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Opinion

Safe and environmentally friendly daily use of clean-energy electromagnetic devices

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Abstract: The daily well-being of modern humanity is closely linked to the use of different devices operating through different sources of energy conversion. Electromagnetic energy obtained from the conversion of clean energy is one of the most used in devices in this context. The use of these devices reflects the expected results, often accompanied by unwanted side effects. These undesirable side effects correspond to the interaction of artificial electromagnetic radiation with living tissues of biodiversity (One Health concept). The corresponding living tissues are related to humans, animals (domestic and wild), birds, plants, etc., and more generally to biodiversity, including the ecosystem. Therefore, these harmful effects could be reduced by intelligent and sustainable construction and protection (Responsible Attitude concept) of these devices. This article aimed to illustrate the implication of the concepts of One Health and Responsible Attitude in the management of the daily use of wireless communication tools with electromagnetic energy, as well as power transfer devices. The two concepts were first discussed. The biological effects on living tissues due to exposure to electromagnetic field radiation were analyzed in the case of humans, animals and plants. The different characteristics of the radiated field and exposed tissues influencing these effects, as well as the governing laws and mathematical modeling of the effects, were examined. Additionally, the means for protecting living tissues from electromagnetic radiation were inspected. The analyses pursued in this article were supported by examples taken from the literature.

Keywords: clean electromagnetic energy; One Health; Responsible Attitude; living tissues; electromagnetic fields; biological effects on biodiversity

1. Introduction

In modern society, different devices are used for human well-being on a daily basis. This involves health, safety, comfort, etc. These devices operate using different sources of energy conversion. Such equipment, in addition to providing the intended services, produces undesired side effects. A constant objective has always been to optimize the use of these devices, thus strengthening the expected results and minimizing unwanted side effects that could affect not only humans but also other associated environmental concerns. The adverse effects mainly concern human health, as well as that of animals, plants and more generally biodiversity, thus calling on the One Health (OH) concept, which includes animal, plant and human health, all threatened by disturbances generated by human activities [1].

On the other hand, energy and environmental sustainability, which constitutes one of the societal challenges, aims to ensure a clean energy supply for human well-being. The management of well-being and harms linked to the use of manufactured devices are governed by the concept of Responsible Attitude (RA) in the conversion and consumption of clean energy. The One Health and Responsible Attitude concepts aim to enable the optimized use of energy for human well-being with minimized harmful side effects to humans, the environment and biodiversity.

Among devices related to human well-being and operating with clean energy, wireless electromagnetic tools occupy an important place. Electromagnetic energy is considered rigorously clean if derived from clean energy conversion, which originates from the use of renewable energy or other decarbonized energy (hydroelectric or nuclear power plants). Wireless electromagnetic tools are mainly everyday communication tools, their tower antenna and wireless energy transfer devices. Such applications, in addition to their objective functions, like many devices, may have their own side effects. Any possible effects are prevented or minimized by standards and regulations. Thus, such devices behave like sources of electromagnetic fields (EMFs), which, due to their wireless nature, emit radiated fields characterized by stray and leakage fields. These unwanted fields are of two categories, near fields and far fields, depending on the distance from the source to the target. Their impact is concentrated on the exposed target at close range, e.g., mobile phones or wireless energy transfer devices [2–4], and homogeneous in distant exposure, e.g., cell phone tower antennas [5].

This communication aimed to illustrate and analyze the behaviors of EMF-radiating devices in the context of the OH concept involving biodiversity and in the context of the RA concept relating to optimized managed clean energy (conversion and consumption). In the next sections, the biological effects on living tissues due to exposure to EMFs are presented. The laws governing the behavior of such effects are also presented. Next, routines for protection against the harmful effects of EMF exposure are discussed. Some examples taken from the literature are cited to illustrate the concepts of OH and RA. This communication does not claim to be an assessment of the effects of EMFs.

