

Preface

Science is today the best means of approaching reality at a given moment. Although its aim is not to enlighten us on the meaning of life or to provide us with 'the Truth', it can contribute to providing decision makers and the general public who make the effort with the foundations on which to form their own opinion.

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Human beings, like all living organisms, have always been exposed to natural radiations, some of which have enabled the development of biodiversity and which remain indispensable for life. Nowadays, our exposure to electromagnetic fields comes from numerous sources, both natural and artificial. The multiplication of artificial sources is linked to technological development. In particular, daily exposure to electromagnetic waves has diversified since the installation of electrical power grids and the development of radio broadcasting at the beginning of the past century. This electromagnetic environment is sometimes known as “electrosmog”. The natural or artificial nature of the exposure occupies a preponderant place in current considerations on the potential environmental risks and the controversies that accompany them.

The range of electromagnetic waves, or radiations, is vast. The electromagnetic spectrum extends from zero frequency with static electric and magnetic fields up to infinity (cosmic radiations). Although, they all have a common physical basis, the energy conveyed by the waves is highly variable. In propagating, they invest a space known as an electromagnetic field, where the term “field” refers more generally to an area where forces are exerted, in the same way as one refers to a gravitational field, or more metaphorically, an action field. It has been known for a little more than a century that these radiations result in a large range of physical phenomena as different as static magnetic fields, electricity, radio waves, microwaves, visible light, Sun’s rays, X-rays, radioactivity etc. As a result of their curious and inventive nature, humans have not failed to explore their properties and quite naturally put them to useful purposes, to grace their daily lives or to use

them in many different medical, industrial or military applications. Our quality of life has become so heavily dependent on the technological advances due to our mastery of these different waves, it would now be difficult to imagine returning to an everyday life without electricity, television, remote controls of all types, radio or wireless telephones.

Biological or health effects result from the nature of the wave-matter interactions, depending on the type of wave and associated with a sufficient power of emission. In fact, the physical variables to take into account vary as a function of the frequency. In the higher frequency ranges of the spectrum, radiation known as ionising radiation has sufficient energy to modify the molecules by tearing off electrons through a phenomenon of ionisation*. This mechanism may result in modifications stemming from poorly repaired breaks within DNA* molecules which are the support for genetic information (mutations). This confers a mutagenic* character to the radiations concerned, which can, as a consequence, prove to be carcinogenic. This is the case for example with gamma rays.

In contrast, electromagnetic fields and radiations whose energy is too low to lead to ionisation in the media that they pass through are grouped together under the generic term of non-ionising radiation (NIR). Their mode of action on the organism is different, based on the circulation of currents and/or heating phenomena, depending on the frequency. Ultraviolet radiations lie at the interface between ionising and non-ionising radiation, but they are classed within the family of NIR even though they are established mutagens. A common error consists in thinking that the potential hazardousness of a NIR increases the higher its frequency, which is not the case since wave-matter interaction and power also have to be taken into account.

With the exception of light, the radiations of the whole range are not perceived immediately by our senses under normal conditions. In fact, all the radiation frequencies are often difficult to conceive in their physical reality, which sometimes makes us demonise them or, quite the opposite, ignore them and not to be on our guard against them when it is necessary.

This work only covers NIR and, in particular, those which are part of our daily environment.

Extra vigilance is necessary with regard to the possible risks, even minor, of such exposures, because they concern a large number of people. Consequently, it is necessary to envisage objectively the potential effects of such exposures on health in order to be able to protect ourselves with full knowledge of the facts. This justifies a meticulous analysis of the effects of NIR on biological systems and the influence that they are likely to have on humans themselves in order to establish maximum exposure limits, guaranteeing the absence of any risks to health (regulations, recommendations). The studies are generally very complex to setup. Such studies call on expertise in both physics and biomedical sciences, resulting in cross-disciplinary collaborations between teams of researchers. It is in this sense that research projects are currently being conducted all over the world. These may involve epidemiological studies in real environments or laboratory experiments. The latter requires specialised and often costly equipment and call on different techniques, depending

on the type of wave and the effects considered. Consequently, the specialists themselves focus their expertise on part of the spectrum and are not experts for all types of radiation.

