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LETTER

Comment on Letter: "Post-Normal Science and the Management of Uncertainty in Bioelectromagnetic Controversies" by A.W.Wood

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Introduction

Andrew Wood touches on some important points in his letter to the editor [Wood, 2019] and should be commended for highlighting problems that we are witnessing in interpreting EMF-related science. Wood notes that half a century of scientific research into the safety of EMFs (from static to 300 GHz) has not resulted in any substantial policy advice changes. The question we believe needs to be asked is as follows: Is the continuing unchanged policy advice on EMFs occurring because those who are trying to advocate change have no voice in the process, and because the process is dominated by groups with self-interests in maintaining status quo?

Radiofrequency Electromagnetic Radiation (RF-EMF) in particular is of critical importance to defence for communications, surveillance, missile guidance and detection. RF technology is a booming multi trillion-dollar industry globally and changing current prescribed safety levels to more stringent standards would bring unfavourable financial consequences and affect industrial and military functions. In some countries, such as Australia, the regulator, which has a health protection responsibility, also sells RF spectrum licences, which represents a clear conflict of interest. The very same agencies with responsibility for providing safety advice to the public are also considered to have been captured by industry [Alster, 2015].

Thermal and non-thermal bio-effects: a paradigm gulf?

Wood suggests that when it comes to low-level effects there is an "apparent" division between expert groups. We do not consider that it is a case of being "apparently" divided, implying this might not really be the case. The reality is far more obvious with a clear division existing between different "camps" that have significant differences of opinion. The International Commission on Non-Ionising Radiation Protection (ICNIRP) [ICNIRP, 2002] vs. BioInitiative group [Sage, 2012] is one clear example. A letter to the UN and its subordinates [IEMFSA, 2014] now signed by 250 concerned international scientists from 42 countries is another example that to date has not been adequately addressed or acknowledged by WHO or other relevant bodies such as ICNIRP. These divergent expert groups are diametrically split based on their understanding and support, or lack of support, for non-thermal bio-effects. Frey [1969] summed this up very succinctly: "Misunderstanding can be traced to the controversy on thermal vs non thermal effects. A very heated controversy

developed between those who thought that only thermal effects could occur and those who thought non-thermal effects could also occur" along with "…investigators polarized into two opposing camps." Nothing has really changed fifty years later. The thermal only effects camp (ICNIRP) still dominates positions of power when it comes to establishing safety guidelines. However, a considerable and developing literature demonstrates that bio-effects are occurring in the absence of heating, with many having potential to cause harm, especially if sustained.

At the Oceania Radiofrequency Scientific Advisory Association (ORSAA), of which we are members, our scientific team has constructed the world's largest categorised online database of peer-reviewed studies on radiofrequency electromagnetic radiation and other man-made electromagnetic fields of lower frequencies. A recent evaluation of 2266 studies (including in-vitro and in-vivo studies in human, animal, and plant experimental systems and population studies) found that most studies (n=1546, 68·2%) have demonstrated significant biological and/or potential health effects associated with exposure to anthropogenic electromagnetic fields. Because these bio-effects defy traditional thinking that the energy from low-level RF non-ionising radiation is too insignificant to cause direct cell damage they do not appear to be taken seriously [ICNIRP, 2002]. Non-ionising radiation may not have sufficient energy to knock electrons off from atoms but it can affect molecular structures and interfere with metabolic processes as evidenced by the categorised biological effects noted in the ORSAA database [Leach et al., 2018].

Science in crisis

Wood refers to the good governance of science and its use or misuse for policy formation. Further, he cautions against clinging to the myth of the value-neutral nature of science. Reinforcing such observations, today we see powerful lobby groups influencing science and government policy. It appears that tobacco science is still alive and well with many of the techniques being adopted and improved upon. Leaked internal memos from telecommunications companies show they are "war gaming" the science [Hertsgaard and Dowie, 2018]**.** Who benefits from such ethically challenged activities?

Lack of Trust

Wood then identifies some of the problems that potentially create friction and discontent with reference to methods of collection, analysis and comparison of evidence. We believe he is right on the mark with this assessment. "Cherry picking" papers, misrepresenting the balance of evidence, the exclusion of evidence under the guise of methodological flaws, avoiding the discussion of topics that challenge safety or worse, or dismissing them as unimportant are just a few examples of the concerns being raised by concerned scientists from around the world. This is most evident with SCENIHR 2015 [Pall, 2018; Sage et al., 2015] the HPA AGNIR report [Starkey, 2016] and even ARPANSA's TRS-164 report [Leach and Weller, 2017].

