ABSTRACT

Title: *In vivo* studies on the health effects of intermediate frequency magnetic fields

Kajal Kumari [a, b], Hennariikka Koivisto [c], Myles Capstick [d], Mikko Herrala [b], Paulraj Rajamani, Jonne Naarala [b], Matti Viluksela [a e], Heikki Tanila [c], Jukka Juutilainen [b]

[a] School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, India
[b] Department of Environmental and Biological Sciences, University of Eastern Finland, Kuopio, Finland
[c] A.I. Virtanen Institute, University of Eastern Finland, Kuopio, Finland
[d] IT'IS Foundation, ETH, Zurich, Switzerland
[e] National Institute for Health and Welfare, Environmental Health Unit, Kuopio, Finland

In the last few decades, manmade appliances emitting electromagnetic fields have become increasingly common, leading to changes in the natural environment. The present study focuses particularly on intermediate frequency (IF) magnetic fields (MF), defined as MFs with frequencies from 300 Hz to 100 kHz. Human exposure to IF MFs is increasing due to new applications such as induction heaters, wireless power transfer (at work or at home), and electronic article surveillance systems (used in, e.g., supermarkets to prevent shoplifting).

The aim of the study was to produce basic data for adequate assessment of the health risks of IF MFs. The study included experiments to assess effects of IF MFs on reproductive health, cognition and behavior, and prenatal development in mice, as well as genotoxicity in mice. The frequency of the MF was 7.5 kHz (used in electronic article surveillance systems) and the field strengths were 12 and 120 µT.

Measurements of fertility-related indicators in male mice exposed to 7.5 kHz MFs did not show adverse effects on reproductive organ weights, sperm counts, sperm head morphology or sperm motility. However, increased sperm motility was observed in high-exposure group.

In the study related to cognition and behavior in adult mice, no effects were observed on spontaneous activity, motor coordination, level of anxiety or aggression. In the Morris swim task, mice in the 120 µT group showed less steep learning curve than the other group. The passive avoidance task indicated a clear impairment of memory over 48 h in the 120 µT group. No effects on astroglial activation or neurogenesis were observed in the hippocampus. The mRNA expression of brain derived neurotrophic factor did not change but expression tumor necrosis factor alpha mRNA was significantly increased in the 120 µT group. These findings suggest that exposure to a 7.5 kHz, 120 µT MF may lead to mild impairment of learning and memory, possibly through an inflammatory reaction in the hippocampus.

A behavioural teratology study did not show any exposure-related differences in spontaneous motor activity, anxiety, spatial learning, or memory. Furthermore, histopathological analysis did not reveal any effects on astroglial activation or hippocampal neurogenesis.

The results of genotoxicity study did not support genotoxicity of 7.5 kHz MFs at magnetic flux densities up to 120 µT *in vivo*. On the contrary, there was some evidence that exposure to 7.5 kHz MFs might reduce the level of genetic damage.

In conclusion, exposure to 7.5 kHz MFs up to 120 µT did not show adverse effects on male fertility indicators, prenatal and early postnatal development of the brain, or genotoxicity *in vivo*. However, mild impairment of learning and memory may result from exposure of adult animals. Interesting findings indicating favourable rather than adverse biological effects included increased sperm motility, increased relative cell number (indicating increased proliferation or reduced cell death) and suggestive decrease in the level of genetic damage.

The work during my doctoral study has given expertise to work in the field of radiation and Prof. Paulraj R. research group also have the same interest to work in the field of radiation which provide a mutual possibility for real collaboration in the future for both research group.