



# Editorial Introduction to the Special Issue "Electromagnetic Waves Pollution"

## Emanuele Calabrò

Department of Mathematics and Informatics Sciences, Physics Sciences and Earth Sciences, University of Messina, Messina, Viale D'Alcontres 31, I-98166 Messina, Italy; e.calabro@yahoo.com

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**Abstract:** Modern technology has largely developed using energy forms of which the most relevant is surely electricity. Electric power stations generate alternate current at frequencies of 50 or 60 Hz, transmitted across high voltage transmission lines that are often located too near to buildings where humans live or work. In addition, home devices that work using alternate current expose humans to extremely low-frequency electromagnetic fields. Furthermore, trams, electric trains, and some industrial processes generate static magnetic fields. Electromagnetic fields produce non-ionizing radiation, which gives rise to the so-called electromagnetic waves pollution, also named electrosmog. A large scientific production study showed harmful effects of exposure to EMFs. In view of these results, the International Commission on Non-Ionizing Radiation Protection published international guidelines in order to recommend exposure limits to EMFs for occupational exposure and for general public exposure. The aim of this thematic issue is to give a further contribution to highlight the problem of electromagnetic waves pollution and to investigate the effects of exposure to EMFs on biological systems even below the EMF limits recommended by ICNIRP.

**Keywords:** electromagnetic waves pollution; electric power lines; static magnetic fields; extremely low-frequency electromagnetic fields; health effects; cellular functions effects

## 1. A Brief Background of the Special Issue

People are commonly exposed to various types of electromagnetic fields (EMFs) that are static magnetic fields (SMFs),  $50 \div 60$  Hz EMFs commonly named extremely low frequencies (ELF) EMFs and high frequencies (HF) EMFs. EMFs are generated everywhere in our living environment by modern electrical systems such as power lines, electrical generators and motors, electrical wiring, home electronic devices, and wireless communication systems. In particular, in close proximity to certain home appliances, the magnetic-field intensities can be as much as few hundred microteslas, whereas in some workplaces they can reach 10 mT.

For instance, low-intensity SMFs ranging from 0.1 to 10 mT can be measured in proximity to the magnetic poles of conventional rail system DC traction motors, audio speaker components, battery-operated motors, refrigerator magnets, and headphones [1–3].

Various experimental observations demonstrated that exposure to SMFs induces unhealthy effects on biological systems and alterations in cellular functions [4–8]. Even significant changes in simple organic systems under exposure to SMFs were observed [9–13].

Regarding the effects of exposure to 50/60 Hz EMFs, some epidemiological studies reported a possible correlation between an increase of risk of cancer and exposure to ELF-EMF [14,15]. Indeed, although 50/60 Hz EMFs seem to not directly lead to genotoxic effects, some studies evidenced that certain cellular processes can be altered by exposure to ELF-EMFs such as changing the structure of DNA, causing strand breaks and other chromosomal aberrations [16]. Genotoxic damage in various cell models due to exposure to ELF-EMFs was also demonstrated [17–19]. Three studies of the

World Health Organization (WHO) also evidenced possible health effects from exposure to static and ELF-EMFs [20–22]. Further alterations in cellular functions due to exposure to ELF-EMFs have been observed [23–26]. Interestingly, protein aggregation induced by exposure to ELF-EMFs was also demonstrated [27–31], leading the researchers to hypothesize a correlation between exposure to EMFs and certain pathologies in humans. Indeed, protein aggregation in fibrillar form can be associated with some types of neurodegenerative disorders that are the first step toward certain pathologies [32–35].

Finally, in recent years, the achievement of wireless technology has induced the growing use of high-frequency electromagnetic fields (HF-EMFs), represented by radiofrequencies (RFs) and microwaves (MWs) emitted by radio stations and wireless home devices, the most used of which is surely mobile phone. Indeed, it is possible that these devices can work near to natural biological frequencies, interfering with sophisticated electric circuits that are present in the human body, for example in the brain [36–39]. In addition, some in vitro experiments showed that RF-MWs can be carcinogens and can induce DNA damage [40–46]. Alterations in the secondary protein's structure were also observed, represented by protein aggregation and alignment towards an applied HF-EMF [47–55], giving evident proof that exposure to HF-EMFs causes significant non-thermal effects even in simple organic systems.

Despite the fact that the International Commission on Non-Ionizing Radiation Protection (ICNIRP) published international guidelines in order to recommend exposure limits to EMFs for occupational exposure and for general public exposure [56–59], significant alterations have been observed even below EMF limits recommended by the ICNIRP, such as shown in the (non-exhaustive) reference list cited above. In this regard, a new approach in order to preserve living beings from electromagnetic waves pollution has been recently proposed [60].

#### 2. The Aim of This Special Issue

The reference list cited above regarding the effects of exposure to EMFs is surely not exhaustive. Despite the fact that some results in previous literature reported no significant alterations in living functions after exposure to EMFs, electromagnetic waves pollution is a problem that cannot be neglected.

In view of these facts, the aim of this thematic issue is to give a further contribution to highlight the effects of exposure to EMFs on biological systems at low frequencies generated by modern electromagnetic systems in use at present, even below the EMF limits recommended by the ICNIRP.

In this regard, the published papers of this special issue give further demonstration of significant harmful effects on biological systems induced by exposure to ELF-EMFs. In particular, it was shown that in vivo cytoxicity is induced by 60 Hz EMFs under a high-voltage substation environment [61], which is an environment to which humans can commonly be exposed. In Ref. [62], measurements of ELF-EMFs intensity were carried out in the rooms of apartments near high- and medium-voltage wiring and transformer stations, which can be generally located inside residential buildings. Magnetic field levels greater than 0.3  $\mu$ T were found, which are comparable to simulation values at which significant effects were observed in previous literature [23–28]. Finally, modulation of Ca2+/H+ and Na/H+ plasma membrane antiporters of human peripheral blood lymphocytes were found in [63] after exposure to a SMF at 6 mT, which is a magnetic field level comparable to SMFs generally measured in proximity to the magnetic poles of conventional rail system DC traction motors, audio speaker components, battery-operated motors, refrigerator magnets, and headphones [1–3].

In conclusion, the studies reported in this thematic issue give further proof of significant effects in cellular functions induced by exposure to intensity levels of ELF-EMFs to which humans are generally exposed. Since it cannot be ruled out that such measured alterations can induce the onset of diseases in humans, it would be advisable to design shielding protection against exposure to EMFs or to plan electromagnetic systems and devices working at frequencies far from natural resonant frequencies of biological systems. These frequencies would be discovered in future research.

Conflicts of Interest: The authors declare no conflicts of interest

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