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BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS

IVA-meddelande 210

ROYAL SWEDISH ACADEMY OF ENGINEERING SCIENCES
Stockholm 1976

PREFACE

Electromagnetic fields are today generated in homes, places of work, hospitals etc. People are everywhere exposed to low frequency fields from electric power lines as well as high frequency from communication systems and radar.

The knowledge of the interaction between biological live materia and electromagnetic fields is not sufficient. Nor is the knowledge about the tolerance of human beings, animals and plants to various frequencies of these fields sufficient. The safety standards are, consequently, arbitrary.

It is important to try to summarize the knowledge and research in different parts of the world, about the vast and complicated field of interaction between biological systems and electromagnetic fields. It is also important to study the results and indicate where new research is desired or necessary.

During the summer of 1973 the IVA for this purpose appointed a committee of the following structure:

Stig Lundquist, Professor, the University of Uppsala
Dag Campbell, Senior Lecturer in Pharmacology,
Pharmacia AB

Bengt Knave, Associate Professor, the National Board
of Occupational Safety and Health
Björn Tengroth, Professor, the Sahlgrenska Hospital
Peter Weissglas, Dr, the Royal Institute of Technology
Karl-Johan Öbrink, Professor, the University of Uppsala

Kerstin Hanzon, M.Eng., IVAs Secretariat for Investigation and Surveys was secretary of the committee

The investigation was mainly financed by the Swedish Board of Technical Development (STU).

Stockholm, October 1974

Gunnar Hambræus Stig Lundquist

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	109	1.1 Background
	115	Electromagnetic fields are to an increasing extent
al tissue	117	present in our environment. This is true for local
	121	fields as well as fields with large ranges of distri-
		bution - low frequency fields from electric power-
		lines as well as high frequency fields from communica-
		tion systems and radar. Electromagnetic fields are
		generated in homes, places of work, hospitals etc.
and CGS	125	It is important to try to summarize the results and
ntities	127	the position of science today regarding the large and
	141	complicated field of knowledge concerning the inter-
	145	action between biological systems and electromagnetic
	153	fields. For this purpose a committee was appointed by
		the IVA during the summer of 1973 in order to summa-
		rize the situation of knowledge and research in dif-
		ferent parts of the world, to estimate the results
		and stress the points where new efforts of research
		are desired or necessary.
		The investigation was defined to concern wavelengths
		of more than 1 mm, i.e. a frequency range of 0-300 GHz.
		This range includes microwaves, radiowaves, power-fre-
		quency electric and magnetic fields and static electric
		and magnetic fields.

The natural background radiation within the frequency range mentioned is small, whereas the fields produced by man have reached ever increasing intensities. The technical development will probably result in increasing radiation in our surroundings.

The human body is not equipped with sense-organs or other mechanisms to detect electromagnetic fields within the frequency range mentioned. This means that we are normally not able to discover the fields that we possibly come across and, consequently, cannot avoid them in a simple way.

The logical question is then if the fields mentioned do have a biological effect - dangerous or not. Theoretically, it is a question of possibly absorbed energy and its effect on the processes of life. Hitherto, mainly phenomenological observations have been made which clearly indicate that the processes of life may be influenced by the fields mentioned. The mechanisms are, however, not well known.

Examples of the effect of electromagnetic fields within the frequency range 0-300 GHz follow:

- changes in the frequency of cell division in the bone-marrow and liver
- light sensation (phosphenes) caused by electric or variable magnetic fields
- stimulation of nerve - muscle preparations in magnetic fields
- influence on heart frequency by pulse modulated microwave fields
- sound sensations in intense radar fields
- disturbance of the behaviour of experimental animals exposed to high frequency electromagnetic fields

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- turbidity of the eye lense caused by long time ex-
posure to microwaves.

These are only some examples from the abundant litera-
ture. The observations do not explain the effects
obtained, but they are unmistakable indications that
the electromagnetic fields, to which we are exposed,
have biological effects, the knowledge of which must
be considerably extended.

1.2 Situation of today

A perusal of the literature shows that the results of
radiation - biological investigations are often con-
tradictory as well as insufficient for positive con-
clusions. The reason for this is deficient knowledge
of the interaction of electromagnetic fields with bio-
logical substance. This new field of research has an
interdisciplinary character and is suffering from the
fact that the development within the disciplines con-
cerned have reached different levels.

