Bulletin de veille
Champs électromagnétiques
N°5 - Janvier 24

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS.

Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

Exposition professionnelle, études épidemiologiques

High Noon for Mobile Networks: Short-Time EMF Measurements to Capture Daily Exposure, ADDA S., L. CHIARAVIGLIO, D. FRANCI, C. LODOVISI, N. PASQUINO, S. PAVONCELLO, C. PEDROLI and R. PELOSINI,
Ieee Transactions on Instrumentation and Measurement 72 (2023),
Exposure from radio base stations (BSs) is often only monitored over short periods, typically during the daily hours of working days. However, BS exposure can vary throughout the day and even between working days and weekends or holidays. The objective of this study is to determine to what extent short-term exposure measurements taken during daily hours are representative of daily average exposure levels. To achieve this goal, we analyzed a set of long-term measurements taken by monitoring units located in sensitive areas, which are characterized by a homogeneous distribution of users over working hours, such as hospitals, train stations, and university centers. Our results reveal that 6-min measurements taken on working days can overestimate the average exposure level over 24 h if taken over a wider time interval than that commonly considered for peak traffic and, therefore, higher exposure. Based on the common pattern of exposure over time

in various locations, an extrapolation factor is proposed to predict daily exposure levels from short-time measurements. https://doi.org/10.1109/tim.2023.3324354

Redox dysregulation in imaging professionals occupationally exposed to ionizing and non-ionizing radiation,
AHMAD I. M., L. BARTENHAGEN, K. MICHAEL and M. Y. ABDALLA,
International Journal of Radiation Biology (2023 Sep 2023),
Purpose: Imaging professionals are occupationally exposed to chronic ionizing radiation (IR) and non-ionizing radiation (NIR). This study aimed to investigate the influence of occupational radiation exposure on oxidative stress and antioxidant levels based on blood biomarkers in different hospital imaging professional groups. Materials and methods: The study groups included 66 imaging professionals occupationally exposed to IR (n = 58, 43 diagnostic radiography (G1), seven nuclear medicine (G2), eight radiation therapy (G3)), and NIR (n = 8, ultrasound imaging (G4)) and 60 non-exposed controls. Blood levels of superoxide (O-2(-)) as an index of oxidative stress, and the antioxidant activities of superoxide dismutase (SOD), glutathione ratio (GSH/GSSG), and catalase (CAT) were measured. Results: The blood values of O-2(.).-, SOD, and CAT were significantly higher in imaging professionals occupationally exposed to radiation than in the control group ($p < .05$), while a significant decrease in the ratio of GSH/GSSG was observed ($p < .05$). The results from the NIR group were significantly higher compared to IR group. Conclusions: Based on these results, chronic exposure to radiation (IR and NIR) is associated with redox dysregulation that may result in damages to cellular biomolecules including lipids, proteins and DNA. Further studies are needed to determine the impact of redox dysregulation and the need for periodic examination among imaging professionals occupationally exposed to IR and NIR.
https://doi.org/10.1080/09553002.2023.2258194

Combined Neurological Syndrome in Electrohypersensitivity and Multiple Chemical Sensitivity: A Clinical Study of 2018 Cases,
BELPOMME D. and P. IRIGARAY,
Journal of Clinical Medicine 12, no. 23 (Dec 2023),
From a cohort of 2018 evaluable consecutive cases issued from the European Clinical Trial Database, we describe the complete clinical symptomatic presentation of electrohypersensitivity (EHS) and multiple chemical sensitivity (MCS) and their association in the framework of a unique, sensitivity-related environmental neurologic syndrome. Eligibility criteria are those of the Atlanta consensus meeting for MCS, and those of WHO for EHS. There were 1428 EHS, 85 MCS and 505 EHS/MCS evaluable cases, so EHS was associated with MCS in 25%. Women appeared to be much more susceptible to EHS and/or to MCS than men, with no statistical significance between the EHS and MCS groups ($p = 0.07$), but the combined group revealed a more significant female sex ratio of 80.4% ($p < 0.0001$). All symptoms except emotional behavior were significantly more frequent in EHS patients than in healthy controls ($p < 0.0001$). We found no pathognomonic symptoms to establish the diagnosis of both disorders or to distinguish EHS from MCS. The three groups of patients were found to share identical symptoms, while several symptoms were found to be more significantly frequent in EHS/MCS than in EHS ($p < 0.0001$). From these data, we suggest that EHS and MCS are new brain disorders, generated via a common etiopathogenic mechanism.
https://doi.org/10.3390/jcm12237421

Interaction of Millimetre Waves Used in 5G Network with Cells and Tissues of Head-and-Neck Region: A Literature Review,
DAGLI N., R. DAGLI and L. THANGAVELU,
Advances in Human Biology 13, no. 2 (Apr-Jun 2023): 168-176,

Fifth-generation mobile technology is supposed to revolutionise the world. It has many features which can benefit humankind, but at the same time, it will expose us to much radiation. Therefore, we need to understand the importance and ill effects of 5 G technology. An online literature search was conducted through PubMed and Scopus databases from April 2021 to May 2021, using the Boolean operators OR, AND and NOT and the keywords '5G Network', 'Human tissues', and 'Animal tissues'. The literature is very scarce in studies on the effects of millimetre waves on various tissues. A total of 1269 studies were identified, and 24 were selected for qualitative evidence synthesis. Randomised control trials, laboratory studies, in-vitro studies, in-vivo studies and ex-vivo studies were included. Data from the studies were collected using the data extraction form, and all the relevant information was summarized. Five of 24 studies were done on animals, four on humans, five on models, and ten on various cells. Ten of 24 studies demonstrated the harmful effects of millimetre waves. Results are ambivalent, and no association is found between particular frequency and impact on tissue, animals or humans. Pathophysiological effects observed in most studies were mild, reversible, and limited to the cellular level. Available evidence reported temperature rise after millimetre wave exposure, which was within safety limits. Any biological impact on a cellular level noticed due to radiation's thermal effects were insignificant and did not affect the organ level. However, only a few studies have mentioned non-thermal impact, but those effects should not be overlooked. Clinical trials on a large population and for a longer duration are required to establish the safety of millimetre waves before deploying a 5G network worldwide.
https://doi.org/10.4103/aihb.aihb_133_22

Reduced subjective sleep quality in people rating themselves as electro-hypersensitive: An observational study,
EICHER C., B. MARTY, P. ACHERMANN, R. HUBER and H. P. LANDOLT,
Sleep Medicine 113 (Jan 2024): 165-171,
Background: Disturbed sleep is among the most frequent health complaints of people exposed to radio frequency electromagnetic fields (RF-EMF) used in mobile telecommunication, particularly in individuals who consider themselves as EMF hypersensitive (EHS). We aimed at investigating whether the EHS status per se is associated with sleep complaints. Because allelic variants of the gene encoding the L-type, voltage-gated calcium channel Cav1.2 (CACNA1C) were previously associated with sleep complaints reminiscent of those reported by EHS individuals, we also explored whether self-rated EHS status and sleep quality associate with these gene variants.Methods: A total of 2 ' 040 participants (1 ' 381 females) aged 18-30 years completed online, validated questionnaires on EMF sensitivity, subjective sleep quality, daytime sleepiness, mentation during sleep, and diurnal preference. They also provided a saliva sample for genotyping three functional variants of CACNA1C (rs7304986, rs16929277 and rs2302729). Eligible participants endorsing the question "Are you electro-hypersensitive?" were considered as "EHS" (n = 105), those denying this question yet believing to develop detrimental health symptoms due to prevailing electromagnetic pollution as "attributers" (n = 254), and the remaining participants as "non-EHS" (n = 1 ' 406). We combined the EHS and attributers into one group for binary analyses. In exploratory analyses, we then tested possible associations between EMF sensitivity, subjective sleep variables and CACNA1C variants using linear and logistic regression. We used age, sex, level of education, presence of sleep disorders and habitual mobile phone use as covariates and corrected with Benjamini-Hochberg False Discovery Rate for multiple comparisons. Results: The EHS/attributers consistently reported prolonged sleep latency, reduced sleep quality, higher sleepiness and more nocturnal mentation when compared to non-EHS. Habitual mobile phone use was not associated with self-rated sleep latency and sleep quality scores. While the T-allele of variant rs2302729 of CACNA1C was associated with both, self-reported EMF sensitivity and reduced subjective sleep quality, we found no evidence for the hypothesis that EHS mediates impaired sleep quality via this allelic variant. Conclusions: Irrespective of reported RF-EMF exposure, self-rated EHS/attributers

rated subjective sleep quality worse than non-EHS individuals.Trial registration: Swiss National Clinical Trials Portal (SNCTP000002285) and ClinicalTrials.gov (NCT03074617). https://doi.org/10.1016/j.sleep.2023.11.029

Recent developments of radiation shielding concrete in nuclear and radioactive waste storage facilities - A state of the art review,
KANAGARAJ B., N. ANAND, D. ANDRUSHIA and M. Z. NASER,
Construction and Building Materials 404 (Nov 2023),
Concrete - known for its inert properties - plays a pivotal role in nuclear and radioactive waste storage, providing a robust barrier against radiation. Blended concrete made up of composite materials, namely, barite or magnetite, was recently employed as radiation shielding concrete (RSC). This survey provides a detailed study of different RSC materials suitable for radiation shielding. This review critically evaluates the efficiency of RSC in terms of shielding performance, hardening characteristics, and serviceability, and it also provides a holistic perspective on the latest advancements in this field. Additionally, this work thoroughly examines the recent progress to gain a comprehensive grasp of the functionality potential of RSC as an innovative building material for creating a durable and environmentally friendly concrete matrix for radiation protection. Finally, this survey highlights current knowledge gaps and future research directions in this critical area of research. https://doi.org/10.1016/j.conbuildmat.2023.133260

DNA damage in foundry workers using non-invasive micronucleus cytome assay,
KHUNIQI H. N., Y. RASOULZADEH and Y. MOHAMMADIAN,
Mutation Research-Genetic Toxicology and Environmental Mutagenesis 891 (Oct 2023),
Workers in the foundry industry are exposed to hazardous chemical agents such as metal fumes, gases, vapor of molten metal, and respirable dust and hazardous physical agents such as heat, noise, and electromagnetic fields. Co-exposures to hazardous physical and chemical agents in foundry workplaces may cause DNA damage in workers. This study aimed to evaluate DNA damage in foundry workers. Thirty-three exposed foundry workers as a exposure groups and 33 non-exposed individuals as a control groups participated in this study. Buccal micronucleus cytome (BMCyt assay) assay was used to assess DNA damage. Results showed that foundry workers were under exposure to hazardous chemical and physical agents such as metal fumes and noise. The percentage of micronucleus (MN) cells in exposure group (0.59 +/- 0.93 %) were statistically higher than control group (0.23 +/- 0.23 %) ($P < 0.05$) %). Also, the percentage of nuclear bud cells and binucleated cells in exposure group were statistically higher than control group ($P < 0.05$). The percentage of differentiated normal cells were significantly higher in the control group compared to the exposed group ($P < 0.05$). Foundry workers are at risk of DNA damage; therefore, prevention measures need to be implemented to reduce exposure to air pollutants in foundry workplaces. https://doi.org/10.1016/j.mrgentox.2023.503686

Safety Assessment of Occupational Electromagnetic Exposure for Subway Attendant by Leaky Coaxial Cable,
LI J. and M. LU,
Journal of Electrical Engineering & Technology (2023 Sep 2023),
The subway attendant is exposed to the radio frequency (RF) electromagnetic exposure of leaky coaxial cable (LCX) which was employed for the subway wireless communication system on the subway platform. To effectively evaluate the safety of subway attendant in this electromagnetic environment, the LCX and human model have been numerically designed. The induced electric field (E-field) and specific absorption rate (SAR) in the human body were obtained by the finite element software HFSS (High Frequency Structure Simulator). Results show that the maximum E-field value in the human tissues at 0.9, 1.8 and 2.4 GHz are 1.7850 x 10-2 V/m, 3.9995 x 10-2 V/m and 8.6827 x

10-2 V/m, respectively, and the maximum SAR value in the human tissues are 1.3017 x 10-7 W/kg, 1.3267 x 10-6 W/kg and 3.6487 x 10-6 W/kg, respectively. It can be found that the induced E-field and SAR in the human tissues increases with frequency. Simulation results at three frequencies were compared with the occupational electromagnetic exposure limits by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Results were well below the ICNIRP limits, which indicate that the health risk of the subway attendant exposed to RF electromagnetic on the subway platform is very low. https://doi.org/10.1007/s42835-023-01607-8

The relationship between radiofrequency-electromagnetic radiation from cell phones and brain tumor: The brain tumor incidence trends in South Korea,
MOON J.,
Environmental Research 226 (Jun 2023),
Introduction: The aim of this study is to investigate the relationship between the nationwide cell phone subscription rate and the nationwide incidence of brain tumors in South Korea. The nationwide cell phone subscription rate was used as a proxy for the RF-EMR exposure assessment. Methods: The data for cell phone subscriptions per 100 persons from 1985 to 2019 were found in the Statistics, International Telecom Union (ITU). The brain tumor incidence data from 1999 to 2018 provided by the South Korea Central Cancer Registry operated by the National Cancer Center were used. Results: In South Korea, the subscription rate increased from 0 per 100 persons in 1991 to 57 per 100 persons in 2000. The subscription rate became 97 per 100 persons in 2009 and 135 per 100 persons in 2019. For the correlation coefficient between cell phone subscription rate before 10 years and ASIR per 100,000, a positive correlation coefficient with a statistical significance was reported in 3 benign brain tumors (International Classification of Diseases, ICD-10 code, D32, D33, and D32.0) and in 3 malignant brain tumors (ICD-10 code, C71.0, C71.1, and C71.2). Positive correlation coefficients with a statistical significance in malignant brain tumors ranged from 0.75 (95% CI 0.46???0.90) for C71.0 to 0.85 (95% CI 0.63???0.93) for C71.1. Discussion: In consideration of the fact that the main route for RF-EMR exposure has been through the frontotemporal side of the brain (the location of both ears), the positive correlation coefficient with a statistical significance in the frontal lobe (C71.1) and temporal lobe (C71.2) can be understood. Statistically insignificant results from recent cohort and large population international studies and contrasting results from many previous case-control studies could indicate a difficulty in identifying a factor as a determinant of a disease in ecological study design. https://doi.org/10.1016/j.envres.2023.115657

