza.
- 5) Spesimen akan disimpan dalam bekas yang tertutup sebelum dipindahkan ke makmal untuk analisis makmal.

#### **4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?**

Kanak-kanak yang tidak memenuhi ciri-ciri berikut tidak dibenarkan untuk mengikuti kajian ini :

- i. Berumur diantara 10-11 tahun.
- ii. Tidak mengambil sebarang ubat-ubatan atau menjalani rawatan kemoterapi.
- iii. Tidak mempunyai sebarang masalah kesihatan seperti malnutrisi, penyakit hati dan sebagainya.

#### **5. APAKAH FAEDAH MENYERTAI KAJIAN INI?**

##### **a) KEPADA ANDA SEBAGAI PESERTA?**

Pada akhir kajian ini, ibubapa/penjaga akan dimaklumkan mengenai keputusan maklumat kesihatan mereka, di mana ini dapat membantu meningkatkan kualiti hidup dalam masa akan datang :

- i. Keputusan analisis sel pipi dapat membantu untuk menentukan jika kanak-kanak tersebut berisiko kepada perencatan kitaran mikronuclei akibat daripada pendedahan jangka panjang terhadap radiofrekuensi stesen pangkalan mudah alih yang terdapat di persekitaran mereka.

Analisis simptom atau kesan kesihatan yang dialami oleh kanak-kanak akan dapat membantu untuk mengenalpasti potensi risiko pendedahan radiofrekuensi stesen pangkalan

mudah alih kepada mereka pada peringkat awal dan mencadangkan langkah pencegahan untuk mengurangkan risiko tersebut.

#### **b) KEPADA PENYELIDIK?**

Di akhir kajian ini, penyelidik akan dapat menyediakan satu gambaran secara keseluruhan tentang rangka kerja penilaian pendedahan dan pendekatan yang mampu mengisi jurang data dalam bidang-bidang berikut :

- i. Dokumentasi hasil kesihatan dalam kalangan kanak-kanak yang berhampiran dengan stesen pangkalan mudah alih.
- ii. Mengutarakan dan menghubungkan status kesihatan yang sedia ada, persekitaran sekeliling dan lokasi sekolah dengan sumber radiofrekuensi stesen pangkalan mudah alih.

#### **6. ADAKAH IA BERISIKO?**

Risiko-risiko utama adalah proses pengumpulan sel pipi, di mana proses pengambilan sel pipi ini akan mengakibatkan ketidakselesaan kepada responden. Proses ini tidak memudaratkan memandangkan penyelidik telah dilatih dengan prosedur standard operasi dalam mengendalikan semua ujian yang terlibat dalam kajian ini, minimum dan sifar risiko akan dipastikan sepanjang proses pengumpulan data.

Pada akhir sesi ini, satu tanda penghargaan akan diberikan kepada peserta dalam kajian ini dan seterusnya menerangkan risiko minimum untuk mendapatkan kesan fizikal selepas pengumpulan data ini.

#### **7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?**

Semua maklumat yang telah dikumpulkan semasa kajian akan dirahsiakan. Maklumat hanya akan mendedahkan dalam mana-mana laporan atau penerbitan secara kolektif. Walaubagaimanapun, keputusan akan dihantar dan dilaporkan kepada anda, hanya jika terdapat permintaan.

**8. SIAPA YANG SAYA PERLU HUBUNGI SEKIRANYA SAYA MEMPUNYAI SOALAN TAMBAHAN SEMASA MENGIKUTI PENYELIDIKAN INI?**

Jika anda mempunyai sebarang pertanyaan semasa penyelidikan, sila hubungi kami untuk maklumat yang lebih lanjut:

<b>Nur Azira binti Baharuddin</b> <b>(Pelajar Ijazah Sarjana Muda)</b>	<b>Dr. Vivien How (Penyelia Projek)</b>
<b>Email: <a href="mailto:azirabaha95@gmail.com">azirabaha95@gmail.com</a></b>	<b>Email: <a href="mailto:vivien@upm.edu.my">vivien@upm.edu.my</a></b>
<b><u>Tel:014-9899096</u></b>	<b>Tel:016-6193697</b>
Jabatan Kesihatan Persekitaran dan Pekerjaan, Fakulti Perubatan dan Sains Kesihatan, UPM, 43400, Serdang, Selangor Darul Ehsan	

Sila tandatangan di sini sekiranya anda telah membaca dan memahami kandungan halaman ini \_\_\_\_\_

**9. PERSETUJUAN**

Saya..... No Kad Pengenalan. ....  
beralamat.....  
.....dengan ini setuju/tidak setuju untuk membenarkan anak saya..... mengambil bahagian dalam penyelidikan yang tersebut di atas \*(kajian klinikal/percubaan ubat-ubatan/rakaman video/kumpulan sasaran/temuduga/ soal selidik).

Saya telah diberi penjelasan secara menyeluruh mengenai penyelidikan ini dari segi metodologi, risiko dan komplikasi (seperti tertulis pada Helaian Penerangan Responden). Saya memahami bahawa anak saya berhak menarik diri dari penyelidikan ini pada bila-bila masa tanpa memberi sebarang alasan.Saya juga memahami bahawa sebarang maklumat yang berkaitan identiti anak saya akan dirahsiakan.

Saya\* berminat / tidak berminat untuk mengetahui keputusan kajian yang melibatkan anak saya.

Saya setuju/tidak bersetuju untuk imei/gambar/rakaman video/ rakaman suara anak saya digunakan dalam apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

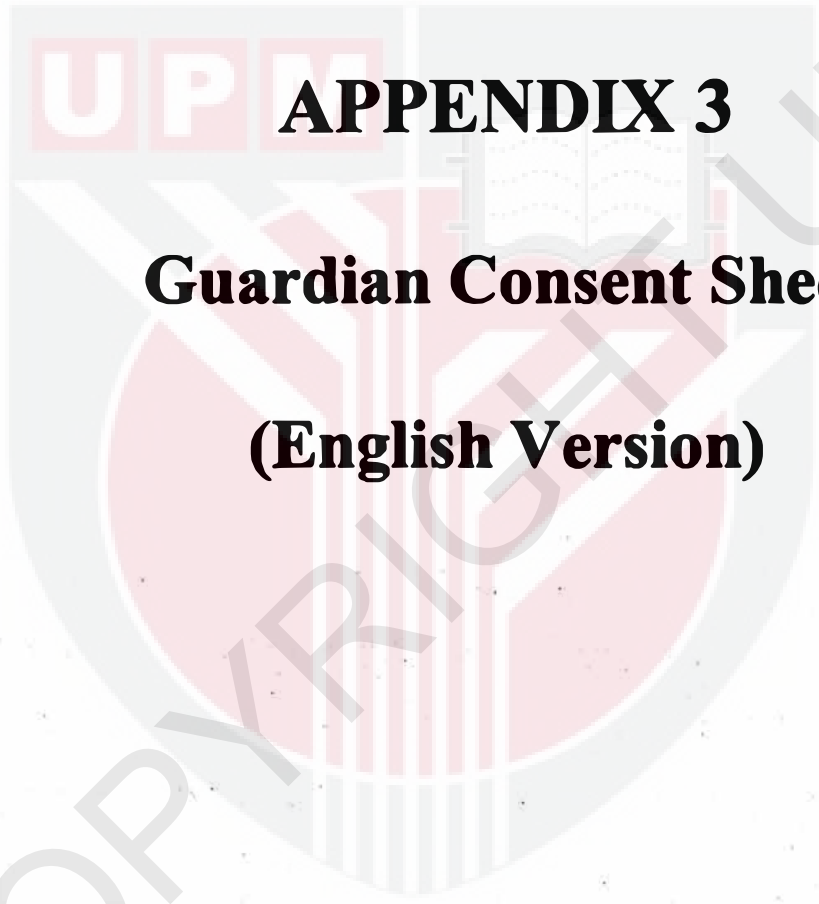
\*potong yang tidak berkenaan

Tandatangan ..... Tandatangan .....  
(ibubapa/Penjaga) (Saksi)

Tarikh :..... Nama :.....  
No. K/P: .....