2. Effects of EMF exposure

EMF exposure relates to the interaction of an electromagnetic field with an exposed matter, resulting in a dissipation of electromagnetic energy in the matter. Such dissipation produces different effects in the matter, related mainly to the frequency range of EMFs. These display a wide frequency range, comprising non-ionizing (10^3–10^{14} Hz) and ionizing (10^{15}–10^{22} Hz) ranges. Non-ionizing EMFs are those expended in daily human activities described earlier. The most common effect of non-ionizing EMFs is a temperature rise, depending on the features of the radiated field and the exposed matter. Exposure features involve an electromagnetic field's strength, frequency and nature (far or near field), as well as exposure period. Effects on a matter correspond to an electromagnetic field's physical properties, involving electrical, dielectric, magnetic, heat and mechanical properties. It is worth noting that excessive field strengths, frequencies or exposure duration can provoke irreversible molecular disturbance.

The effects of EMF exposure could be intended (beneficial), e.g., induction and microwave heating [6,7] and hyperthermia medical therapies [8]. The effects could also be unwanted (adverse) effects, e.g., electronic device perturbations and living tissue biological effects [9].

3. EMF exposure's adverse biological effects on living tissues

The biological effects (BE) of EMFs are generally, as mentioned previously, thermal effects resulting from energy dissipation in tissues. The harmful effects of radiated EMFs are generally thermal, affecting living tissues, including humans, fauna and flora. An immediate BE is the increase in internal tissues' temperature. The natural defense of these living tissues is mainly adapting to exposure to the surface, such as exposure to sunlight. In this case, heat slowly penetrates by conduction into the tissues, which are normally irrigated by fluids to allow the tissues to function properly. Focused heating in tissues, especially in tissues poorly perfused by blood or sap under EMF radiation, could be dangerous, depending on the characteristics of the exposure and the tissue [10,11]. Different adverse effects could be checked by comparison with thresholds fixed by standards and accounting for tissue nature, exposure functionality and exposure conditions (for human and fauna [12–14], and for plants (corresponding to public thresholds) [15,16]).

4. Governing laws of EMF effects

The involved phenomena in expected or unwanted effects due to the interaction of EMFs with matters are the electromagnetic phenomenon and the heat transfer phenomenon. The electromagnetic and heat transfer phenomena are via the dissipated power in conducting and dielectric matters via electric conductivity and permittivity (its imaginary part), respectively. A typical example of EMF interaction with a conducting matter corresponds to induction heating [6]. For dielectric matters, such as living tissues, the interaction with EMFs involves the extended heat transfer phenomenon, i.e., the bioheat transfer phenomenon. Characteristic examples in living tissues are the blood-irrigated case for humans or animals [17] and the sap-irrigated case for plants [11].

5. Protection against adverse effects of EMF exposure

Improving the expected functions, as well as reducing the harmful effects, of EMF-producing devices could be managed by optimizing their design or monitoring. Shielding sources or targets, or both, could achieve, in theory, protection against adverse EMF effects. Generally, such a solution is not consistent because the functioning principle of a wireless device is related to its emitted field. In the absence of a design rigorously restraining EMF exposure, only restricted-time or restricted-area use of devices could be a reliable solution. Such a solution can involve public parks, urban districts or whole cities [18–20]. This protection concentrates mostly on anthropogenic modernizations and their connection with biodiversity and the environment, thus reflecting the One Health concept [1]. A less efficient strategy for the reduction of EMF radiation from sources of slight EMFs could be the utilization of EMF absorbers [21,22] or various types of ornamental plants, such as the snake plant (*Dracaena trifasciata*) [23,24].