Pesticides as a potential independent childhood leukemia risk factor and as a potential confounder for electromagnetic fields exposure,
NGUYEN A., C. M. CRESPI, X. VERGARA and L. KHEIFETS,
Environmental Research 238 (Dec 2023),
Background: Both pesticides and high magnetic fields are suspected to be childhood leukemia risk factors. Pesticides are utilized at commercial plant nurseries, which sometimes occupy the areas underneath high-voltage powerlines. Objectives: To evaluate whether potential pesticide exposures (intended use, chemical class, active ingredient) utilized at plant nurseries act as an independent childhood leukemia risk factor or as a confounder for proximity to, or magnetic fields exposure from, high-voltage powerlines. Methods: We conducted a state-wide records-based case-control study for California with 5788 childhood leukemia cases and 5788 controls that examined specific pesticide use, magnetic field exposures and distances to both powerlines and plant nurseries. Exposure assessment incorporated geographic information systems, aerial satellite images, and other historical information. Results: Childhood leukemia risk was potentially elevated for several active pesticide ingredients: permethrin (odds ratio (OR) 1.49, 95% confidence interval (CI) (0.83-2.67), chlorpyrifos (OR 1.29, 95% CI 0.89-1.87), dimethoate (OR 1.79, 95% CI 0.85-3.76), mancozeb (OR 1.41, 95% CI 0.85-2.33), oxyfluorfen (OR 1.41, 95% CI 0.75-2.66), oryzalin (OR 1.60, 95% CI 0.97-

2.63), and pendimethalin (OR 1.82, 95% CI 0.81-2.25). Rodenticide (OR 1.42, 95% CI 0.78-2.56) and molluscicide (OR 1.22, 95% CI 0.82-1.81) exposure also presented potentially elevated childhood leukemia risks. Childhood leukemia associations with calculated fields or powerline proximity did not materially change after adjusting for pesticide exposure. Childhood leukemia risks with powerline proximity remained similar when pesticide exposures were excluded. Discussion: Pesticide exposure may be an independent childhood leukemia risk factor. Childhood leukemia risks for powerline proximity and magnetic fields exposure were not explained by pesticide exposure.
https://doi.org/10.1016/j.envres.2023.116899

Occupational exposure to extremely low-frequency magnetic fields and follicular lymphoma risk: a family case-control study,
ODUTOLA M. K., M. T. VAN LEEUWEN, F. J. BRUINSMA, G. BENKE, M. C. TURNER, J. TROTMAN, J. TURNER, J. F. SEYMOUR, H. M. PRINCE, S. T. MILLIKEN, C. TILEY, M. HERTZBERG, F. RONCOLATO, S. OPAT, R. LINDEMAN, E. VERNER, C. R. UNDERHILL, E. CARDIS, G. GILES and C. M. VAJDIC,
Occupational and Environmental Medicine (2023 Sep 2023),
ObjectivesWe aimed to examine the relationship between occupational exposure to extremely low-frequency magnetic fields (ELF-MFs) and follicular lymphoma (FL) risk.MethodsWe conducted a family case-control study between 2011 and 2016 in Australia and included 681 cases. Controls were either a family member of cases (related (n=294), unrelated (n=179)) or were unrelated recruited for a similarly designed Australian multiple myeloma study (n=711). We obtained detailed job histories using lifetime work calendars. We assigned exposure to ELF-MFs using an enhanced job exposure matrix, with a lag period of 10 years. We examined associations with FL risk using logistic regression accounting for relatedness between cases and controls. We performed sensitivity analyses including by control type, by sex, complete case analyses, ELF-MF exposure percentiles in addition to quartiles, ELF-MF exposure in the maximum exposed job, a shorter lag period (1 year) and the cumulative exposure in the most recent time period (1-9 years).ResultsWe observed no association with the average intensity, duration or lifetime cumulative exposure to occupational ELF-MF exposure in the primary or sensitivity analyses.ConclusionsOur findings do not support an association between occupational ELF-MF exposure and FL risk. Although the inclusion of family members as part of the larger control group may have biased our risk estimates towards the null, findings were similar in sensitivity analyses restricted to cases and unrelated controls. Further research incorporating enhanced exposure assessment to ELF-MF is warranted to inform occupational safety regulations and any potential role in lymphomagenesis.
https://doi.org/10.1136/oemed-2023-108949

Electromagnetic Fields - Do They Pose a Cardiovascular Risk?,
PARIZEK D., N. VISNOVCOVA, K. H. SLADICEKOVA, J. MISEK, J. JAKUS, J. JAKUSOVA, M. KOHAN, Z. VISNOVCOVA, N. FERENCOVA and I. TONHAJZEROVA,
Physiological Research 72, no. 2 (Apr 2023): 199-208,
Mobile wireless communication technologies have now become an everyday part of our lives, 24 hours a day, 7 days a week. Monitoring the autonomous system under exposition to electromagnetic fields may play an important role in broading of our still limited knowledge on their effect on human body. Thus, we studied the interaction of the high frequency electromagnetic field (HF EMF) with living body and its effect on the autonomic control of heart rate using Heart Rate Variability (HRV) linear and nonlinear analyses in healthy volunteers. A group of young healthy probands (n=30, age mean: 24.2 +/- 3.5 years) without any symptoms of disease was exposed to EMF with f=2400 MHz (Wi-Fi), and f=2600 MHz (4G) for 5 minutes applied on the chest area. The short-term heart rate variability (HRV) metrics were used as an indicator of complex cardiac autonomic control. The evaluated HRV parameters: RR interval (ms), high frequency spectral power (HF-HRV in [ln(ms(2))]) as an index of cardiovagal control, and a symbolic dynamic index of 0V %,

indicating cardiac sympathetic activity. The cardiac-linked parasympathetic index HF-HRV was significantly reduced (p =0.036) and sympathetically mediated HRV index 0V % was significantly higher (p=0.002) during EMF exposure at 2400 MHz (Wi-Fi), compared to simulated 4G frequency 2600 MHz. No significant differences were found in the RR intervals. Our results revealed a shift in cardiac autonomic regulation towards sympathetic overactivity and parasympathetic underactivity indexed by HRV parameters during EMF exposure in young healthy persons. It seems that HF EMF exposure results in abnormal complex cardiac autonomic regulatory integrity which may be associated with higher risk of later cardiovascular complications already in healthy probands. https://doi.org/10.33549/physiolres.934938

Association between self-reported mobile phone use and the semen quality of young men, RAHBAN R., A. SENN, S. NEF and M. ROOSLI,
Fertility and Sterility 120, no. 6 (Dec 2023): 1181-1192,
Objectives: To investigate the association between mobile phone exposure and semen parameters.Design: A nationwide cross-sectional study.Setting: Andrology laboratories in close proximity to 6 army recruitment centers.Patients: In total, 2886 men from the general Swiss population, 18-22 years old, were recruited between 2005 and 2018 during military conscription.Intervention: Participants delivered a semen sample and completed a questionnaire on health and lifestyle, including the number of hours they spent using their mobile phones and where they placed them when not in use.Main Outcome Measures: Using logistic and multiple linear regression models, adjusted odds ratios and /5 coefficients were determined, respectively. The association between mobile phone exposure and semen parameters such as volume, sperm concentration, total sperm count (TSC), motility, and morphology was then evaluated.Results: A total of 2759 men answered the question concerning their mobile phone use, and 2764 gave details on the position of their mobile phone when not in use. In the adjusted linear model, a higher frequency of mobile phone use (>20 times per day) was associated with a lower sperm concentration (adjusted /5: -0.152; 95% confidence interval: -0.316; 0.011) and a lower TSC (adjusted /5: -0.271; 95% confidence interval: -0.515; -0.027). In the adjusted logistic regression model, this translates to a 30% and 21% increased risk for sperm concentration and TSC to be below the World Health Organization reference values for fertile men, respectively. This inverse association was found to be more pronounced in the first study period (2005-2007) and gradually decreased with time (2008-2011 and 2012-2018). No consistent associations were observed between mobile phone use and sperm motility or sperm morphology. Keeping a mobile phone in the pants pocket was not found to be associated with lower semen parameters.Conclusion: This large population-based study suggests that higher mobile phone use is associated with lower sperm concentration and TSC. The observed time trend of decreasing association is in line with the transition to new technologies and the corresponding decrease in mobile phone output power. Prospective studies with improved exposure assessment are needed to confirm whether the observed associations are causal. https://doi.org/10.1016/j.fertnstert.2023.09.009

Association Between the Use of Induction Heating Cookers and Delivery Outcomes in Pregnant Women: An Internet-Based Cohort Study,
SATO Y., M. TAKI and N. KOJIMAHARA,
Environmental Health Insights 17 (2023),
The number of devices that generate intermediate-frequency electromagnetic fields (IF-EMFs) in the living environment has been increasing. As the public has vague concerns about new devices, it is necessary to clarify the safety of IF-EMFs. Therefore, the present study aimed to examine the possible health effects of IF-EMFs by clarifying the relationship between the use of induction heating (IH) cookers and delivery outcomes. The study participants were pregnant women over the age of 20 years who were registered in panels with an Internet research firm. A total of 8920

pregnant women participated in the baseline survey. Of those who responded to the follow-up survey, 5022 who had a singleton birth were included in the analysis. We then examined the relationship between the use of IH cookers and gestational week at delivery (<37th/>= 37th week) or birth weight (<2500/>= 2500 g) using logistic regression models. No association was found between the use of IH cookers and birth weight, but weak associations were found between the use of stationary- and tabletop-type IH cookers and gestational week at delivery. After all considerations, we determined that the observed increased odds ratio did not indicate an increased risk of premature birth. https://doi.org/10.1177/11786302231211114

Narrativer Review mit Schwerpunkt Schlaf als mögliches Bindeglied,
SAUTER C., H. DORN, J. HELLMANN-REGEN, A. BUENO-LOPEZ and H. DANKER-HOPFE,
Somnologie (2023 Oct 2023),
Background: A part of the population fears the negative effects of low-frequency magnetic fields (NF-MF), for example, from high-voltage lines and other systems and devices using a frequency of 50 or 16 2/3 Hz. Some studies show an association between NF-MF exposure and an increased risk of neurodegenerative diseases, including Alzheimer's dementia (AD).Objectives and methods: In the present narrative review, the current state of research on NF-MF and possible effects on the risk of AD and on sleep is summarized based on epidemiological and experimental studies and is critically discussed in terms of methods.Results and conclusions: In epidemiological studies on occupational exposure to low-frequency magnetic fields and in studies considering high-voltage power lines, a slight increased risk of Alzheimer's dementia was observed. However, this risk was only found to be significant in the meta-analyses on occupational exposure. The studies are characterized by great heterogeneity, which is why it remains open whether the observations are based on a causal relationship. While a mechanism of action is not yet known, sleep may play a key role in the search for one. Since disturbed sleep has been shown to lead to an increased concentration of the biomarkers of Alzheimer's dementia (amyloid and tau and their deposits), a disturbance by external factors as triggers or amplifiers is conceivable. Epidemiological and experimental studies partially show a negative effect of NF-MF on human sleep. However, it should be kept in mind that the informative value of most of these studies is only very limited, since the quality of the studies is lacking. In epidemiological studies, sleep can only be measured very imprecisely and is susceptible to confounders that can be better controlled in experimental studies.Results and conclusions: In epidemiological studies on occupational exposure to low-frequency magnetic fields and in studies considering high-voltage power lines, a slight increased risk of Alzheimer's dementia was observed. However, this risk was only found to be significant in the meta-analyses on occupational exposure. The studies are characterized by great heterogeneity, which is why it remains open whether the observations are based on a causal relationship. While a mechanism of action is not yet known, sleep may play a key role in the search for one. Since disturbed sleep has been shown to lead to an increased concentration of the biomarkers of Alzheimer's dementia (amyloid and tau and their deposits), a disturbance by external factors as triggers or amplifiers is conceivable.Epidemiological and experimental studies partially show a negative effect of NF-MF on human sleep. However, it should be kept in mind that the informative value of most of these studies is only very limited, since the quality of the studies is lacking.In epidemiological studies, sleep can only be measured very imprecisely and is susceptible to confounders that can be better controlled in experimental studies.
https://doi.org/10.1007/s11818-023-00425-4

Safety Concerns and Recommendations during Work in the Vicinity of Energized Lines
SZABÓ D., L. GVERGYÁDESZ, B. NÉMETH, E. RAMIREZ-BETTONI and IEEE (2023). IEEE-Power-and-Energy-Society General Meeting (PESGM), Orlando, FL.