Saya mengesahkan bahawa saya telah menerangkan kepada ibubapa/penjaga responden ini sifat dan tujuan penyelidikan yang tersebut di atas.

Tarikh ..... Tandatangan .....  
(Penyelidik)



**APPENDIX 3**

**Guardian Consent Sheet**

**(English Version)**

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**FORM 2.5: RESPONDENT'S INFORMATION SHEET AND GUARDIAN'S/PARENT'S CONSENT**

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

**1. STUDY TITLE :**

The effects of radiofrequency (RF) radiation from mobile base station on DNA damage and its health effects among primary school children in Selangor.

**2. INTRODUCTION:**

There are many impressive changes from years ago to now, 2017. The change also includes development in mobile communication technology and led to the huge growth of the number of mobile base station towers. Mobile phone users are exposed to radiofrequency (RF) (EMR) electromagnetic radiation which is energy transfer through waves.

Radiofrequency is often used for telecommunication purposes. Examples of sources of radiofrequency radiation are radio and television broadcasting, mobile phones, pagers, wireless phones, microwaves and others.

The importance of this study is based on some previous studies and this study also will conducted a research regarding radiofrequency radiation effects on DNA damage and their health effects on primary school children.

**3. WHAT WILL YOU HAVE TO DO?**

Parents/guardian only need to sign an agreement form on behalf of children to engage in this study. Only children who have been approved by the parents/guardian will be taken as a

respondent in this study. Respondents are required to complete each test under the direction of the researcher:

- i. Questionnaire form
- ii. Collection of buccal mucosa cell

The procedures of collecting buccal mucosa cell are :

- 1) Respondent will first be instructed to rinse their mouth with water before the sampling began.
- 2) A sterile cytology brush will use to collect exfoliated buccal mucosa cell from respondents.
- 3) Respondents will instruct to rub the brush firmly up and down along the inside of the cheek 30 times.
- 4) The cytology brush will be washed with phosphate buffered saline (PBS) and normal saline in the different 1.5ml micro centrifuge tube.
- 5) The specimens will store in a sealed container before being transferred to the laboratory for laboratory analysis.

#### **4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?**

Children who do not meet the following characteristics are not allowed to follow this study:

- i. Aged between 10-11 years old.
- ii. Do not take any medication or undergo chemotherapy treatment.
- iii. Have no health problems like malnutrition, liver disease and so on.

#### **5. WHAT WILL BE THE BENEFITS OF THE STUDY:**

##### **(a) TO YOU AS THE SUBJECT?**

At the end of the study, parents/guardian will be informed of their health information decisions, which can help improve the quality of life in the future:

- i. The results of the cheek cell analysis can help to determine if the child is at risk of micronuclei frequency inhibition as a result of long-term exposure to radiofrequency of the mobile base stations found around their environment.
- ii. The symptom analysis or health effects experienced by children will be helpful in identifying the potential risks of radiofrequency exposure to mobile base stations to them at an early stage and proposing preventative measures to mitigate these risks.

**(b) TO THE INVESTIGATOR?**

At the end of the study, researchers will be able to provide an overall picture of the disclosure assessment framework and approaches that are capable of dividing the data gap in the following areas:

- i. Document health outcomes among children near a mobile base station.
- ii. Address and relate existing health status, surroundings and school location with radiofrequency sources of mobile base stations.

**6. WHAT ARE THE POSSIBLE RISKS?**

The main risks are the process of collecting cheek cells, in which the process of taking the cheek cells will cause discomfort to the respondents. This process is not detrimental as researchers have been trained with standard operating procedures in handling all the tests involved in this study, minimum and zero risk will be ascertained throughout the data collection process.

