Assessment of Possible Health Risks of Electromagnetic Field Exposures due to Emerging Technologies

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Abstract—Safety issues of electromagnetic field (EMF) exposures are discussed. The topics include safety of millimetre and terahertz waves, wireless power transfer, and emerging wireless communication systems of complex nature. Difficulties of epidemiological studies is also discussed. The author suggests that a relevant level of caution is recommended for this issue which allows safety use of electromagnetic energy with reasonable efforts.

I. INTRODUCTION

Effects of electromagnetic fields (EMFs) have been of concern of people for a long time. Established effects are thermal effect for high-frequency EMFs (>100 kHz) and stimulation effect for low frequency EMFs (<10 MHz). Those established effects are acute effects of short-term exposure. They provide basis for guidelines to limit exposure to EMFs [1][2]. The use of EMF energy is now regulated by authorities in many countries to comply with those guidelines. However, there are still needs to investigate this issue from several reasons.

One is the application of those guidelines to emerging new technologies which are not exactly covered by the guidelines. We experienced this problem when the mobile phones became common to the majority of people. Mobile phones are used in the close proximity to human head while the early guidelines did not cover such kind of near-field exposures. Early guidelines just exempted devices with output power less than 7W from evaluation with exposure guidelines [3]. Exposure guidelines need to be grown up with the emerging technologies. The revision should include both exposure guidelines itself and method for the assessment of compliance with the guidelines.

Another issue is the ever-lasting concerns of public about possible effects of low level long-term exposures. There is no convincing evidence for long-term health effects. Epidemiological studies are deemed to be most reliable means to investigate such effects. National and international researches of epidemiological studies have been organized. However, exposure assessment for those studies becomes more and more complex due to the rapid development of communication technologies.

In this presentation, I would introduce some topics related to EMF exposures due to emerging technologies related to both short-term and long-term exposures.

II. MILLIMETRE- AND TERAHERTZ WAVE APPLICATIONS

Millimetre-waves and terahertz waves are expected to be used for daily-life applications in the near future. Exposure guidelines include frequencies up to 300 GHz [1] and higher frequencies are covered by safety guideline for infrared radiations [4]. Those guidelines, however, have little evidence obtained from experiments at those frequencies but based on the extrapolation from data at lower or higher frequencies.

The energy absorption in those frequencies is superficial and the interaction occurs only in the limited tissues on the body surface. Recent results of millimetre-wave effect on the rabbit eyes revealed complex interaction between millimetre-waves and cornea [5]. Time constant should be revisited to determine the averaging time of exposure.

Terahertz waves are even less explored than millimetre-waves in terms of biological effects. There was hypothetical theory proposed by H. Fröhlich [6] that electromagnetic fields at around $10^{11}$ Hz could interact with cellular functions. Understanding interaction between terahertz waves and biological systems [7] is important in the development of applications using those waves.

III. WIRELESS POWER TRANSFER

Wireless power transfer is a technology that attracts hot attention in recent years. This technology is historically originated from Tesla’s “World system” proposed one hundred years ago. Recently the resonance-type wireless power transfer was demonstrated to be feasible in transmission of energy to a certain distance with a good efficiency [8]. This report stimulated the interest in this technology all over the world.

This technology emits EMF to the environment, resulting in the interaction with other electronic systems and human body. The issue of electromagnetic compatibility as well as human safety should be explored before the implementation of the system.

Another topic about wireless power transfer is the idea of space solar power satellite (SSPS) [9]. This technology has pros and cons about the impact on environment. It is free from production of carbon dioxide while microwaves are potentially concerned by general public as an impact on environment. The current exposure guidelines consider only
human body to protect while ecological considerations for animals and plants should be included in the analysis of environmental impact due to SSPS.

IV. EMERGING WIRELESS COMMUNICATIONS

Radiofrequency (RF) EMF has been classified to be “possibly carcinogenic to humans” (Group 2B) by International Agency of Research on Cancer (IARC) of World Health Organization (WHO) in June 2011 [10]. The key to this classification was the evidence from epidemiological studies on the association between the incidence of brain tumour and mobile phone use. The INTERPHONE study organized by IARC was a large scale international collaborating study with 13 participating countries including Japan [11]. The result was not clear enough but the evidence from epidemiological studies including INTERPHONE was evaluated “limited evidence”. This result inevitably lead the classification to “Group 2B” or higher.

The IARC recommended further research on this issue especially with the focus on children. The Mobi-Kids project is ongoing in response to the recommendation. Exposure assessment is the key to the reliability of the epidemiological studies. The exposure assessment system, however, find difficulty in this task because of the recent change in wireless communication technology.

The mobile phone system has been replaced from 2nd generation (2G) to 3rd generation (3G) or later very quickly. The data communication becomes rather prevailing over voice communications and voice communication on Wifi network has become common to many users. In addition to the variation of communication modality the 3G network systems have quite different characteristics of power control from 2G network systems. The average output power from 3G phones is about 1 % of 2G phones which were majority in the INTERPHONE. The low power nature of 3G phones makes it necessary to consider other EMF sources including cordless phones, Wifi, and so on [12].

Epidemiological studies play an important role in the risk assessment but we should note the difficulty in exposure assessment. The interpretation of the result should be relevantly done with consideration of the difficulty.

V. THE WAY FORWARD

There have been tremendous efforts and resources devoted to EMF safety since 1996 when the International EMF Project of WHO started. With all those efforts we have not completed the task yet. In consideration of rapid development of technology it is not likely that the task of fully understanding the issue will be completed. Experiments on carcinogenicity, for example, have been conducted for as many different signals as possible for each frequency and for different signals specific to the system. We now recognize this approach is not realistic in consideration of the rapid progress in the technology. We should find a way to deal with the safety issue of EMF exposure at a reasonable cost with a good reliability. This is a challenge but should be overcome for the future development of new technologies.

REFERENCES