This paper covers an in-depth review of the hazards that are present during vicinity work on de-energized lines near live power lines. This work reviews regulations, occupational limits, types of hazards, risk assessment, and recommendations on mitigation. Line workers may be exposed to thermal exposure from arc events, ignition of material, and induced current. There is also exposure to electric shock hazards due to direct contact, AC induction, line trapped charges, etc. They are also susceptible to exposure to high electric, magnetic, and electromagnetic fields. Latest developments for AC induction protection and PPE are also presented. Finally, recommendations for mitigation of all hazards are given. https://doi.org/10.1109/pesgm52003.2023.10253419

Personal exposure to radiofrequency electromagnetic fields in various occupations in Spain and France,
TURUBAN M., H. KROMHOUT, J. VILA, M. VALLBONA-VISTÓS, I. BALDI and M. C. TURNER,
Environment International 180 (Oct 2023),
Background: A preliminary job-exposure matrix (JEM) for radiofrequency electromagnetic fields (RF-EMF) was created based on self-reported occupational information from a multi-country population-based study of approximately 10,000 participants combined with available measurement data compiled in a source-exposure matrix (spot measurements). In order to address the limited personal occupational RF-EMF measurement data available in the literature, we performed a measurement campaign among workers in various occupations in Spain and France.Methods: Personal full-shift measurements were conducted using RadMan 2XTTM (Narda) devices. A worker diary was used to capture information on occupational and background sources of RF exposure during the shift. Inclusion of occupations to be measured was initially based on exposure prevalence and level information in the preliminary JEM and expert judgment.Results: Personal full-shift measurements were conducted among 333 workers representing 46 ISCO88 occupations. Exposure to electric (E) and magnetic (H) fields was infrequent with >99% of measurements below the detection limit of the device (>= 1% of the 1998 ICNIRP standards). A total of 50.2% and 77.2% of workers were ever exposed to E and H fields respectively (having at least one recorded 1-second measurement above the detection limit). Workers in elementary occupations, technicians and associate professionals, plant and machine operators and assemblers had somewhat greater numbers of measurements above the detection limit, higher maximum values and longer exposure durations. A small proportion of measurements were >= 100% of the standards, though these exceedances were brief (generally a few seconds in duration). Female workers and workers reporting use of any RF-EMF emitting source were more likely to have a measured exposure to E and H fields.Conclusion: We conducted personal RF-EMF measurements among workers in various occupations in Spain and France. Overall, RF-EMF exposure >= 1 % ICNIRP was infrequent, despite some intermittent exposures >= 100% observed among workers in some occupations. https://doi.org/10.1016/j.envint.2023.108156

Risk Assessment of Human Subjects occupationally exposed to Extremely Low Frequency Electromagnetic Fields (ELF-EMFs) and Light at Night (LAN) with particular reference to Melatonin Hypothesis,
VEMULA S., V. KAVITHA, P. R. BABU and R. TIWARI,
Research Journal of Biotechnology 18, no. 9 (Sep 2023): 205-215,
Modern society makes pervasive use of electric power producing electromagnetic Fields (EMFs) and light at night (LAN). This has resulted in the indiscriminate use of electrical and electronic gadgets which release electromagnetic radiations which are supposed to cause the biological effects by some scientists. However, ELF- EMFs and LAN are hypothesized to be responsible for the changes in hormonal configurations leading to development of cancer in women particularly nurses who are occupationally exposed to ELF- EMFs and LAN. The blood samples of 342 exposed subjects and 150 non exposed individuals were analyzed. Plasma melatonin was measured by radioimmunoassay

(RIA). DNA damage was studied by alkaline comet assay along with micronucleus test and RT- PCR. Our results suggest that the plasma melatonin levels were significantly suppressed in the occupationally exposed subjects ($p < 0.05$) and DNA damage ranged between 8 mu m to 10 mu m. Group-C exposed subjects showed more DNA damage. The occupationally exposed subjects were found to be vulnerable for electromagnetic stress with decreased melatonin concentrations and increased DNA damage. https://doi.org/10.25303/1809rjbt2050215

Occupational risk factors for multiple sclerosis: a systematic review with meta-analysis, VITTURI B. K., A. MONTECUCCO, A. RAHMANI, G. DINI and P. DURANDO, *Frontiers in Public Health* 11 (Nov 2023),
Objective: We decided to conduct the first systematic review with meta-analysis to provide the highest level of up-to-date evidence on the occupational risk factors for Multiple Sclerosis.Methods: A systematic, comprehensive literature search was performed in four electronic academic databases. We included any case-control study that enrolled working-age subjects and compared the proportion of MS cases with controls who were not exposed to an occupational risk factor. The primary outcome was the occurrence of MS. The quality assessment was performed with the Critical Appraisal Checklist for Case Control Studies, developed, and validated by the Joanna Briggs Institute. All the selection process was also carried out by two independent and previously trained researchers.Results: Overall, the total sample included 19,004 people with MS and 4,164,162 controls. Agricultural workers (OR = 1.44, 95% CI 1.13-1.83), offshore workers (OR = 3.56, 95% CI 2.74-4.61), and hairdressers (OR = 8.25, 95% CI 1.02-66.52) were associated with a higher probability of being diagnosed with MS. In parallel, workers exposed to toxic fumes from oil wells (OR = 16.80, 95% CI 8.33-33.90), low-frequency magnetic fields (OR = 1.71, 95% CI 1.03-2.72), and pesticides (OR = 3.17, 95% CI = 2.53-3.99) also had an increased likelihood of having MS.Conclusion: Our study has the potential to influence more assertive public policies. Nevertheless, future studies on how the occupational setting may contribute to the incidence of MS are highly recommended.Systematic review registration The protocol was registered in the international prospective register of systematic reviews (PROSPERO- CRD42023443257). https://doi.org/10.3389/fpubh.2023.1285103

Effects of ultra-high field MRI environment on cognitive performance in healthy participants, WENNBERG L., J. MARTENSSON, L. LANGENSEE, P. C. SUNDGREN, K. M. BLOCH and B. HANSSON, *Radiography* 30, no. 1 (Jan 2024): 95-99,
Introduction: Ultra-high field MRI (UHF MRI) is rapidly becoming an essential part of our toolbox within health care and research studies; therefore, we need to get a deeper understanding of the physiological effects of ultra-high field. This study aims to investigate the cognitive performance of healthy participants in a 7 T (T) MRI environment in connection with subjectively experienced effects.Methods: We measured cognitive performance before and after a 1-h 7T MRI scanning session using a Digit Symbol Substitution Test (DSST) in 42 subjects. Furthermore, a computer-based survey regarding the subjectively experienced effects in connection with the MRI examination was distributed. Similarly, two DSSTs were also performed by a control group of 40 participants.Results: Even though dizziness was the strongest sensory perception in connection to the MRI scanning, we did not find any correlation between dizziness and cognitive performance. Whilst the control group improved ($p=<0.001$) on their second DSST the MRI group showed no significant difference ($p=0.741$) in the DSST before and after MRI scanning.Conclusion: Transient effect on cognition after undergoing MRI scanning can't be ruled out as the expected learning effect on the DSST was not observed.(c) 2023 Published by Elsevier Ltd on behalf of The College of Radiographers. https://doi.org/10.1016/j.radi.2023.10.006

Evaluation de l'exposition

A New Intelligent Estimation Method Based on the Cascade-Forward Neural Network for the Electric and Magnetic Fields in the Vicinity of the High Voltage Overhead Transmission Lines,
BONAB S. A., W. J. SONG and M. YAZDANI-ASRAMI,
Applied Sciences-Basel 13, no. 20 (Oct 2023),
The evaluation and estimation of the electric and magnetic field (EMF) intensity in the vicinity of overhead transmission lines (OHTL) is of paramount importance for residents' healthcare and industrial monitoring purposes. Using artificial intelligence (AI) techniques makes researchers able to estimate EMF with extremely high accuracy in a significantly short time. In this paper, two models based on the Artificial Neural Network (ANN) have been developed for estimating electric and magnetic fields, i.e., feed-forward neural network (FFNN) and cascade-forward neural network (CFNN). By performing the sensitivity analysis on controlling/hyper-parameters of these two ANN models, the best setup resulting in the highest possible accuracy considering their response time has been chosen. Overall, the CFNN achieved a significant 56% reduction in Root Mean Squared Error (RMSE) for the electric field and a 5% reduction for the magnetic field, compared to the FFNN. This indicates that the CFNN model provided more accurate predictions, particularly for the electric field than the proposed methods in other recent works, making it a promising choice for this application. When the model is trained, it will be tested by a different dataset. Then, the accuracy and response time of the model for new data points of that layout will be evaluated through this process. The model can predict the fields with an accuracy near 99.999% of the actual values in times under 10 ms. Also, the results of sensitivity analysis indicated that the CFNN models with triple and double hidden layers are the best options for the electric and magnetic field estimation, respectively. https://doi.org/10.3390/app132011180

Artificial Neural Network Based Prediction of Long-Term Electric Field Strength Level Emitted by 2G/3G/4G Base Station,
ENGIZ B. K.,
Applied Sciences-Basel 13, no. 19 (Oct 2023),
Accurate predictions of radio frequency electromagnetic field (RF-EMF) levels can help implement measures to reduce exposure and check regulatory compliance. Therefore, this study aims to predict the RF-EMF levels in the medium using an artificial neural network (ANN). The work was conducted at Ondokuz Mayis University, Kurupelit Campus, where the measurement location has line-of-sight to the base stations. Band selective measurements were also performed to assess the contribution of 2G/3G/4G services to the total RF-EMF level, which was found to be the highest among all services within the total band. Long-term RF-EMF measurements were carried out for 35 days within the frequencies of 100 kHz to 3 GHz. Then, an ANN model with Levenberg-Marquardt (LM) and Bayesian Regulation (BR) algorithms was proposed, which utilized inputs from real-time RF-EMF measurements. The performance of the models was assessed in terms of mean squared error (MSE) and regression performance. The average MSE and regression performances of the models were similar, with the lowest testing MSEs of 2.78 x 10-3 and 3.76 x 10-3 for LM and BR methods, respectively. The analysis of the models showed that the proposed models help to predict the RF-EMF level in the medium with up to 99% accuracy. https://doi.org/10.3390/app131910621

Measurement and risk perception of non-ionizing radiation from base transceiver stations in Dhaka City of Bangladesh,
ISLAM M. S., A. PAL, M. S. NOOR and I. U. SAZZAD,

Environmental Monitoring and Assessment 195, no. 10 (Oct 2023),
Multiple harmful health effects can have on the population from non-ionizing radiation (NIR) sources. To date, there has been no extensive data collection about NIR emitted from base transceiver stations in Dhaka City, Bangladesh. This study aims to remedy that by collecting data and comparing the processed data to the international standards, International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, and standards of other countries. For this, measurement data were collected from 361 different publicly accessible locations in Dhaka City applying a convenience sampling approach. The measured average electric field exceeded the 1800 MHz threshold values of 36.84, 33.5, and 7.5% of the time compared with the thresholds of China, India, and Japan, respectively, followed by the measured average electromagnetic field values, which were 57, 52, and 29%, respectively. No exceedance was seen for radiofrequency power flux for the investigated countries. Approximately 35% of the calculated average specific energy absorption rate values exceeded the ICNIRP recommended public exposure limit of 0.08 W/kg. Based on this data, it is suggested that detailed NIR exposure regulations need to be created and proper oversight and enforcement over operators are required to avoid potential health effects. https://doi.org/10.1007/s10661-023-11812-7

Comparison of ambient radiofrequency electromagnetic field (RF-EMF) levels in outdoor areas and public transport in Switzerland in 2014 and 2021,
LOIZEAU N., M. ZAHNER, J. SCHINDLER, C. STEPHAN, J. FRÖHLICH, M. GUGLER, T. ZIEGLER and M. RÖÖSLI,
Environmental Research 237 (Nov 2023),
Mobile communication technology has evolved rapidly over the last ten years with a drastic increase in wireless data traffic and the deployment of new telecommunication technologies. The aim of this study was to evaluate the ambient radiofrequency electromagnetic field (RF-EMF) levels and temporal changes in various microenvironments in Switzerland in 2014 and 2021. We measured the ambient RF-EMF levels in V/m in the same 49 outdoor areas and in public transport in 2014 and 2021 using portable RF-EMF exposure meters carried in a backpack. The areas were selected to represent some typical types of microenvironments (e.g. urban city centres, suburban and rural areas). We calculated the summary statistics (mean, percentiles) in mW/m2 and converted back to V/m for each microenvironment. We evaluated the distribution and the variability of the ambient RFEMF levels per microenvironment types in 2021. Finally, we compared the ambient RF-EMF mean levels in 2014 and 2021 using multilevel regression modelling. In outdoor areas, the average ambient RF-EMF mean levels per microenvironment in 2021 ranged from 0.19 V/m in rural areas to 0.43 V/m in industrial areas (overall mean: 0.27 V/m). In public transports, the mean levels were 0.27 V/m in buses, 0.33 V/m in trains and 0.36 V/m in trams. In 2021, mean levels across all outdoor areas were -0.022 V/m lower (95% confidence interval: -0.072, 0.030) than in 2014. Results from our comprehensive measurement study across Switzerland suggest that RFEMF levels in public places have not significantly changed between 2014 and 2021 despite an 18-fold increase in mobile data transmission during that period. The absence of temporal changes may be owed to the shift to newer mobile communication technologies, which are more efficient. https://doi.org/10.1016/j.envres.2023.116921