Standards exist that aim to avert the harmful effects that could be brought about by exposure to NIR under certain conditions. In Europe, these standards are based on the works of the ICNIRP,¹ which defines the basic restrictions (recommended thresholds) used to establish European recommendations and directives, which are in turn employed in each country to draft appropriate decrees aiming to apply the regulations in a practical manner. For the evaluation of risks, the ICNIRP bases its conclusions on a critical review of the scientific literature and keeps a permanent track of the bibliography. The United States follow the recommendations of the Institute of Electrical and Electronics Engineers (IEEE) for electromagnetic radiation with the exception of optical radiation.² In parallel, expert appraisal reports and opinions can be delivered by institutions such as the WHO³ on a global level, or Afsset⁴ (now known as Anses⁵) in France. Such organisations make it possible to ensure that the limit values are sufficiently protective regarding the use of NIR, particularly by new technologies, and promote avenues of research if necessary. On a national scale, these opinions provide governance aids in terms of risk management. Governmental authorities are responsible for taking the measures considered necessary to protect the public on the basis of the scientific data while taking account of societal aspects, which does not always necessarily lead to decisions founded on scientific rationality.

In the present context, where communications are dominated by short and mediated messages, it is not easy to provide the public information of a scientific nature on electromagnetic fields, nor on their biological and health effects, in a language that can easily be understood by everybody. Biological effects found in experimental studies are sometimes directly assimilated with health effects, although this is not necessarily the case. In addition, in order for an effect to be established, it must be able to be reproduced not only when the experiment is repeated, but also in several different studies giving consistent results. Numerous false or preconceived notions circulate concerning the effects of NIR. There is sometimes an excessive simplification of the question, unfortunate amalgams, or a

¹ ICNIRP, the International Commission on Non-Ionising Radiation Protection, is a non-governmental organisation (NGO) stemming from International Radiation Protection Association (IRPA), officially recognised by the World Health Organisation (WHO) and the International Labor Organisation (ILO) in the field of non-ionising radiation. <http://www.icnirp.org/>.

² Institute of Electrical and Electronics Engineer (2005) IEEE standard for safety levels with respect to human exposure to radiofrequency electromagnetic fields, 3 kHz to 300 GHz. IEEE Std C95.1.

³ World Health Organisation.

⁴ Agence française de sécurité sanitaire de l'environnement et du travail (Afsset), French Agency for Environmental and Occupational Health & Safety.

⁵ Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail (Anses), French Agency for Food, Environmental and Occupational Health & Safety.

biased manner of dealing with current data in favor of preconceived ideas. The effects may be exaggerated or instead minimised. The final result is that extrapolations and hasty conclusions, often sensational, regularly fill columns and even manage to get into certain more specialised journals.

Following a general presentation of NIR, this work resumes in a simple manner, but as faithfully as possible, our current state of knowledge on the different categories of electromagnetic fields likely to be encountered in our daily environments. This concerns above all exposure of the public and not the industrial or occupational applications that may be mentioned in passing. Two medical techniques will nonetheless be described in detail even though neither is, strictly speaking, a source of exposure encountered on a daily basis. First, MRI*, which is becoming an exploration method to which doctors are turning more and more frequently. Second, electrochemotherapy*, which is a recent therapeutic method; its presentation provides the opportunity to broach the specific effects of electrical pulses and the uses that may be made of them. The different chapters, arranged in order of increasing frequencies, each deal with a particular type of radiation while being, whenever possible, centred on a representative source of emission: MRI and static fields, electrochemotherapy and electrical pulses, electricity and extremely low frequencies, induction and intermediate frequencies, wireless communications and radio-frequencies*, RFID*, infrared radiation, light and visible radiation, Sun and ultraviolet radiation and finally, lasers*. The specific characteristics of these fields are discussed in the first instance. A review is then made of the main emission sources, current knowledge of the biological effects and the exposure limits recommended by the international organisations in order to be able to use them in complete safety.

Specialists, medical doctors, biophysicists, physicists, engineers and researchers have joined forces to draft the different sections in their areas of expertise. We have opted for a layout that readers can dip in and out of depending on their curiosity and current state of knowledge. It is neither an exhaustive catalogue of all the studies carried out to date on the biological and health effects of electromagnetic fields, nor a reduction in the state of knowledge to several selected studies. Furthermore, the aim is not to present all of the sources of NIR. To find out more, the reader can consult a certain number of bibliographic summary reports available and documents referenced in the various chapters.

A list of abbreviations, the main units employed and a glossary in which are defined words marked with an asterisk (*) are given at the end of the book.

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