At the end of this session, a token of appreciation will be awarded to participants in this study and further explain the minimal risks of getting physical hurts aftermath of this data collection.

**7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?**

All the information that has been collected during the study will be kept confidential. Information will only be disclosed in any collective report or publication. However, the results will be sent and reported to you, only if there is a request.

**9. GUARDIAN'S/PARENT'S CONSENT**

I ..... Identity Card No. ....  
address.....

.....hereby voluntarily agree to allow my \*son / daughter / ward..... to take part in the research stated above \*(clinical/ questionnaire/drug trial/video recording/ focus group/interview).

I have been informed about the nature of the research in terms of methodology, possible adverse effects and complications (as written in the Respondent's Information Sheet). I understand that my \*son / daughter / ward has the right to withdraw from this research at any time without giving any reason whatsoever. I also understand that this study is confidential and all information provided with regard to the identity of my\* son / daughter / ward will remain private and confidential.

I\* wish / do not wish to know the results related to my my \*son's / daughter's / ward's participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to my son/daughter/ward be used in any form of publication or presentation. (if applicable).

\* delete where necessary

Signature .....  
(Parent/Guardian)

Signature .....  
(Witness)

Date :.....

Name :.....

I/C No. :.....

I confirm that I have explained to the respondent's parent/guardian the nature and purpose of the above-mentioned research.

Date .....

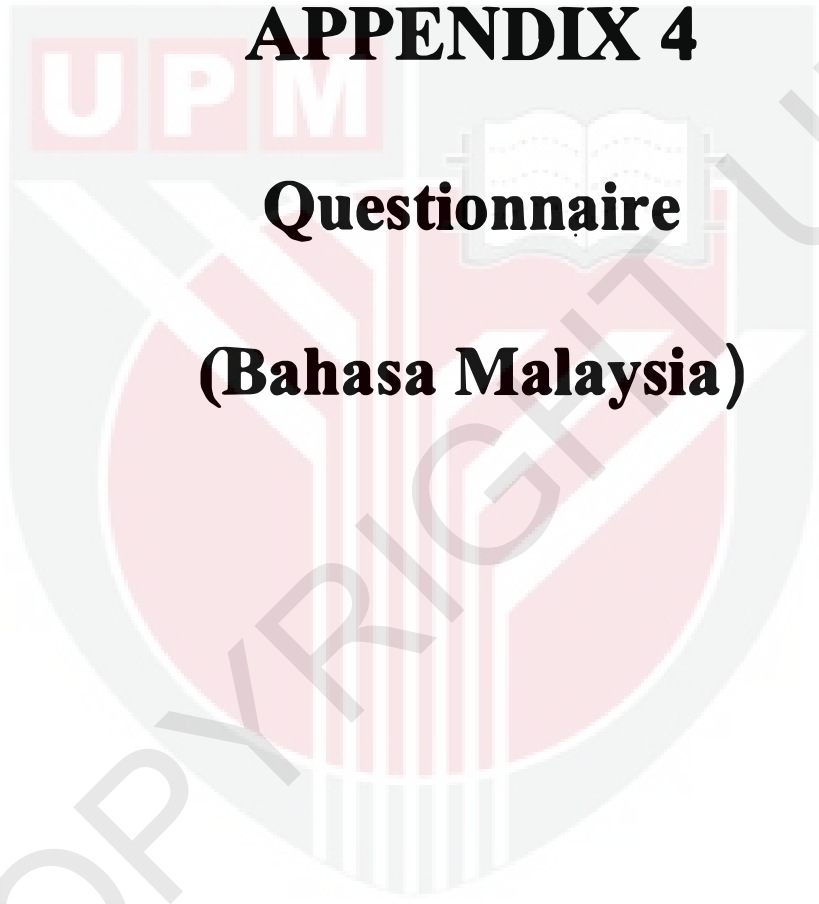
Signature .....  
(Researcher)

**8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?**

If you have any questions during the research, please contact us for more information:

<b>Nur Azira Baharuddin (Student of Bachelor in Science of Environmental and Occupational Health)</b>	<b>Dr. Vivien How (Project Supervisor)</b>
<b>Email: azirabaha95@gmail.com</b>	<b>Email: vivien@upm.edu.my</b>
<b>Tel no: 014-9899096</b>	<b>Tel no: 016-6193697</b>
Jabatan Kesihatan Persekitaran dan Pekerjaan, Fakulti Perubatan dan Sains Kesihatan, UPM, 43400, Serdang, Selangor Darul Ehsan	

Please initial here if you have read and understood the contents of this page \_\_\_\_\_



**APPENDIX 4**  
**Questionnaire**  
**(Bahasa Malaysia)**

## Screening Questionnaire

1. Adakah anak anda mempunyai sejarah pendedahan kepada ubat terapeutik cytotoxic (kemoterapi)?

Ya

Tidak

2. Adakah anak anda mempunyai masalah kesihatan seperti malnutrisi, anemia, sawan, masalah buah pinggang dan penyakit hati?

Ya

Tidak

3. Pernahkah anak anda menjalani ujian X-Ray sepanjang minggu lepas?

Ya

Tidak



1.9 Adakah anak-anak anda telah didiagnosis untuk sebarang penyakit di bawah?

A7

Kencing Manis

Ya

Tidak

Asma

Ya

Tidak

Karies gigi

Ya

Tidak

Sebarang penyakit yang berkaitan dengan gigi (cth: Periodontal)

Ya

Tidak

1.10 Adakah anak anda sedang mengambil sebarang ubat-ubatan atau dalam tempoh 48 bulan yang lepas?

A8

Ya

Tidak

1.11 Jika Ya pada soalan 1.10, nyatakan nama ubat-ubatan tersebut?

A9

.....

1.12 Adakah anak anda mengambil sebarang suplemen atau vitamin?

A10

Ya

Tidak

1.13 Jika Ya pada soalan 1.12, nyatakan nama suplemen atau vitamin tersebut?

A11

.....

1.14 Adakah anak anda vegetarian?

A12

Ya

Tidak

1.15 Adakah anak anda alah kepada produk gluten (gluten intolerance)?

A13

Ya

Tidak

1.16 Adakah anak anda mempunyai alahan berikut?

A14

Resdung

Ya

Tidak

Sebarang penyakit  
kulit (cth : Atopic Dermatitis)

Ya

Tidak



---

**BAHAGIAN B: IBUBAPA PELAJAR**

---

1.17 Alamat rumah

.....  
.....  
.....  
.....

B1

1.18 Berapa lamakah anda telah tinggal di kawasan kejiranan ini?

.....

B2

1.19 Apakah hubungan anda dengan pelajar?

Ayah	Ya	<input type="text"/>	Tidak	<input type="text"/>
Ibu	Ya	<input type="text"/>	Tidak	<input type="text"/>
Lain-lain (Sila nyatakan)	Ya	<input type="text"/>	Tidak	<input type="text"/>

B3

1.20 Adakah mana-mana ahli keluarga anda merokok sejak anak anda dilahirkan?

Ayah	Ya	<input type="text"/>	Tidak	<input type="text"/>
Ibu	Ya	<input type="text"/>	Tidak	<input type="text"/>
Ahli Keluarga yang lain	Ya	<input type="text"/>	Tidak	<input type="text"/>

B4

1.21 Jika Ya pada soalan 1.12, nyatakan kekerapan anda merokok?

.....

B5

1.22 Jika Ya pada soalan 1.12, nyatakan bilangan rokok yang anda hisap sehari?

.....

B6

1.23 Apakah tahap pendidikan anda?

B7

Penilaian Menengah Rendah (PMR)

Sijil Peperiksaan Malaysia (SPM)

Certificate

Diploma

Ijazah Sarjana Muda

Ijazah Sarjana

Doktor Falsafah (PhD)

1.24 Apakah pekerjaan anda?  
.....

B8

1.25 Sila nyatakan jenis rumah anda?  
.....

Adakah anda tinggal di dalam persekitaran yang berdebu? (Contoh: berhampiran dengan kawasan pembinaan, jalan utama, kawasan perindustrian, kuari dan lain-lain)?