Pacemakers, Implantable Defibrillators, and 5G Technology: What We Need to Know,
MATTEI E., C. VIVARELLI, D. FRANCI, S. PAVONCELLO, T. AURELI, G. CALCAGNINI and F. CENSI,
Health Physics 125, no. 3 (Sep 2023): 202-206,
Pacemakers (PM) and implantable cardioverter defibrillators (ICD) are active implantable medical devices (AIMD) needed in case of cardiac arrhythmias. Given their potentially life-sustaining nature, the interaction between any source of electromagnetic field and these AIMDs is an ongoing concern of patients, industry, and regulators. According to the current regulatory framework, the

required immunity of PM and ICD provides a reasonable unperturbed behavior in the presence of cell phones and base stations that use pre-5G technologies. PM/ICD international standards do not consider some peculiar characteristics of 5G technology and some of the 5G technology frequency bands (those above 3 GHz), since these frequencies are considered not to add risks to the AIMD functioning. Here we analyze the theoretical issues about the interference between 5G technology and PM/ICD and propose an experimental approach to perform a measurement campaign. https://doi.org/10.1097/hp.0000000000001699

Impact of Indoor Distributed Antenna System on RF-EMF Global Exposure,
MAZLOUM T., S. S. WANG and J. WIART,
Ieee Access 11 (2023): 70587-70597,
The deployment of Distributed Antenna Systems (DAS) in poorly covered indoor areas has been a strategy to improve and extend radio-frequency (RF) coverage. However, this may imply a rise in the risk perception related to human exposure to electromagnetic fields (EMF), despite the existence of protection limits. Therefore, the objective of the current study is to analyze the overall impact of the installation of indoor DAS on the global human exposure. This analysis takes into account both downlink exposure, which includes exposure from outdoor base stations and indoor DAS, as well as uplink exposure induced by mobile phones. To this end, we carried out measurement campaigns in the premises of an organization and two subway stations in France, with the capability to selectively activate or deactivate the DAS antennas. The global exposure is evaluated using the 'Exposure Index (EI)' metric, which was developed as part of the European project LEXNET. The EI metric takes into consideration the exposure induced by both base stations and mobile devices, as well as the specific usage service (such as data or voice calls). The results have shown that deploying indoor DAS implies a reduction in the global EMF exposure while improving the quality of the cellular network connectivity. In addition to the impact of the usage service of mobile phones, the extent of EMF decrease is heavily influenced by the presence of additional RF sources. Specifically, significant reductions in EMF exposure have been observed in locations with minimal additional RF sources, whereas relatively lower reduction factors have been observed in locations with additional RF sources. https://doi.org/10.1109/access.2023.3293642

Assessment of radio frequency fields in the 2.45 GHz band produced by smart home devices,
MCKENZIE R. J., S. ISKRA and P. KNIPE,
Bioelectromagnetics (2023 Nov 2023),
This paper describes the assessment of the electromagnetic fields produced by consumer "smart" devices used to control and monitor everyday equipment and appliances in a modern "smart" home. The assessment is based on the careful measurement of fields produced by a range of such devices in a laboratory environment configured to operate in a condition simulating high user activity. All devices included in this study operate in the 2.4 GHz band utilizing either Wi-Fi or Bluetooth connectivity. Overall results indicate very low levels of electromagnetic fields for all IoT smart devices in terms of human exposure safety standards (typically much less than 1%) with very low duty cycles (also less than 1%) resulting in even lower time-averaged exposure levels. These low levels of exposure, along with rapid reduction of levels with distance from the devices, suggests that the cumulative effect of multiple devices in a "smart" home are not significant. This paper provides a detailed assessment of the radiofrequency electromagnetic fields produced by a range of consumer "smart" devices that may be present in a typical "smart" home.Results of these measurements indicate such devices produce very low levels of radiofrequency electromagnetic fields at even close distances of exposure, together with very intermittent operation reducing such exposure even further.Such low exposures, along with rapid reduction of fields with distance from the devices provides confidence the that cumulative effects of multiple devices in a smart home are not significant for human exposure. https://doi.org/10.1002/bem.22492

Safety assessment of wireless chargers for electric vehicles considering thermal characteristics,
MOU W. T. and M. LU,
Radiation Protection Dosimetry (2023 Nov 2023),
This study employs the transient finite element method and electromagnetic heat transfer theory to assess the heating generated by high-power wireless chargers during electric vehicle charging. The analysis includes simulating and analyzing the temperature distribution of two different types of shielding plates of the wireless charger and the specific absorption rate (SAR) and head temperature rise of both adults and children in close proximity to the charger. Simulation results show that the maximum temperature rise of the copper shielding plate is 16 degrees C lower than that of the aluminum shielding plate after charging for 1 h. This temperature increase does not affect the chassis' s equipment. Regarding human safety, the induced electric field strength and SAR values in the child's head tissue are higher than those in the adult, meeting the International Commission on Non-Ionizing Radiation Protection (ICNIRP) limits. When the initial temperature is set to 37 degrees C, the temperature rise in the heads of both adults and children is approximately equal after 1 h of charging, reaching a maximum temperature rise of 0.21 and 0.23 degrees C, respectively. These values remain below the thermal limit of ICNIRP (2 degrees C for Type 2 tissues). The findings indicate that the copper shielding plate can provide both electromagnetic shielding and heat dissipation functions, and the electromagnetic exposure absorbed by the human body and head temperature rise within safe ranges. https://doi.org/10.1093/rpd/ncad288

Study How the Hand Affects on the Mobile Phone Dipole Antenna Matching Conditions to the Free Space at 3700 MHz Frequency
NOZADZE T., K. HENKE, M. KURTSIKIDZE, V. JELADZE, G. GHVEDASHVILI and R. ZARIDZE (2022). IEEE 2nd Ukrainian Microwave Week (UkrMW), Kharkiv, UKRAINE.
the purpose of the presented study is to investigate EM exposure on realistic inhomogeneous human models to test mobile phones in terms of electromagnetic (EM) safety. The influence of the human hand (fingers positions) during communication on the mobile phones' antenna matching conditions was studied through computer modeling using the Finite-Difference Time-Domain (FDTD) method for the 3700 MHz communication frequency. Dielectric heating effects caused by EMF absorption in human tissues have been considered in this paper.
https://doi.org/10.1109/ukrmw58013.2022.10037056

Personal exposure from free Wi-Fi hotspots in downtown Mexico City,
RAMIREZ-VAZQUEZ R., I. ESCOBAR, J. J. H. MORENO, A. MARTINEZ-PLAZA, S. MAFFEY and E. ARRIBAS,
Environmental Science and Pollution Research (2023 Jul 2023),
In 2019, the Government of Mexico City implemented actions that allowed citizens to approach a free Wi-Fi hotspot, where more than 13000 points have been installed throughout the city. In this work, we present the results of the measurements of personal exposure to Radiofrequency Electromagnetic Fields carried out in Plaza de la Constitucion, better known as Zocalo located in the center of Mexico City. The measurements were taken by one of the researchers while walking on a weekday morning and afternoon, in different microenvironments (on the street, on public transport: subway, at the Zocalo, and finally, at home). We also carry out spot measurements in the center of the Zocalo. Subsequently, we carried out a comparative analysis of the different microenvironments, through box plot and violin plot, and we elaborate georeferenced and interpolated maps with intensity levels through the Kriging method, using the Geographic Information System. The Kriging interpolation gives us a good visualization of the spatial distribution of RF-EMF exposure in the study area, showing the highest and lowest intensity levels. The mean values recorded at the measured points in the Zocalo were 326 & mu;W/m(2) in the 2.4-

to 2.5-GHz Wi-Fi band and 2370 & mu;W/m(2) in the 5.15- to 5.85-GHz Wi-Fi band. In the case of the mean values recorded on the street, they were 119 & mu;W/m(2) in the 2.4- to 2.5-GHz frequency band and 31.8 & mu;W/m(2) in the 5.15- to 5.85-GHz frequency band, like the values recorded at home, 122 & mu;W/m(2) and 33.9 & mu;W/m(2), respectively. All values are well below the reference levels established by the International Commission on Non-Ionizing Radiation Protection. https://doi.org/10.1007/s11356-023-28839-5

Conservative Analytical Assessments of Localized RF Exposure From Small Magnetic Field Sources, ROUSE C. D.,
Ieee Transactions on Electromagnetic Compatibility (2023 Nov 2023),
A conservative analytical framework for assessing radiofrequency exposure from small magnetic field sources near the body is presented, with an emphasis on the 3 kHz-10 MHz frequency range. Worst-case exposure models are proposed and analyzed for both homogeneous and heterogeneous tissue based on source dimensions, drive current, and separation distance. Electromagnetic analysis of induced field enhancements due to tissue heterogeneity is presented. Maximum drive currents for compliance with the basic restrictions are obtained for both tissue models. In the heterogeneous case, field enhancement in thin regions of low conductivity leads to significantly lower allowable drive levels for nerve stimulation compliance. Guidance is provided regarding how to account for such enhancements for various internal E-field calculation methods. The impact of these field enhancements on 10-g specific absorption rate (SAR) is found to be small, i.e., the homogeneous tissue assumption appears to be sufficiently conservative. A small enhancement factor may be appropriate for 1-g SAR. The benefit of assessing against the basic restrictions instead of the reference levels is also explored. This work can be leveraged by regulatory and standardization bodies to develop exemption levels for small magnetic field sources, e.g., inductive chargers, to significantly reduce compliance burdens.
https://doi.org/10.1109/temc.2023.3328820

Simulation of the magnetic field in residential buildings with built-in substations based on a two-phase multi-dipole model of a three-phase current conductor,
ROZOV V. Y., D. Y. PELEVIN and K. D. KUNDIUS,
Electrical Engineering & Electromechanics, no. 5 (2023): 87-93,
Problem. Substations 10(6)/ 0.4 kV built into residential buildings create a magnetic field with magnetic flux density of more than 10 mu T in nearby residential premises, which is a danger to the health of the population and makes the study of this magnetic field relevant for the development of methods for its protection. The main source of the substations external magnetic field is their lowvoltage current conductor, the contribution of which to the total level of the magnetic field is more than 90 %. Multi-dipole mathematical models, which have a clear physical interpretation, are a promising method of modeling the substations magnetic field, which is important for the further development of methods of population protection. The purpose of the work is to modify the well-known multi-dipole model for calculation based on it with a limited error of the external magnetic field of current conductors of built-in substations that are close to residential buildings at a distance of up to one meter. Methodology. A modified two-phase multi-dipole mathematical model of the main source of the external magnetic field of substation - its threephase low- voltage current conductors - is proposed, which, unlike the existing model, is based on a two- you to halve the distance to the area of calculation without increasing the error. Verification. An experimental verification of the modified twophase multi-dipole model of the magnetic field of a three-phase 100 kVA transformer substation on its full- scale physical model was carried out, and the results of the experiment were presented, confirming the coincidence of the calculation and the experiment with a spread of no more than 7 %. References 37, tables 1, figures 10.
https://doi.org/10.20998/2074-272x.2023.5.13

Calculation of Electric Field Induced in the Human Body for Simultaneous Exposure to Spatially Uniform ELF Electric and Magnetic Fields With a Phase Difference,
SEKIBA Y., S. KODERA, K. YAMAZAKI and A. HIRATA,
Ieee Access 11 (2023): 95455-95466,
International exposure guidelines such as ICNIRP guidelines and IEEE C95.1 standard are published to protect human from potential adverse health effect. These guidelines and standards establish the limit for the induced electric field, also called the basic restriction. The permissible external field strength-known as the reference level-is then conservatively derived from the basic restriction. Though the reference level is calculated assuming that the human body is exposed to electric or magnetic fields separately, in reality, simultaneous exposure to both fields may occur. Such exposures are particularly likely when a human body is positioned under overhead transmission lines. Under such circumstances, a phase difference between the electric and magnetic fields occur due to the phase difference between the power line's voltage and current. We investigated the impact of external electric and magnetic field phase differences on the induced electric field in numerical human models. This was done under simultaneous exposure to a spatially uniform vertical electric field and horizontal magnetic fields at 50 Hz. Our computational findings revealed that the strength of the induced electric field fluctuates with the phase difference and that the variation caused by this difference varies across different body parts. The basic restrictions of the ICNIRP guidelines were met under the simultaneous exposure to electric and magnetic fields at the reference level, even when considering the phase difference.
https://doi.org/10.1109/access.2023.3311517

A Unified Quantitative Index to Assess Nonionizing Radiation Safety,
WANG H., K. F. TSANG, Y. WEI, Y. C. LIU, C. H. KOO and W. H. WAN,
Ieee Consumer Electronics Magazine 12, no. 4 (Jul 2023): 84-93,
The enormous increase of intelligent devices for smart city development brings convenient services to consumers. The continuous radio waves emission raises the public's concern about the safety level of nonionizing radiation (NIR). Global NIR safety guidelines have been devised to limit the radiation level in response to public concerns. However, there is no consensus on radiation safety restrictions among various standards, causing confusion and rendering the public difficult to adapt. To address this issue, in this article, a novel index, namely Non-ionizing Radiation Safety Index (NRSDex) is proposed. NRSDex is a unified quantitative evaluation of the NIR safety which mitigates the conflicting multiple relative standards and provides a comprehensive quantified index for decision making. The development of NRSDex is motivated by the IEEE P2668 global standard, which aims to evaluate the Internet of Things (IoT) maturity by constructing an IoT index (i.e., IDex). A special form of IDex, referred as NRSDex, has been developed to provide a unified and quantified view of NIR safety to provide guidance for the public to understand the safety level. Besides, NRSDex provides insights to the specific NIR safety difference between numerous health hazard standards. To highlight the significance of NRSDex, the effects of NIR on the human body are revisited and the NIR safety standards adopted by numerous countries with top rank healthcare device markets are examined and benchmarked. The NRSDex is detailed with its framework, methodology, as well as case studies. https://doi.org/10.1109/mce.2022.3178200