As part of a post-normal science paradigm, we are witnessing an unprecedented number of public websites being established by concerned citizens and independent scientists to address what they consider to be government and industry rhetoric via media channels on the benefits of wireless technology.

Professional scientific organisations such as the International EMF Alliance, the Oceania Radiofrequency Scientific Advisory Association (ORSAA), and the Environmental Health

Trust (EHT) have been established in order to provide support services and unfiltered scientific advice that is absent from regulators and radiation protection authorities. The issue of trust is at the forefront of this activity. After all, we only have to look at the recent past to see how governments and "mainstream" science have got it wrong before - many times. Tobacco smoking, asbestos, Agent Orange and thalidomide are just a few obvious examples. A current topical example in Australia is buildings covered in flammable cladding that now has to be removed at huge financial cost. RF-EMF is also likely to be a candidate added to this growing list of government/ industry mishandling and misconduct.

Risk Management Avoidance

Evidence of potential harm is being downplayed, or worse, swept under the carpet by the dominant industry groups and government regulatory bodies. Financial gains masked by claims of community benefits appear to be a higher priority than disclosing the long-term risks to public health. Nation states (predominantly western) regulatory bodies and the non-ionizing radiation protection NGO, ICNIRP, are looking for established evidence of harm before they will act, which is not a recognized world's best practice for risk management. To establish harm is the point at which a potential risk materialises and automatically becomes an issue, which is far too late given the size of the population being exposed without any formal consent.

Risk management best practice calls for the identification of all potential risks, weighing them and developing mitigation strategies to prevent them from developing into full-blown problems. We need to change behaviour to promote better practices that result in reduced exposures to microwave radiation from mobile phones, cell towers and other wireless devices, in light of growing scientific concerns about the impact such radiation may have on the developing brain and body. Wireless devices are not risk free and the public must be informed so that they can make informed decisions about how they choose to use wireless technology.

Precautionary Approach and the Precautionary Principle

Currently, there are thousands of well-conducted peer-reviewed studies that show non-thermal bio-effects that pose real risks to health [Leach et al., 2018]. The Precautionary Approach is used as a risk management framework in the face of scientific uncertainty [Gee, 2009]. It is curious indeed that Wood's letter on "uncertainty in bioelectromagnetic controversies" makes no mention of this important principle. The trigger points for invoking the Precautionary Principle can be variable depending on the perceived or likelihood of risk [Leach and Bromwich, 2018].
There are two main factors that trigger the precautionary approach. These are:

- the strength or balance of evidence and
- the potential cost of doing nothing.

David Gee's paper "Late Lessons from Early Warnings" [Gee, 2009] underlines the importance of timing. For example, the time from the first scientifically based early warnings for many toxic agents (1896 for medical X-rays, 1897 for benzene, 1898 for asbestos) to the time of risk reduction policy action has often been 30 to 100 years, during which time exposure increased considerably. One consequence of failure to act in time is greater and irreversible damage over longer time periods. A further example is chlorofluorocarbons (CFCs) which were discovered in 1928 and later put into industrial use as refrigerants. It turned out that ignorance of the effects CFCs have on stratospheric ozone became a major

life-threatening gap in understanding, when it was discovered in the 1980s there was a huge hole in the ozone layer over the South Pole. Predictions of significant increases in the incidence of skin cancer resulting from continued use of CFCs spurred international action. In 1987, 56 countries agreed under what became known as the Montreal Protocol to phase out ozone depleting substances. 197 parties have now ratified the Montreal Protocol.

Use of the ORSAA database can readily identify risks, which need to be handled appropriately. Accumulated evidence is suggesting chronic exposures to man-made RF-EMF can damage DNA, not only in humans, but also in insects, plants and animals. Prolonged exposure to man-made RF-EMF results in cellular stress and the production of free radicals, disruption of the endocrine system and changes in neurotransmitter levels [Leach and Weller, 2017]. The health risks from this subset of an even greater list of bio-effects noted in research include cancer, neurodegeneration, mental illness, fertility issues and cardiovascular disease to name but a few [Hardell, 2017].