1.26

Kawasan perindustrian	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>
Jalan utama	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>
Kawasan Perindustrian	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>
Kuari	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>

B9

B10

**BAHAGIAN C : SUMBER RADIASI DI RUMAH**

1.29 Apakah jenis aktiviti (hobi) yang biasa anak anda lakukan ?

Jenis aktiviti	Kali dalam seminggu	Tempoh masa

C1





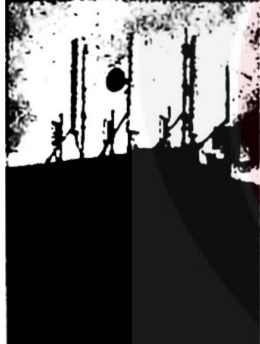


1.30 Adakah anda membenarkan anak anda untuk bermain peralatan elektronik (telefon bimbit, komputer riba, permainan video)?

C2

Telefon bimbit	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>
Komputer Riba	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>
Permainan Video	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>
Desktop	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>
Tablet	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>
Mp3	Ya	<input type="checkbox"/>	Tidak	<input type="checkbox"/>



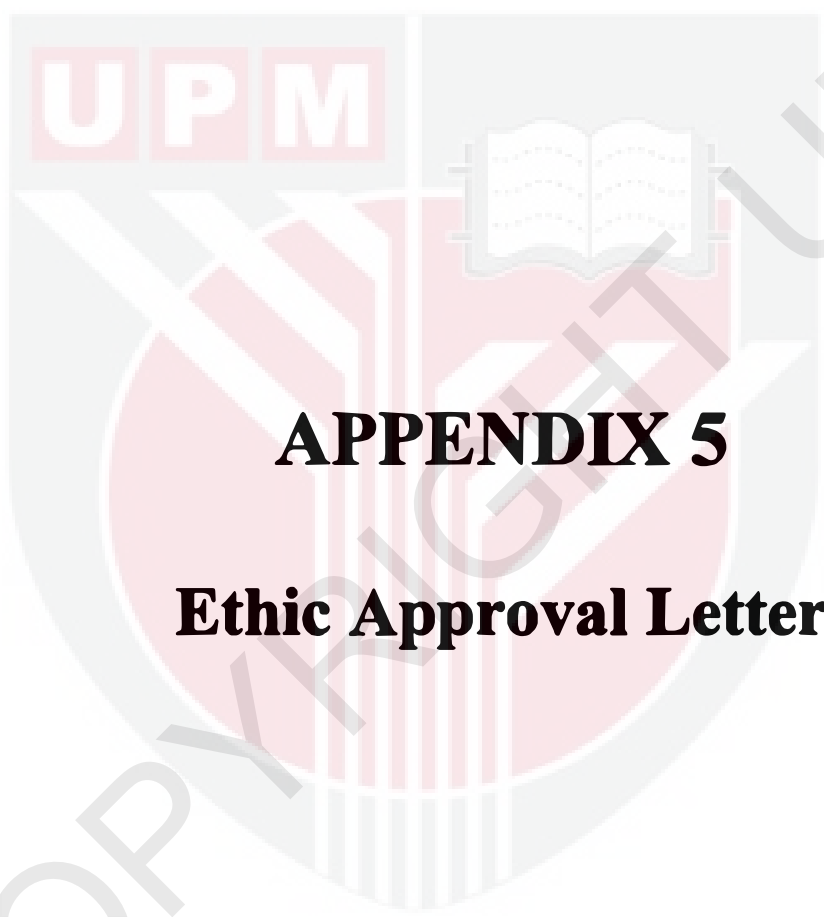
### Sistem Menara Telekomunikasi

	Ya	Tidak
Adakah anda tahu apa itu stesen pangkalan telefon bimbit?	( )	( )
Adakah terdapat stesen pangkalan telefon bimbit berhampiran / sekitar rumah anda?	( )	( )
<p>Apakah jenis stesen pangkalan telefon bimbit yang anda dapati berhampiran / sekitar rumah anda?(Sumber: Korsortium Jaringan Selangor)</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;">  <p>Four Legs Tower 60 -75m ( )</p> </div> <div style="text-align: center;">  <p>Monopole Tree 30 - 45 m ( )</p> </div> <div style="text-align: center;">  <p>Lamp pole 30 m ( )</p> </div> <div style="text-align: center;">  <p>Mono Pole plain 30-45 m ( )</p> </div> </div> <div style="display: flex; justify-content: space-around; align-items: flex-start; margin-top: 20px;"> <div style="text-align: center;">  <p>Roof top 6m ( )</p> </div> <div style="text-align: center;">  <p>Rapid Deployment Structure 30 - 45 m ( )</p> </div> <div style="text-align: center;">  <p>Lamp pole 20-24m ( )</p> </div> </div>		
<p>Sila nyatakan bilangan stesen pangkalan telefon bimbit berhampiran / sekitar rumah anda Bilangan stesen : .....</p>		