Evaluation of Electromagnetic Exposure of the Human with a Coronary Stent Implant from an Electric Vehicle Wireless Power Transfer Device,
WANG T. H., B. LI, K. F. ZHAO, Q. Y. YU, L. L. XU, Y. D. CHI and S. S. GUAN,
Electronics 12, no. 20 (Oct 2023),
The aim of this paper is to analyze in depth the coupling between leakage electromagnetic fields (EMFs) generated by an electric vehicle wireless power transfer (EV-WPT) device under misaligned

operating conditions and metallic coronary stents, which could be potentially hazardous to human electromagnetic safety. In this paper, we established that a standing human with a coronary stent implant and a sitting human with a coronary stent implant are exposed to the leaked EMFs of an EV-WPT device with a transmission power of 11 kW and 22 kW and a transmission frequency of 85 kHz, and we quantified the induced E-field strength of the human body by considering the x- and z-axis misalignment ranges of the WPT device as [-75 mm, 75 mm]. The results showed that the enhancement of the induced E-field in the human tissues near the sharp edges of the implant is significant. Meanwhile, the larger the WPT device misalignment generated, the higher the transmission power, and the closer the human body is to the WPT device, the larger the induced E-fieldmax value of the human body is, which has the possibility of exceeding the ICNIRP safety limit, and there is a potential human body electromagnetic safety problem.
https://doi.org/10.3390/electronics12204231

A Study on EMF Exposure Assessments With Different Metrics for User Equipment Antennas at 6 and 10 GHz,
ZHEKOV S. S., M. YAO, C. DI PAOLA, B. XU and S. ZHANG,
Ieee Transactions on Electromagnetic Compatibility (2023 Oct 2023),
User equipment (UE) needs to comply with regulations limiting the exposure of the human body to electromagnetic fields (EMFs). In this article, three exposure metrics, including specific absorption rate (SAR), incident power density (IPD), and absorbed power density (APD), are quantified for different UE antenna designs. The exposure ratios of the metrics are quantified according to the relevant EMF limit values. The investigations are performed at or close to the transition frequency between different exposure metrics: the range 6-10 GHz being of research interest and currently attracting attention for emerging mobile technologies. The study demonstrates that the IPD does not correlate well with the APD, within the investigated frequency region, when the reactive near-field of the antenna is of interest. This is in accordance with the International Commission on Nonionizing Radiation Protection 2020 guidelines meaning that the APD should be used for compliance purposes. For validation purposes, prototypes are fabricated, and SAR and IPD are measured. The average difference between the numerical and experimental results is 0.4 dB for SAR and 0.9 dB for the IPD, meaning that good agreement between simulations and measurements is obtained. https://doi.org/10.1109/temc.2023.3324032

Toxicité sur l'homme

A systematic review on cellular responses of Escherichia coli to nonthermal electromagnetic irradiation,
ASKARIPOUR K. and A. ZAK,
Bioelectromagnetics (2023 Oct 2023),
Investigation of Escherichia coli under electromagnetic fields is of significance in human studies owing to its short doubling time and human-like DNA mechanisms. The present review aims to systematically evaluate the literature to conclude causality between 0 and 300 GHz electromagnetic fields and biological effects in E. coli. To that end, the OHAT methodology and risk of bias tool were employed. Exponentially growing cells exposed for over 30 min at temperatures up to 37(degrees)C with fluctuations below 1(degrees)C were included from the Web-of-Knowledge, PubMed, or EMF-Portal databases. Out of 904 records identified, 25 articles satisfied the selection criteria, with four excluded during internal validation. These articles examined cell growth (11 studies), morphology (three studies), and gene regulation (11 studies). Most

experiments (85%) in the included studies focused on the extremely low-frequency (ELF) range, with 60% specifically at 50 Hz. Changes in growth rate were observed in 74% of ELF experiments and 71% of radio frequency (RF) experiments. Additionally, 80% of ELF experiments showed morphology changes, while gene expression changes were seen in 33% (ELF) and 50% (RF) experiments. Due to the limited number of studies, especially in the intermediate frequency and RF ranges, establishing correlations between EMF exposure and biological effects on E. coli is not possible. https://doi.org/10.1002/bem.22484

Visualization of the frequency effect of pulsed electric field on enzymatic browning of peel ground tissue,
AYUB M. and M. FINCAN,
Food and Bioproducts Processing 142 (Nov 2023): 82-93,
The enzymatic browning behavior of a model ground tissue, banana peel, influenced by the frequency variable of pulsed electric field (PEF), has been visualized and studied. The tissue was PEF-treated with 15 mu s pulse at 3.3 kV/cm using trains of 5, 15, and 30 pulses, each varying from 0.1 Hz to 10 Hz; images and electrical conductivity were recorded intermittently throughout the incubation. The degree of browning was quantified with a browning index (BI) term, and the uniformity of browning was visually assessed by inspecting the pattern of pigment distribution. Moreover, the degree of tissue disintegration was calculated using a conductivity-based tissue disintegration index (DI) and compared to the BI and specific energy input. Browning uniformity was found to be significantly affected and increased with decreasing frequency. The effect was most noticeable up to disintegration degree of about 63, DI, or when the frequency of 5 or 15 pulses was reduced from 1 Hz to 0.1 Hz. Remarkably, the decrease at 5 pulses resulted in a significant increase in BI without a substantial increase in DI. The observed effect has been attributed to increased electrophoretic mobility of browning agents along the extracellular path during 0.1 Hz pulsation. Furthermore, lowering the frequency to 0.1 Hz reduced the energy required for a browning level close to saturation by about 57% compared to 10 Hz.
https://doi.org/10.1016/j.fbp.2023.09.003

Static electric field (SEF) exposure promotes the proliferation of B lymphocytes,
DONG L., Y. H. CHEN, K. Y. WANG, H. X. LI and G. Q. DI,
International Immunopharmacology 125 (Dec 2023),
With the rapid development of ultra-high voltage direct current (UHV DC) transmission technology, the intensity of electric fields in the surrounding environment of UHV DC transmission lines significantly increased, which raised public concerns about the potential health effects of electric fields. Previous studies have shown that the exposure of electromagnetic field was associated with cancer. B lymphocytes can produce autoantibodies and tumor growth factors through proliferation, which contributes to the development of cancer. Therefore, this study explored the effect and mechanism of static electric field (SEF) generated by DC transmission lines on the proliferation levels of B lymphocytes. Male mice were exposed to SEF. After the exposure of 7 and 14 days, the proliferation levels of B lymphocytes in the spleens of mice were measured, respectively. To validate biological effect discovered in animal experiments and elucidate the mechanism of the effect from the perspective of signaling pathways, lymphocytes were exposed to SEF. After the exposure of 24, 48 or 72 h, the proliferation levels of B lymphocytes, the expression levels of key proteins and cell cycle were determined. This study found that SEF exposure activated NF-KB pathway by stimulating ERK1/2 pathway and promoted B lymphocytes to enter S phase from G0/G1 phase. Meanwhile, SEF exposure also promoted B lymphocytes to enter G2 phase. Namely, SEF exposure significantly promoted the proliferation of B lymphocytes. This discovery provided theoretical and practical support for the prevention or application of negative or positive effects

caused by SEF exposure and provided directions for future research.
https://doi.org/10.1016/j.intimp.2023.111006

Electromagnetic interference and the effect of low-voltage protective measures at electric vehicle charging stations,
FÜRNSCHUSS M., D. HERBST, P. REICHEL, D. STAHLEDER, C. AUER, E. SCHMAUTZER and R. SCHÜRHUBER,
Elektrotechnik Und Informationstechnik (2023 Nov 2023),
The nominal power of electric vehicle charging stations or charging parks is constantly increasing. Most of the users are ordinary persons and handle such equipment with a rated power of several 100 kW. Until now, equipment with such power ratings was only common in electrical operating facilities such as industrial plants where the users are at least instructed and protective measures are specified. If ordinary persons handle equipment with such power ratings in the field, the question arises as to whether the conventional safety goals are met in the event of an electrical fault. The consideration is: If the power increases so much, it can be assumed that the short-circuit power and thus the fault current increase and so does the risk of a dangerous electric shock. In this contribution, calculations of line-to-earth short-circuits on the low-voltage AC side of the three-phase system and their effects in typical configurations of charging stations are carried out. Considering the electromagnetic interference, the calculations provide the fault current and its distribution to determine the electrical potentials during the fault. From this, the (partial) fault voltages and active fault voltages are calculated. Based on the active fault voltage, the expected body impedance and consequently, the body current can be determined. With the body current and the break time of the protection device the risk of electric shock using international standards as guidelines is evaluated. As a result, recommendations for the planning, installation and safe operation of charging stations are given. It turns out that considering certain aspects like the conductor cross-sections or the electromagnetic interference, the risk of electric shock can be reduced to a conventional level. Periodic testing of the electrical system is necessary for safe and reliable operation. For example, follow-on faults due to unintended, improper use by ordinary persons can be prevented. Also, regular inspection of the electrical system is necessary for safe and reliable operation to prevent hazards due to aging or wear. However, it seems challenging to define an installation guideline that applies to all configurations as the boundary conditions vary depending on the type of system, installations in the area of interference and environmental influences. Die Anschlussleistung von Ladestationen bzw. Ladeparks fur Elektrofahrzeuge erhohen sich standig. So hantieren die Benutzer, welche meist elektrotechnische Laien sind, mit Betriebsmitteln, welche Nennleistungen von mehreren 100 kW haben konnen. ublich waren Betriebsmittel mit solchen Nennleistungen bis vor Kurzem nur in elektrischen Betriebsstatten wie z. B. Industriebetrieben, wo die Benutzer zumindest unterwiesen sind und spezielle Anforderungen an die Schutzmassnahmen und -vorkehrungen gestellt werden. Hantieren Laien im Feld mit Betriebsmitteln in dieser Leistungsklasse, stellt sich die Frage, ob die vereinbarten Schutzziele bei einem elektrischen (Isolations-)Fehler erreicht werden. Die uberlegung dahinter ist folgende: Wenn die Anschlussleistung steigt, ist davon auszugehen, dass ebenso der Fehlerstrom steigt und sich dadurch das Risiko eines elektrischen Schlages erhoht. In diesem Beitrag werden Berechnungen von Erdkurzschlussen auf Seite der Niederspannungs-Drehstromversorgung und deren Auswirkungen bei typischen Anordnungen von Ladestationen durchgefuhrt. Die Berechnungen liefern unter Berucksichtigung der elektromagnetischen Beeinflussung den Fehlerstrom und dessen Aufteilung, um die elektrischen Potenziale zu bestimmen. Daraus werden die im Fehlerfall auftretenden (Teil-)Fehlerspannungen und Wirkfehlerspannungen berechnet. Anhand der Wirkfehlerspannung lasst sich die zu erwartende Korperimpedanz und infolgedessen der Strom, der durch eine Person bei Beruhrung leitfahiger Teile fliesst, bestimmen. Mit dem sogenannten Korperstrom und der Ausschaltzeit der Schutzeinrichtung wird die Gefahrdung eines elektrischen Schlages auf Basis

internationaler Normen evaluiert. Resultierend werden Empfehlungen fur die Errichtung und den sicheren Betrieb von Ladestationen gegeben. Es zeigt sich, dass unter Berucksichtigung wichtiger Aspekte, wie z. B. dem Leitungsquerschnitt oder der elektromagnetischen Beeinflussung, die Reduktion des Risikos eines elektrischen Schlages auf ein gesellschaftlich vertretbares Niveau moglich ist. Eine regelmassige uberprufung der elektrischen Anlage ist fur den sicheren und zuverlassigen Betrieb erforderlich. Ebenso ist eine regelmassige Inspektion der elektrischen Anlage fur den sicheren und zuverlassigen Betrieb notwendig, um Gefahrdungen wie durch Alterung oder Verschleiss zu vermeiden. So konnen z. B. Folgefehler aufgrund von unwissentlicher, unsachgemasser Benutzung durch Laien hintangehalten werden. Eine einheitliche Festlegung von Errichtungsvorschriften, welche samtliche Konfigurationsmoglichkeiten einschliesst, stellt eine grosse Herausforderung dar, da die Randbedingungen je nach Art der Anlage, Installationen im Beeinflussungsbereich und Umgebungseinflussen variieren. https://doi.org/10.1007/s00502-023-01180-y