Characteristics of electromagnetic fields can be de-
fined almost exactly from the physical point of view,
as well as the interaction between the fields and cer-
tain simple systems. The effect on liquids is e.g.
still an unsolved problem, however.

Already the interaction between the fields and simple
chemical systems, such as individual molecules, has
many unknown components. The biological substance is
most complex and the structure to a large extent un-
known. In spite of the fact that the properties of the
electromagnetic fields are known, it is almost impos-
sible to interpret their effects on biological sub-
stance, with respect to the existing knowledge. This
is the case for the primary as well as the secondary
effects of the fields.

The primary interaction between the electromagnetic field and the living cell takes place on the molecular level. This interaction may then cause biological effects on cells, tissues and organs, so that finally there are consequences for the whole organism. This effect therefore belongs to the study of many different biological disciplines. The effects should be followed and investigated (simultaneously, if possible) in several different ways, which puts great demands on each discipline, at the same time as a far reaching interdisciplinary integration is necessary.

Not until the last decade has the field of molecular biology made a certain understanding of the primary phenomena possible. The knowledge of cell physiological conditions and how the cells govern and control each other is still so scarce that only with difficulty is it today possible to make a comprehensible picture of how the secondary effect arises. Even when we approach the problem of interaction by trying to study the effects obtained in a group of exposed persons, we still have great problems, as the phenomena important for each individual cannot be shown statistically in an easy way.

To determine the characteristics of the electromagnetic fields is really not an easy problem. Instruments and probes for measurement in most cases generate induced currents and charges, which cause a more or less strong disturbance of the electromagnetic field measured. This is even more apparent when there is biological substance within the field. This means a disturbance which often makes a direct use of the obtained measuring values impossible.

Moreover, there are great difficulties in determining the local distribution of the field in the very inhomogeneous medium which biological substance constitutes. Measurements were normally made only on dead material.

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A correct use of measuring equipment usually requires (e.g. due to properties dependent on frequency and polarisation) qualified knowledge of the techniques of electrical measuring. This is not always taken into consideration. It is today impossible to compare the results of different investigations, especially due to the lack of detailed descriptions of the methods used for measurement.

Instruments for measuring biological material are little developed.

By studying the literature it also appeared that the clinical methods used for examination and interpretation of different symptoms differ greatly for example in the USSR and the Anglosaxon countries. This has lead to considerable differences between the safety standards of these countries.

1.3 Need for research work

1.3.1 Development of measuring techniques

The committee considers it necessary to give priority to research and development in the field of measuring techniques, in order to get a good basis for further research within the field.

For this reason, further studies on the macroscopic electromagnetic properties of biological tissues are necessary, especially with regard to their dependency on frequency and amplitude.

A determination of possible risks or calculation of doses require not only knowledge of nondisturbed fields, but also for example how electric and magnetic fields are distributed around a human being. Methods

for calculation and measuring of such a distribution ought to be developed.

Amongst the measuring instruments that ought to be developed or improved are small field-probes which are easy to handle, not sensitive to polarisation and with broad frequency bands and also thermal sensors for non-disturbing measurement of temperature changes in biological tissues. Dosimeters which could easily be carried by the personnel working in intense radiation are other examples.

1.3.2 Epidemiological field studies

The committee is of the opinion that the researchwork to come must be concentrated on an inventory of the sources of radiation existing in this country at present. For this purpose, the survey in the recently published investigation from the National Institute of Radiation Protection (D 53) would be useful. The committee also recommends that the real intensity of nearby- and distant radiation should be determined from different types of radiation sources. The results of such investigations would be of utmost importance when determining a possible effect on persons exposed to radiation. This effect could, according to the literature, be expected to vary as well as in many cases be difficult to measure. This background in mind, the committee is of the opinion that the results obtained as far as possible should be used as a basis for epidemiological field studies; in which the probable biological effects are being investigated and surveyed in relation to the intensity of radiation.

It is also necessary, but not at all sufficient that standardized methods for measurement are developed.

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1.3.3 Basic research

The achievements proposed above may produce results rapidly, which is necessary in order to meet the acute problems already existing in our society. In the long run, however, our knowledge must be increased by a continued intensified basic research concerning the effect of the non-ionized electromagnetic fields on simple as well as on complex biological systems.

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