Post-Normal Science

Hardell [2017] notes that the International Commission on Non-Ionizing Radiation Protection (ICNIRP), has not recognised non-thermal bio-effects as being a health hazard. Non-thermal biological effects from RF radiation are dismissed as constituting scientific evidence. Numerous health hazards are disregarded such as cancer, neurodegeneration, blood-brain-barrier, cognition, psychological addiction, sleep, behavioural problems, and fertility effects [Hardell, 2017].
This reflects the "situation of science in its social context" discussed by a pioneer of post-normal science concepts [Ravetz, 1999]. Ravetz asks "in whose interest, and under whose control, the basic science is done." He questions "scientists who present themselves as impartial judges when they are actually committed advocates" and calls for an "extended peer community", consisting "not merely of persons with some form or other of institutional accreditation ('stakeholders')", but rather all those seeking a broad base of consensus including scientists with a differing viewpoint and communities via citizens' juries and so on. Instructive in relation to community groups wishing to place a moratorium on implementing 5G, Ravetz says "it turns out that educated common sense can be quite effective in the assessment of policy implications of even the most technical of scientific subjects."

Paper Counts

Wood discussed the limited value of simply capturing paper counts of "Effects" vs. "No Effects". Without digging deeper into the data, this statement has merit. However, paper counts can provide a wealth of information when used in conjunction with other attributes such as, but not limited to:

- Specific bio-effect endpoints,
- Cell types (for *in vitro* studies),
- Funding sources,
- Country where principal research is conducted,
- Signal Type (Pulsed or Continuous, Amplitude Modulated or Frequency Modulated),
- Signal Source (Real Mobile Phone or Signal Generator),
- Authors of Papers.

This approach allows discerning researchers to look for trends and possible relationships between these parameters and possible influences that may affect outcomes. It can help highlight potential sources of uncertainty.

Typical categories of biological effects include:

- Oxidative stress/ROS/super oxides/free radicals/lipid peroxidation
- Altered enzyme activity/protein damage/altered protein levels
- Biochemical changes
- Cell irregularities/cell damage/morphological change/apoptosis
- Sperm effects

To counter the cloning effect of coalitions of experts with similar core values, it is important to determine whether review panels are suitably established with people who:

a) are adequately qualified,
b) cover a wide range of viewpoints, and
c) include representation from countries that have more stringent scientifically based RF Standards.

This approach is consistent with the post-normal science concept of the "extended peer community". The last point is extremely important if the WHO wishes to continue its efforts to establish a global harmonised RF Standard, something that is absent in ICNIRP representation. One can also mine the data to see if uncertainty is real or potentially manufactured. A clear example includes the use of signal generators vs real mobile phone emissions as shown in Table 1 [Leach et al. 2018].

Table 1. Number of bio-effect Mobile phone studies with Signal Type and Waveform.

Research Categories	Real Mobile Phone used in Experiments			Simulated Mobile Phone used in Experiments		
Wave form	Pulsed			Pulsed		
Outcome	#Effect	#No Effect	#Uncertain Effect	#Effect	#No Effect	#Uncertain Effect
in vivo	120	18	11	69	49	8
in vitro	28	8	1	60	63	7

Researchers use both real mobile phone signals in their experiments as well as simulated signals and it is clear that real-polarised-pulsed RF signals with complex patterns of low-frequency modulations, which vary in intensity, are much more bio-active. This is symptomatic of the organisms' defence systems being placed under stress and struggling to adapt [Panagopoulos, 2015]. Simulated signals therefore don't give a realistic world picture.

Conclusion

Wood's letter states that there are now probably more phone handsets than people in the world, and the stakes of overlooking harm are high. We agree, but consider that the management of uncertainty requires a far more rigorous precautionary approach than he appears to advocate. The wide divergence in legislated maximum exposure limits in different countries suggests there is no such thing as scientific consensus on EMF safety. People from countries following the FCC or ICNIRP standards need to ask why their regulators hold such opposed views from the same body of scientific research. Low dose ionising radiation dose limits are in the same category as man-made RF-EMF, yet the International Commission on Radiological Protection (ICRP) takes a precautionary approach when setting limits whereas this paradigm is completely absent in the ICNIRP philosophy on radiation protection. Post-Normal Science (PNS) critiques "science in its social context" with too much

acceptance of the role of institutional stakeholders and opens the debate via the PNS concept of the "extended peer community". ICNIRP's international guidelines only recognise thermal effects, and pay no recognition to the non-thermal effects of non-ionizing EMF. However, a large body of scientific evidence suggests that bio-effects and health impacts can and do occur at low exposure levels, which can be thousands of times below public safety limits. That is, the presumption by ICNIRP that exposure to non-thermal levels is safe is fundamentally flawed.

Useful policy recommendations and challenges for research arising from rapid technological changes are outlined by Miller et al. [2019]. As well as addressing total cumulative exposure across the spectrum from multiple sources and for sensitive populations such as children, there is an increasing need to address changes in carrier frequencies and the growing complexity of modulation technologies, rendering yesterday's research and standards obsolete.

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