Millimeter-Wave Induced Heating of Cutaneous Nerves and Capillaries,
HAIDER Z., J. MODOLO, M. LIBERTI, F. APOLLONIO and M. ZHADOBOV,
Ieee Journal of Microwaves 3, no. 1 (Jan 2023): 170-180,
In this study, we quantify microscale heating at the level of cutaneous nerves and capillaries due to continuous and pulsed plane-wave exposure at 60 GHz. The thermal properties of the nerves and capillaries were derived using mixture equations based on their water content. The electromagnetic problem was solved in conjunction with Pennes bioheat equation and Arrhenius equation using finite element method to evaluate the spatial and temporal evolution of temperature along with thermal damage within cutaneous nerves and capillaries. Although, the maximum power density within the nerve (41.6 kW/m(3)) and capillary (20 kW/m(3)) was 37.3% and 30.2% higher than surrounding skin for a continuous exposure at 10 W/m(2), the peak temperature elevation (Delta T) within the nerve (93.3 n degrees C) and capillary (90.7 n degrees C) occurred after 5 mu s and 10 mu s of exposure and was 19.2% and 17.7% higher than surrounding skin, respectively. The nerve and capillary attained thermal equilibrium with skin after roughly 10 ms. The maximal Delta T within the nerve (0.5 degrees C) and capillary (0.25 degrees C) due to nano- and micro-second 60 GHz pulses with highest fluence (0.48 kJ/m(2)) permitted under ICNIRP guidelines was 34% and 24% higher than in the surrounding skin. Ten 3 mu s 60 GHz pulses (power density = 13.4 GW/m(2)) separated by 10 s of cooling period were used to demonstrate the possibility of selective thermal ablation of cutaneous nerves [damage index (Omega)=1.1)] without damaging skin (Omega = 0.15). The results provide valuable insights into local millimeter-wave induced heating within various skin substructures. https://doi.org/10.1109/jmw.2022.3199989

Extremely low-frequency electromagnetic field induces acetylation of heat shock proteins and enhances protein folding,
HUANG Z. Z., M. ITO, S. C. ZHANG, T. TODA, J. I. TAKEDA, T. OGI and K. OHNO,
Ecotoxicology and Environmental Safety 264 (Oct 2023),
The pervasive weak electromagnetic fields (EMF) inundate the industrialized society, but the biological effects of EMF as weak as 10 mu T have been scarcely analyzed. Heat shock proteins (HSPs) are molecular chaperones that mediate a sequential stress response. HSP70 and HSP90 provide cells under undesirable situations with either assisting covalent folding of proteins or degrading improperly folded proteins in an ATP-dependent manner. Here we examined the effect of extremely low-frequency (ELF)-EMF on AML12 and HEK293 cells. Although the protein expression levels of HSP70 and HSP90 were reduced after an exposure to ELF-EMF for 3 h, acetylations of HSP70 and HSP90 were increased, which was followed by an enhanced binding affinities of HSP70 and HSP90 for HSP70/HSP90-organizing protein (HOP/STIP1). After 3 h exposure to ELF-EMF, the amount of mitochondria was reduced but the ATP level and the maximal

mitochondrial oxygen consumption were increased, which was followed by the reduced protein aggregates and the increased cell viability. Thus, ELF-EMF exposure for 3 h activated acetylation of HSPs to enhance protein folding, which was returned to the basal level at 12 h. The proteostatic effects of ELF-EMF will be able to be applied to treat pathological states in humans. https://doi.org/10.1016/j.ecoenv.2023.115482

Wireless Bioelectronic Interfaces Electromagnetic Performance and Safety
KIM H. J., Z. Y. DONG and J. S. HO. 2023.
Bioelectronic devices residing within the human body often rely on radio-frequency wireless systems in order to interact with the external world. These systems are critical for the long-term functionality of bioelectronic devices because they generally constitute one of their largest and most energy-demanding components. At the physical level, the performance of the wireless system is determined by the configuration of the electromagnetic field in the body and the thresholds at which it induces adverse tissue effects. This chapter provides an overview of this physical interaction between radio-frequency electromagnetic fields and the body and how this interaction can be modeled using computational tools to design wireless interfaces for sensing, communication, and power transfer. https://doi.org/10.1007/978-981-16-5540-1_24

Determination of the Impact of High-Intensity Pulsed Electromagnetic Fields on the Release of Damage-Associated Molecular Pattern Molecules,
KRANJC M., T. POLAJZER, V. NOVICKIJ and D. MIKLAVCIC,
International Journal of Molecular Sciences 24, no. 19 (Oct 2023),
High-Intensity Pulsed Electromagnetic Fields (HI-PEMF) treatment is an emerging noninvasive and contactless alternative to conventional electroporation, since the electric field inside the tissue is induced remotely by an externally applied pulsed magnetic field. Recently, HI-PEMF has been successfully used in the transfer of plasmid DNA and siRNA in vivo, with no or minimal infiltration of immune cells. In addition to gene electrotransfer, treatment with HI-PEMF has also shown potential for electrochemotherapy, where activation of the immune response contributes to the treatment outcome. The immune response can be triggered by immunogenic cell death that is characterized by the release of damage-associated molecular patterns (DAMPs) from damaged or/and dying cells. In this study, the release of the best-known DAMP molecules, i.e., adenosine triphosphate (ATP), calreticulin and high mobility group box 1 protein (HMBG1), after HI-PEMF treatment was investigated in vitro on three different cell lines of different tissue origin and compared with conventional electroporation treatment parameters. We have shown that HI-PEMF by itself does not cause the release of HMGB1 or calreticulin, whereas the release of ATP was detected immediately after HI-PEMF treatment. Our results indicate that HI-PEMF treatment causes no to minimal release of DAMP molecules, which results in minimal/limited activation of the immune response. https://doi.org/10.3390/ijms241914607

Impact of silver ions and silver nanoparticles on biochemical parameters and antioxidant enzyme modulations in Saccharomyces cerevisiae under co-exposure to static magnetic field: a comparative investigation,
KTHIRI A., S. HAMIMED, W. TAHRI, A. LANDOULSI, S. O'SULLIVAN and D. SHEEHAN,
International Microbiology (2023 Nov 2023),
The increase in simultaneous exposure to magnetic fields and other hazardous compounds released from industrial applications poses multiple stress conditions on the ecosystems and public human health. In this work, we investigated the effects of co-exposure to a static magnetic field (SMF) and silver ions (AgNO3) on biochemical parameters and antioxidant enzyme activities in the yeast Saccharomyces cerevisiae. Sub-chronic exposure to AgNO3 (0.5 mM) for 9 h resulted in a significant decrease in antioxidant enzyme activity, including glutathione peroxidase (GPx), catalase (CAT),

superoxide dismutase (SOD), and glutathione transferase (GST). The total glutathione (GSH) level increased in yeast cells exposed to Ag. Additionally, a notable elevation in malondialdehyde (MDA) levels and protein carbonyl content was observed in both the AgNP and AgNO3 groups compared to the control group. Interestingly, the SMF alleviated the oxidative stress induced by silver nitrate, normalizing antioxidant enzyme activities by reducing cellular ROS formation, MDA levels, and protein carbonylation (PCO) concentrations. https://doi.org/10.1007/s10123-023-00453-y

Thermal damage analysis in tissue caused by electromagnetic radiation using space-time collocation method,
MEENA B. S. and S. KUMAR,
Journal of Thermal Biology 117 (Oct 2023),
Over the past half-century, the usage of external heat sources in medical applications has increased substantially. Controlling heat damage is essential for ensuring the efficacy of the treatment. Living tissues are highly non-homogeneous; hence, it is important to take into account the effects of local non-equilibrium on their thermal behavior. In the present study, two- and three- space dimensional time-space fractional singlephase-lag (SPL) and dual-phase-lag (DPL) models for bio-heat transfer in tissue are considered to study the thermal damage and temperature in tissue caused by electromagnetic radiation as an external heat source. The considered mathematical models are more general and consider non-Fourier as well as non-local effects. We obtain the numerical solution for the models by combining Gaussian RBFs and shifted Chebyshev polynomials in the space and time directions, respectively. The RBFs depend on Euclidean distance, so they can easily be used in multidimensional space domain, and the use of Chebyshev polynomials gives spectral accuracy in time direction. It is also explored how different parameters, such as blood perfusion rate W-b, phase lags iota(q),iota(t), and fractional derivatives alpha,beta, affect the temperature distribution and thermal damage in the tissue. https://doi.org/10.1016/j.jtherbio.2023.103715

Evaluation of mitochondrial stress following ultraviolet radiation and 5G radiofrequency field exposure in human skin cells,
PATRIGNONI L., A. HURTIER, R. ORLACCHIO, A. JOUSHOMME, F. P. DE GANNES, P. LEVEQUE, D. ARNAUD-CORMOS, H. R. REVZANI, W. MAHFOUF, A. GARENNE, Y. PERCHERANCIER and I. LAGROYE,
Bioelectromagnetics (2023 Dec 2023),
Whether human cells are impacted by environmental electromagnetic fields (EMF) is still a matter of debate. With the deployment of the fifth generation (5G) of mobile communication technologies, the carrier frequency is increasing and the human skin becomes the main biological target. Here, we evaluated the impact of 5G-modulated 3.5 GHz radiofrequency (RF) EMF on mitochondrial stress in human fibroblasts and keratinocytes that were exposed for 24 h at specific absorption rate of 0.25, 1, and 4 W/kg. We assessed cell viability, mitochondrial reactive oxygen species (ROS) production, and membrane polarization. Knowing that human skin is the main target of environmental ultraviolet (UV), using the same read-out, we investigated whether subsequent exposure to 5G signal could alter the capacity of UV-B to damage skin cells. We found a statistically significant reduction in mitochondrial ROS concentration in fibroblasts exposed to 5G signal at 1 W/kg. On the contrary, the RF exposure slightly but statistically significantly enhanced the effects of UV-B radiation specifically in keratinocytes at 0.25 and 1 W/kg. No effect was found on mitochondrial membrane potential or apoptosis in any cell types or exposure conditions suggesting that the type and amplitude of the observed effects are very punctual. A 24 h exposure to a 5G signal at 3.5 GHz was able to statistically significantly alter the mitochondrial reactive oxygen species (ROS) production in human skin fibroblasts (decrease at 1 W/Kg) and in human keratinocytes after UV-B irradiation (increase at 0.25 and 1 W/kg).A 24 h exposure to a 5G signal at 3.5 GHz was not able to alter cell viability, apoptosis and mitochondrial membrane potential in human skin cells, either alone or after UV-B irradiation.Further studies on 3D or in vivo skin models

would be needed to conclude about a possible effect of 5G 3.5 GHz signal on ROS production.
https://doi.org/10.1002/bem.22495

PHAGOCYTOSIS OF LATEX BEADS BY A HUMAN MONOCYTIC MONO MAC 6 CELL LINE AND EFFECTS OF LOW-FREQUENCY ELECTROMAGNETIC FIELD INTERACTION,
PISZCZEK P., K. WOJCIK-PIOTROWICZ, B. NOWAK, P. GUZDEK, P. NOVAK, J. PYTKO-POLONCZYK, K. GIL and J. KASZUBA-ZWOINSKA,
Journal of Physiology and Pharmacology 74, no. 2 (Apr 2023): 235-247,
Some studies have shown that electromagnetic fields (EMFs) may impact immune response cells and their functions. The first stage of the defense from pathogens is innate immunity encompassing phagocytosis and phagocytosis-related intracellular effects. Our work aimed to determine the influence of a low-frequency electromagnetic field (7 Hz, 30 mTrms) on the phagocytosis process of latex beads (LBs), the production of reactive oxygen species (ROS), and viability changes in a human monocytic Mono Mac 6 (MM6) cell line as an experimental model of the phagocytosing cells in in vitro cell culture conditions. For these purposes, cells were firstly activated with infectious agents such as lipopolysaccharide (LPS), Staphylococcal enterotoxin B (SEB), or the proliferatory agent phytohaemagglutinin (PHA), and then a phagocytosis test was performed. Cell viability and range of phagocytosis of latex beads by MM6 cells were measured by flow cytometry, and the level of ROS was evaluated with the use of a cytochrome C reduction test. The obtained results revealed that applied EMF exposure mainly increased the necrosis parameter of cell death when they were pre-stimulated with SEB as an infectious factor and subsequently phagocytosed LBs (P=0.001). Prestimulation with other agents like LPS or PHA preceding phagocytosis resulted in no statistically significant changes in cell death parameters. The level of ROS depended on the used stimulatory agent, phagocytosis, and/or EMF exposure. The obtained effects for EMF exposure indicated only a slight decrease in the ROS level for cells phagocytosing latex beads and being treated with SEB or PHA, while the opposite effect was observed for LPS pre-stimulated cells (data not statistically significant). The results concerning the viability of phagocytosing cells, the effectiveness of the phagocytosis process, and the level of radical forms might result from applied EMF parameters like signal waveform, frequency, flux density, and especially single EMF exposure.
https://doi.org/10.26402/jpp.2023.2.10

Inhibition of mitochondrial calcium uptake by Ru360 enhances the effect of 1800 MHz radio-frequency electromagnetic fields on DNA damage,
SUN C., L. T. ZHU, H. B. QIN, H. L. SU, J. ZHANG, S. Y. WANG, X. G. XU, Z. L. ZHAO, G. X. MAO and J. CHEN,
Ecotoxicology and Environmental Safety 264 (Oct 2023),
Today, the existence of radio-frequency electromagnetic fields (RF-EMF) emitted from cell phones, wireless routers, base stations, and other sources are everywhere around our living environment, and the dose is increasing. RF-EMF have been reported to be cytotoxic and supposed to be a risk factor for various human diseases, thus, more attention is necessary. In recent years, interfere with mitochondrial calcium uptake by using mitochondrial calcium uniporter (MCU) inhibitor were suggested to be potential clinical treatment in mitochondrial calcium overload diseases, like neurodegeneration, ischemia/reperfusion injury, and cancer, but whether this approach increases the health risk of RF-EMF exposure are unknown. To address our concern, we did a preliminary study to determine whether inhibition of MCU will increase the genotoxicity of RF-EMF exposure in cells, and found that short-time (15 min) exposure to 1800 MHz RF-EMF induced significant DNA damage and cell apoptosis in mouse embryonic fibroblasts (MEFs) treated with Ruthenium 360 (Ru360), a specific inhibitor of MCU, but no significant effects on cell cycle, cell proliferation, or cell viability were observed. In conclusion, our results indicated that inhibiting MCU increases the genotoxicity of RF-EMF exposure, and more attention needs to be paid to the possible health

impact of RF-EMF exposure under these treatments.
https://doi.org/10.1016/j.ecoenv.2023.115472