6. Discussion

This article focused on the concept of RA through the optimized use of clean energy conversion supply, and the concept of OH via the consideration of biodiversity, in the treatment of the adverse side effects of EMF exposure. At this point, some aspects deserve consideration:

Unusual adverse effects of EMF exposure: The most common adverse effects of EMF exposure were considered, namely thermal BEs due to non-ionizing EMFs, which can be controlled via thresholds set by health safety standards. Other effects of EMF exposure could occur, but often less so. This concern sustained thermal effects, non-thermal effects, effects presenting atypical symptoms and effects of ionizing EMFs. Tissue-dissipated energy is characterized by the specific absorption rate (SAR, in watt/kg) and exposure time. Sustained tissue heating and non-thermal effects are linked to these two quantities. Excessive electromagnetic field strengths (and hence the SAR) and frequencies (ionizing), as well as exposure duration, lead to engendering molecular disorders and, subsequently, tissue damage [25–32]. These effects concern living tissues in general, involving humans and the whole biodiversity. Effects presenting atypical symptoms correspond to humans with electromagnetic hypersensitivity (EHS), a condition named idiopathic environmental intolerance. These have two categories, where the first shows nonspecific marks caused by negligible radiations with a trivial period and well below the safety limits of standards [33–36], while the second suffers from cognitive disturbance due to durable EMF exposure [37–39]. The manifestation of EHS atypical symptoms, which look real, could be obliquely linked to EMFs. With such ambiguity, one can rationalize that invisible effects today could be clarified later. Nevertheless, such uncertainty can justify a cautious attitude [40]. Hence, pending more exploration, individuals with these symptoms could reasonably be reflected medically with a chronic illness, recognizing that the chief cause remains an environment with EMFs.

Mathematical modeling of involved physical phenomena: In the above analysis, the governing laws of EMF effects through the involved physical phenomena, namely, electromagnetic and bioheat transfer, were discussed. These phenomena are generally mathematically represented by differential microscopic local equations. The electromagnetic equations (see details in Razek's work [9]) are in terms of the vectors of electric field (E), magnetic field (H), electric induction (D), magnetic induction (B) and current density (J). The involved parameters, in addition to frequency (f), are magnetic permeability ($\mu = B/H$), electric permittivity ($\varepsilon = D/E$) and electric conductivity ($\sigma = J/E$). These equations set permit the computation, in addition to the different induced fields due to a given source, of the global amount of the dissipated electric power loss (P). The bioheat transfer equation (see details in Razek's work [11]) is in terms of the temperature rise (T) (and its time and space derivatives), heat source (P), thermal conductivity (k), specific heat (c) and density (ρ) of the substance. The biological terms concern the tissue self-heat source (P_t) (relative to animals or plants) and the involved convective heat transfer via the irrigating fluid (blood in animals or sap in plants). The electromagnetic and bioheat transfer equations are coupled via the electrical dissipated power, P. This coupling, reflecting distant time constants (electromagnetic and thermal), will be weak (an iterative and not simultaneous solution). Given the geometric complexity and inhomogeneity of a tissue, the solution must be local in the tissue using discretized 3D techniques, such as finite elements [41–46], in the appropriate element of the tissue.

7. Conclusion

The analyses accomplished in the above sections can be summarized as follows. Optimizing human-made devices using clean energy involves improving the performance required for human well-being and minimizing undesirable side effects for biodiversity safety. These eco-design and eco-protection actions are part of the Responsible Attitude approach. Biodiversity security involves protecting the living tissues of humans, fauna and flora, which corresponds to the One Health concept.

This article illustrated that the optimized use by humans of clean sources of electromagnetic energy conversion allows the expected well-being of humans and considers biodiversity in the treatment of harmful side effects of EMF exposure. In this context, the evaluation of the effects of electromagnetic fields on living tissues, as well as the reduction of EMF exposure through protection routines, were presented and analyzed. This shows that the role of the concepts of Responsible Attitude and One Health is perfectly integrated.

The analyses indicated that in the absence of a design strictly limiting EMF exposure, only the constraint of the performance and use of clean-energy electromagnetic devices constitutes reliable solutions for preserving biodiversity. Thus, the use of such devices at specific time periods and in specific areas, as well as the establishment of radiation-free zones, can preserve the biodiversity of vulnerable living tissues, including humans, animals and fragile plants.

Conflict of interest: The author declares no conflict of interest.

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