Adakah terdapat kehadiran atau tidak (Santini et al., 2003) i. Kabel elektrik berkuasatinggi (kurang daripada 100 m) ii. Pemancar radio dan televisyen ( sekurang-kurangnya jauh dari 4 km) iii. Transformer elektrik (kurang daripada 10 m)	Ya	Tidak
	( )	( )
	( )	( )
Bolehkah anda menganggarkan jarak dari stesen pangkalan telefon ke rumah anda?	( )	kurang dari 10 m
	( )	10-50 m
	( )	50-100 m.
	( )	100-200 m
	( )	200-300 m
	( )	Lebih daripada 300 m

**BAHAGIAN D: SIMPTOM BERKAITAN KESIHATAN**

Tandakan(/) mana-mana simptom kesihatan yang dihadapi oleh anak anda:

No	Perkara	Ya	Tidak
1	Adakah anak anda pernah mengalami rasa pening yang berpanjangan tanpa melakukan sebarang aktiviti berat dan hanya berada dalam keadaan rehat di dalam rumah untuk tempoh yang lama?		
2	Adakah anak anda pernah mengalami rasa panas badan yang berpanjangan ketika berada di rumah walaupun dalam keadaan sihat iaitu tidak demam atau sakit serta tidak melakukan aktiviti berat dan hanya berehat di rumah untuk tempoh yang lama?		
3	Adakah anak anda mengalami gangguan tidur?		
4	Adakah anak anda kerap berasa loya?		
5	Adakah anak anda kerap merasa sakit pada sendi dan otot?		
6	Adakah anak anda sering mengalami masalah sukar member tumpuan terhadap sebarang aktiviti yang memerlukan kadar tumpuan yang tinggi seperti mengulangkaji pelajaran?		
7	Adakah anak anda sering berasa gelisah yang keterlaluan dan berpanjangan?		
8	Adakah anak anda mengalami rasa panas pada bahagian kulit untuk tempoh masa yang lama?		
9	Pernahkah anak anda mengalami masalah kesihatan berkaitan penglihatan dalam tempoh 6 bulan kebelakangan ini?		
10	Adakah anak anda mengalami masalah keguguran rambut yang banyak?		
11	Adakah anak anda mengalami keletihan yang berpanjangan walaupun tidak melakukan aktiviti berat?		
12	Adakah anak anda mengalami sesak nafas dalam tempoh 6 bulan ini?		
13	Adakah anak anda mempunyai sebarang penyakit serius? Jika ya, sila nyatakan :		



**APPENDIX 5**

**Ethic Approval Letter**

**UPM**



## **APPENDIX 6**

### **Ministry of Education Approval Letter**

**UPM**

## **APPENDIX 7**

### **Department of Education of Selangor Approval Letter**