System-level biological effects of extremely low-frequency electromagnetic fields: an in vivo experimental review,
TIAN H. Y., H. Z. ZHU, C. H. GAO, M. X. SHI, D. K. YANG, M. Y. JIN, F. H. WANG and X. H. SUI,
Frontiers in Neuroscience 17 (Oct 2023),
During the past decades, the potential effects of extremely low-frequency electromagnetic fields (ELF-EMFs) on human health have gained great interest all around the world. Though the International Commission on Non-Ionizing Radiation Protection recommended a 100 mu T, and then a 200 mu T magnetic field limit, the long-term effects of ELF-EMFs on organisms and systems need to be further investigated. It was reported that both electrotherapy and possible effects on human health could be induced under ELF-EM radiation with varied EM frequencies and fields. This present article intends to systematically review the in vivo experimental outcome and the corresponding mechanisms to shed some light on the safety considerations of ELF-EMFs. This will further advance the subsequent application of electrotherapy in human health.
https://doi.org/10.3389/fnins.2023.1247021

Research on the influence of power frequency electric field of pantograph on passengers' health in high-speed EMU,
TIAN R., J. Q. ZHANG and M. LU,
Archives of Electrical Engineering 72, no. 2 (2023): 483-501,
In this work we discussed the safety of the electric field environment in the No.3 carriage where the pantograph is located. DSA380 pantograph, CRH5 EMU carriage and passengers' models were established to study the electric field exposure of passengers at different positions. The results showed that symbolscript the carriage without passengers is symbolscript symbolscript symbolscript mV/m. Then we set the passengers' positions according to the electric field distribution in the carriage without passengers and obtained that symbolscript in the carriage with passengers is symbolscript symbolscript symbolscript mV/m. It can be seen that the maximum induced electric field intensity of passengers at different positions appears on the soles of shoes, the maximum value is symbolscript symbolscript symbolscript mV/m, the maximum induced current density occurs at the ankle, its maximum value is symbolscript symbolscript symbolscript symbolscript It can be concluded that the maximum induced electric field intensity of passenger's head appears in the cerebrospinal fluid area, with a maximum value of 202.817 mV/m, and the maximum induced electric field intensity of passenger's head at the door is larger than that in the middle of the carriage. The maximum values of the induced electric field intensity in all tissues of passengers are much smaller than the basic limits of electromagnetic exposure to the public set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). This study indicated that the pantograph has little influence on the electric field environment in the carriage under working state, and will not cause any health hazard to the passengers in this working frequency electric field environment. https://doi.org/10.24425/aee.2023.145421

Thermal Effects of Electromagnetic Energy on Skin in Contact with Metal: A Numerical Analysis,
WESSAPAN T., P. RATTANADECHO, N. SOMSUK, M. YAMFANG, M. GUPTASA and P. MONTIENTHONG,
Energies 16, no. 16 (Aug 2023),
It has been well recognized that interactions between electromagnetic fields and metals are very strong. The consequence of human tissue in contact with metal, when subjected to an alternating electromagnetic field, is an increase in tissue temperature, which results from metals absorbing the energy obtained through induction. However, the electromagnetic induction characteristics and

tissue energy absorbed caused by various electromagnetic field exposure conditions have not been well understood. A computational model was developed and employed in this study to assess the temporal and spatial temperature increases in skin due to contact with a highly conductive metallic plate while subjected to a high-intensity electromagnetic field. The effects of plate material, plate thickness, coil distance, and exposure time on temperature increase in the skin were computationally investigated. The electromagnetic and temperature distributions in skin layers during exposure to electromagnetic fields were achieved using models of electromagnetic wave propagation and an unsteady bioheat transfer. The modeling approach used indicates that the plate thickness, plate material, coil distance, and exposure time have a significant impact on the temperature change in the skin. The most important parameter was found to be the metal type. Iron has the greatest effect on skin temperature increase when subjected to external electromagnetic induction. These results allow the researchers to estimate more precisely the exposure limits for induction coils. https://doi.org/10.3390/en16165925

Méthodes

EMEMI: An interference-free mini-incubator with integrated electric and magnetic field exposure for real-time microscopic imaging of field effects,
ALIZADEH F., M. SAVIZ, F. KHORAMINIA, A. TALEBIPOUR, R. IMANI and I. SHABANI,
Bioelectromagnetics (2023 Oct 2023),
Uninterrupted microscopic observation and real-time imaging of cell behavior during exposure to the stimulus, for example, electric and/or magnetic fields, especially for periods of several days, has been a challenge in experimental bioelectromagnetics due to a lack of proper gas/temperature conditions outside the incubator. Conventional mini-incubators might suffer from stray fields produced by heating elements. We report an in vitro electric and magnetic fields (EMF) exposure system embedded inside a novel under-the-microscope mini-CO2-incubator with a unique design to avoid electromagnetic interference from the heating and circulation functions while ensuring the requisite temperature. A unique, reconfigurable array of electrodes and/or coils excited by calculated current distributions among array elements is designed to provide excellent field uniformity and controllable linear or circular polarization (even at very low frequencies) of the EMF within the cell culture. Using standard biochemical assays, long-term cell viability has been verified and compared with a conventional incubator. Cell orientation/migration in three-dimensional culture made of collagen-hydrogels has been successfully observed in vitro, in long-term, and in real-time under the influence of DC electric fields with the device. Uninterrupted Microscopic Observation: The study addresses the challenge of continuous real-time imaging of cell behavior during exposure to stimuli like electric and magnetic fields, especially for extended periods.Under-the-Microscope Mini-Incubator: A novel incubator design is introduced, embedded with an electric and magnetic fields (EMF) exposure system, enabling observations of cell responses while avoiding electromagnetic interference.Field Uniformity and Polarization Control: A unique array of electrodes and/or coils with calculated current distributions is designed to ensure excellent field uniformity and controllable polarization of the EMF.Viability and Cell Behavior Analysis: The study verifies mini-incubator with cell viability using standard assays and successfully observes cell orientation and migration in three-dimensional collagen-hydrogel cultures under the influence of DC electric fields. https://doi.org/10.1002/bem.22483

Development of a 6 GHz RF-EMF Exposure System for Investigating Human Skin Temperature Responses: Characterization, Integration, and Pilot Testing,
ALZAHED A., E. LEMAY, M. ZHUK, G. B. GAJDA, J. P. MCNAMEE and G. W. MCGARR,
Ieee Access 11 (2023): 100343-100354,
We developed a radiofrequency electromagnetic field (RF-EMF) exposure system to investigatehuman skin temperature responses to localized exposures. The system was designed to project a 6 GHzRF-EMF beam with enough energy to rapidly increase peak local skin temperature on the human forearmfrom a baseline of 30-32 degrees C to similar to 38 degrees C within 6 min. First, the RF-EMF exposure conditions were charac-terized using computer simulations to confirm that the antenna produced the desired spot size (4 cm) andresultant temperature rise in the skin. ANSYS-HFSS and Sim4Life electromagnetic and thermal simulationswere performed to fully characterize the relation between electromagnetic physics and the bioheat thermalconduction problem. Next, an open-ended waveguide antenna was integrated with other hardware peripheralsto comprise the full RF-EMF exposure system. Finally, human pilot testing was conducted while participantswere seated comfortably with the antenna 5 cm above the skin surface on the volar (i.e. palm side) forearm.Local skin temperatures were monitored continuously with a thermal camera, which automatically identifiedand continuously tracked the peak skin temperature under the projected beam. Both electromagnetic andthermal data plots are presented to illustrate the bioelectromagnetic response for the exposure system. Futureexperimental studies using this system will examine individual and environmental factors that may influencelocal human skin temperature responses to RF-EMF exposures on the forearm and other body regions.
https://doi.org/10.1109/access.2023.3313971

Musa acuminata as electroporation model,
ANDRADE D., G. B. PINTARELLI, J. ROSA, I. B. PARO, P. J. T. PAGANO, J. C. N. SILVA and D. O. H. SUZUKI,
Bioelectrochemistry 154 (Dec 2023),
Electrochemotherapy (ECT) and Irreversible electroporation (IRE) are cancer treatments based on electric field distribution in tissues. Solanum tuberosum (potato tissue) phantom is known to mimic changes in the electrical conductivity that occur in animal tissues during electroporation (EP). Electric field distribution is assessed through enzymatic staining. However, the 24-h wait for this assessment could slow agile response scenarios. We developed and validated the Musa acuminata (cavendish banana) conductivity model, which quickly evaluates EP by tissue staining. We investigated the frequency response of the tissue using impedance spectroscopy analysis, conductivity changes, and enzymatic staining. We optimized three usual EP models: adapted Gompertz, smoothed Heaviside, and the sigmoid or logistic function. We found dielectric parameters in banana tissue similar to those in potato (electrical conductivity of 0.035 S/m and relative permittivity of 4.1 x 104). The coefficients of determination R2 were 99.94% (Gompertz), 99.85% (Heaviside), and 99.58% (sigmoid). The sigmoid and Heaviside functions described the calibration and validation electric currents with 95% confidence. We observed the electroporated areas in bananas 3h30m after EP. Staining was significant after 450 V/cm. The conductivity model of Musa acuminata suits treatment planning, hardware development, and training scenarios. Banana phantom supports the 3Rs practice and is a reliable alternative for potato in EP studies.
https://doi.org/10.1016/j.bioelechem.2023.108549

Comparison of two thermal probe technologies for the dosimetric investigations of RF exposure systems
BENJAMIN C., F. T. EMMANUEL, D. DAVID, G. KATIA and IEEE (2023). IEEE MTT-S International Microwave Biomedical Conference (IMBioC), Leuven, BELGIUM.

Exposure to radiofrequency waves (RF) happens everyday but little is know about the potential induced toxicity. It is therefore essential to carry out studies with rigorous experimental protocols and accurate dosimetry. To do this, we can characterize the dosimetric characteristics, namely the specific absorption rate (SAR) of the emitted RF waves and the induced thermal increment by monitoring the temperature over time. Different types of thermal probes may be used for such a study. We were interested in comparing two types of probes that can be used in conditions suitable for in vitro measurements, in a traditional biological consumable, 96-well plate. Such particular conditions require extreme precision in the positioning of the probe, its sensitivity and its measurement accuracy. We have chosen to compare a microscale thermocouple, an inexpensive but often criticized technology as it is metallic and therefore capable of interfering with the electromagnetic field, with a much more expensive fiber optic probe. We have highlighted the advantages and disadvantages of each in the context of this specific type of measurement. https://doi.org/10.1109/imbioc56839.2023.10305111

Joint Uplink and Downlink EMF Exposure: Performance Analysis and Design Insights,
CHEN L., A. ELZANATY, M. A. KISHK, L. CHIARAVIGLIO and M. S. ALOUINI,
Ieee Transactions on Wireless Communications 22, no. 10 (Oct 2023): 6474-6488,
Installing more base stations (BSs) into the existing cellular infrastructure is an essential way to provide greater network capacity and higher data rates in the 5th-generation cellular networks (5G). However, a non-negligible amount of the population is concerned that such network densification will generate a notable increase in exposure to electric and magnetic fields (EMF) over the territory. In this paper, we analyze the downlink, uplink, and joint downlink&uplink exposure induced by the radiation from BSs and personal user equipment (UE), respectively, in terms of the received power density and exposure index. In our analysis, we consider the EMF restrictions set by the regulatory authorities such as the minimum distance between restricted areas (e.g., schools and hospitals) and BSs, and the maximum permitted exposure. Exploiting tools from stochastic geometry, mathematical expressions for the coverage probability and statistical EMF exposure are derived and validated. Tuning the system parameters such as the BS density and the minimum distance from a BS to restricted areas, we show a tradeoff between reducing the population's exposure to EMF and enhancing the network coverage performance. Then, we formulate optimization problems to maximize the performance of the EMF-aware cellular network while ensuring that the EMF exposure complies with the standard regulation limits with high probability. For instance, the exposure from BSs is two orders of magnitude less than the maximum permissible level when the density of BSs is less than 20 BSs/km(2). https://doi.org/10.1109/twc.2023.3244155

Large space Wireless Power Transfer System that Meets Human Electromagnetic Safety Limits
IEEE (2023). IEEE Wireless Power Technology Conference and Expo (WPTCE), San Diego, CA.
This paper presents a wireless power transfer system that allows for the free reception of energy throughout a room while meeting human electromagnetic safety standards. We optimized the working frequency, coil size, and excitation current of the energy transmission coil to reduce the potential harm of electromagnetic fields on the human body. Finally, a prototype of a dual circular energy emission system with a working frequency of 1.53 MHz, a radius of 2 m, and a distance of 2 m was built, and a receiver was tuned and matched. In a space of approximately 25 m(3), a single receiver can achieve wireless power transmission of about 40 W, with a transmission efficiency of 30%. This research demonstrates the possibility of humans breaking free from cable constraints in medium and low-power application scenarios, having significant theoretical significance and practical value. https://doi.org/10.1109/wptce56855.2023.10215869

Limiting magnetic exposures using ferrite core and shielding in wireless charging of mobile phones,

ILERI R. and A. AGÇAL,
Microwave and Optical Technology Letters 65, no. 12 (Dec 2023): 3204-3210,
The frequent cable breaks and socket failures experienced by users of mobile devices such as smartphones and tablets have become a problem. In this study, wireless charging of mobile phones is provided with inductive coupling. The wireless power transfer (WPT) system has a diameter of 5 cm, operates at 10 MHz, and has an output power of 5 W. The coil design includes a ferrite core and shielding for reducing electromagnetic scattering. The paper used mathematical calculations and simulation tools, including MATLAB, Simulink, Maxwell 3D, and HFSS, to analyze the WPT design and its effects on human health at various conditions. As a result, the magnetic exposure was kept below the limit value in this WPT design, thus protecting the person and the device. In addition, the WPT design achieved high efficiency with a maximum air gap of 2 cm when aligned, and up to 2 cm misalignment at 0.5 cm air gap. https://doi.org/10.1002/mop.33871

Validated E-field Measurement Setup for SAR Estimation in Human Phantom Model
PÉREZ M., R. URBINA, C. DURÁN, G. MARTÍNEZ, A. GALLEGO, A. FAJARDO, C. I. PÁEZ-RUEDA, J. L. ARAQUE and IEEE (2023). 17th European Conference on Antennas and Propagation (EuCAP), Florence, ITALY.
This paper describes the validation of an experimental E-field and Specific Absorption Rate (SAR) measurement setup for RF exposure assessment in a human flat phantom model. The requirements of standards related to RF dosimetry were taken into account for the integration of the experimental setup. From the various test cases tackled, we present results on the accuracy and precision of the E-field probe tracking system, and the comparison of measured E-field/SAR hot maps with simulations, which presented good agreement. https://doi.org/

Design of a Compact Dual-Polarized Wearable Antenna With Spatial Diversity Reception for Into-Body Communications,
WANG H., L. ZHU, Y. FENG and Y. X. GUO,
Ieee Transactions on Antennas and Propagation 71, no. 10 (Oct 2023): 7911-7923,
In this article, a novel compact dual-polarized wearable antenna is proposed for into-body bio-telemetric applications. Dual-polarization is realized using a meandered rectangular loop and an open-ended slot, which are both designed on a flexible printed circuit board (FPCB). The inner patch with an open-ended slot not only serves as a capacitive loading for the adjacent loop but also generates a new orthogonal radiation by properly adjusting the structure of the modified T-shaped open slot. The simulated wearable antenna maintains wide -10-dB impedance bandwidths of 2.26-2.78 GHz (21.22%) for the rectangular loop element and 2.20-2.71 GHz (20.82%) for the open-ended slot element, with in-band port isolation of more than 25 dB. Moreover, for evaluating the into-body communication link with both polarization and spatial diversities, a proof-of-concept design of the linearly polarized in-body antenna is also reported with varied positions and orientations inside the homogeneous phantom. And a comprehensive link measurement is conducted by adopting multiple proposed wearable antennas which tightly attach to the phantom surface with specific separation distances. The measured results indicate a peak transmission performance of 38.9 dB with a 60-mm implant depth. And the dual-polarized and spatial configurations of the wearable antennas also enable the synthesis of the into-body communication link to mitigate the uncertain positions and rotations of the in-body antenna in practical scenarios. https://doi.org/10.1109/tap.2023.3303032

Automatic Containment of Field Exposure for Roadway Wireless Electric Vehicle Charger,
YANG Y., J. Y. WANG, Z. C. HUANG, I. W. IAM and C. S. LAM,
Ieee Transactions on Transportation Electrification 9, no. 3 (Sep 2023): 4121-4131,

Inductive power transfer (IPT) has found application prospect in dynamic wireless electric vehicle (EV) charging as it can avoid the constraints of physical connection. With the commonly used LCC compensation, the ground-assembled transmitter coil is always excited by a fixed standby current even if there is no receiver coil coverage. As for dynamic wireless PT (DWPT) systems, even without EV charging, the underground transmitter coils typically remain activated at full power output to wait for the receivers in most cases, resulting in huge standby current and magnetic exposure safety concerns. In this article, we proposed a method for automatic containment of field exposure caused by standby current in the transmitter coil of wireless chargers, which applies LCC compensation networks requiring only primary-side control with the elimination of wireless feedback communication and extra detection. The wireless chargers can be automatically deactivated once EVs depart, as well as automatically activated once detecting the presence of EVs. Also, its excellent interoperability for different loads and types of compensation topology has been well analyzed and then verified. Moreover, experiments demonstrate that the magnetic field exposure is merely 11.66% of the ICNIRP 2010 standard exposure limit with the proposed modulation, which is suppressed by 94.64% than before. https://doi.org/10.1109/tte.2023.3236684

RIS-Aided mmWave Network Planning Toward Connectivity Enhancement and Minimal Electromagnetic Field Exposure,
YIN B., W. JOSEPH and M. DERUYCK,
Ieee Access 11 (2023): 115911-115923,
The utilization of millimeter wave (mmWave) technology has emerged as a key enabler for the advancement of future wireless networks. However, the widespread deployment of mmWave communication is impeded by the challenges posed by its harsh propagation characteristics. To overcome this limitation, the reconfigurable intelligent surface (RIS) is envisioned as a potential solution to enhance mmWave coverage by intelligently controlling signal reflections. In this paper, we study a RIS-aided multi-user downlink multiple-input single-output (MISO) mmWave network. We formulate the RIS-aided network planning as mixed-integer nonlinear programming (MINLP) by jointly optimizing the placement of infrastructure and link associations to maximize the connectivity while considering electromagnetic field (EMF) exposure constraints. To address this intractable problem, we transform it into mixed-integer linear programming (MILP) and then propose a power-efficient algorithm to solve it effectively. Numerical results show that substantial performance improvements are achieved by incorporating the RIS in mmWave networks. In particular, the proposed algorithm outperforms the conventional benchmark that does not employ the RIS, with up to 20% enhancement in connectivity and 14% reduction in EMF exposure.
https://doi.org/10.1109/access.2023.3325678

Actualités, société

'Scaling up' our understanding of environmental effects of marine renewable energy development from single devices to large-scale commercial arrays,
HASSELMAN D. J., L. G. HEMERY, A. E. COPPING, E. A. FULTON, J. FOX, A. B. GILL and B. POLAGYE,
Science of the Total Environment 904 (Dec 2023),
Global expansion of marine renewable energy (MRE) technologies is needed to help address the impacts of climate change, to ensure a sustainable transition from carbon-based energy sources, and to meet national energy security needs using locally-generated electricity. However, the MRE sector has yet to realize its full potential due to the limited scale of device deployments (i.e., single devices or small demonstration-scale arrays), and is hampered by various factors including uncertainty about environmental effects and how the magnitude of these effects scale with an increasing number of devices. This paper seeks to expand our understanding of the environmental

effects of MRE arrays using existing frameworks and through the adaptation and application of cumulative environmental effects terminology to key stressor-receptor interactions. This approach facilitates the development of generalized concepts for the scaling of environmental effects for key stressor-receptor in-teractions, identifying high priority risks and revealing knowledge gaps that require investigation to aid expansion of the MRE sector. Results suggest that effects of collision risk for an array may be additive, antag-onistic, or synergistic, but are likely dependent on array location and configuration. Effects of underwater noise are likely additive as additional devices are deployed in an array, while the effects of electromagnetic fields may be dominant, additive, or antagonistic. Changes to benthic habitats are likely additive, but may be dependent on array configuration and could be antagonistic or synergistic at the ecosystem scale. Effects of displacement, entanglement, and changes to oceanographic systems for arrays are less certain because little information is available about effects at the current scale of MRE development.
https://doi.org/10.1016/j.scitotenv.2023.166801

AC Induction Conductive Suit-A New Way of Protecting Linemen in the Vicinity of Energized Parts,
RAMIREZ-BETTONI E. and B. NEMETH,
Ieee Transactions on Industry Applications 59, no. 4 (Jul-Aug 2023): 5169-5177,
Conductive suits are widely used in the industry for live work on transmission lines. This paper covers the use of special conductive suits for AC induction protection on de-energized lines. During de-energized work in the vicinity of live conductors, inductive and capacitive coupling may result in dangerous voltages and currents. Several accidents show that de-energized work has a high-risk level. The main reason is that de-energized parts are supposed to be grounded but line workers often do not have the proper knowledge and safety gear to assess and to protect against sources of induced voltages and currents. A US electric utility in co-operation with the High Voltage Laboratory of the Budapest University of Technology and Economics developed an "AC induction suit"; a special conductive suit designed to protect line workers against induced voltage and current while working on de-energized systems in the vicinity of energized lines. The range of induced voltage and current was analyzed based on preliminary calculations, and field measurements. The design of the special protective suit was based on these physical values. Several laboratory tests were performed to validate the results and to inspect prototypes at extreme voltages and currents. The aim of the developers is to increase the overall level of safety during vicinity work in transmission corridors with high AC induction and to greatly reduce accidents. Requirements for induction suits and test methods to prove protective capabilities will be standardized in the future. Based on the positive results of the prototype tests, a new product was introduced in the US market. The suits are currently being tested by the electric utility to gather experience, develop field procedures, and to effectively reduce the risk level, treating safety always as priority.
https://doi.org/10.1109/tia.2023.3272305

Assessment of a Functional Electromagnetic Compatibility Analysis of Near-Body Medical Devices Subject to Electromagnetic Field Perturbation,
RAZEK A.,
Electronics 12, no. 23 (Dec 2023),
This article aims to assess, discuss and analyze the disturbances caused by electromagnetic field (EMF) noise of medical devices used near living tissues, as well as the corresponding functional control via the electromagnetic compatibility (EMC) of these devices. These are minimally invasive and non-ionizing devices allowing various healthcare actions involving monitoring, assistance, diagnoses and image-guided medical interventions. Following an introduction of the main items of the paper, the different imaging methodologies are conferred, accounting for their nature, functioning, employment condition and patient comfort and safety. Then the magnetic resonance imaging (MRI) components and their fields, the consequential MRI-compatibility concept and

possible image artifacts are detailed and analyzed. Next, the MRI-assisted robotic treatments, the possible robotic external matter introductions in the MRI scaffold, the features of MRI-compatible materials and the conformity control of such compatibility are analyzed and conferred. Afterward, the embedded, wearable and detachable medical devices, their EMF perturbation control and their necessary protection via shielding technologies are presented and analyzed. Then, the EMC control procedure, the EMF governing equations and the body numerical virtual models are conferred and reviewed. A qualitative methodology, case study and simple example illustrating the mentioned methodology are presented. The last section of the paper discusses potential details and expansions of the different notions conferred in the paper, in the perspective of monitoring the disturbances due to EMF noise of medical devices working near living tissues. This contribution highlights the possibility of the proper functioning of medical instruments working close to the patient's body tissues and their protection by monitoring possible disturbances. Thanks to these commitments, various health recommendations have been taken into account. This concerns piezoelectric actuated robotics, assisted with MRI and the possible use of conductive materials in this imager under certain conditions. The safe use of onboard devices with EMF-insensitive or intelligently shielded materials with short exposure intervals is also of concern. Additionally, the need to monitor body temperature in case of prolonged exposure of onboard devices to EMF is analyzed in the Discussion section. Moreover, the use of virtual tissue models in EMC testing to achieve more realistic evaluation capabilities also features in the Discussion section. https://doi.org/10.3390/electronics12234780

Toxicité sur les animaux et l'environnement

Effects of Radio Waves on the Immune System of an Animal Model,
AKBARI H., L. TAGHAVI, S. K. E. HOSSAINI, M. GHOLAMI-FESHARAKI and S. A. H. MIRZAHOSSEINI,
Trauma Monthly 28, no. 4 (Jul-Aug 2023): 876-881,
Introduction: Radio waves, such as cordless phones and wireless modems, have increased significantly. This study aimed to measure the effects of the 2.45 GHz wave on a mice's immune system's blood markers.Method: Seventy-two male mice were used. Mice's were divided into one control group and two radiation-exposed groups (A and B). Then, there were two Wi-Fi modems, one plain and without an antenna, for group a mouse contact. The other was the type with two antennas; the mice in group B were brought into contact. After exposure, blood samples regarding white blood cells, monocytes, lymphocytes, and neutrophils were analyzed.Results: White blood cells, monocytes, lymphocytes, and neutrophils increased in the control group ($P<0.001$). However, these parameters significantly declined over time in the two intervention groups ($P<0.001$). The blood parameters of the mice in the two intervention groups exposed to various modems were similar ($P>0.05$).Conclusion: The results indicated the interference of waves of this spectrum, mainly radio frequency, with the immune system of exposed mice. Blood cells are more susceptible to long-term exposure to Wi-Fi waves and have a downward trend in terms of number. Also, no significant difference was observed between the blood parameters of the two groups with different modems. https://doi.org/10.30491/tm.2023.401812.1608

A primary study on rat fetal development and brain-derived neurotrophic factor levels under the control of electromagnetic fields,
DASTAMOOZ S., S. T. BROUJENI and N. SARAHIAN,
Journal of Public Health in Africa 14, no. 6 (2023),
Background. In previous researches, electromagnetic fields have been shown to adversely affect the behavior and biology of humans and animals; however, body growth and brain-derived neurotrophic factor levels were not evaluated.Objective. The original investigation aimed to

examine whether Electromagnetic Fields (EMF) exposure had adverse effects on spatial learning and motor function in rats and if physical activity could diminish the damaging effects of EMF exposure. In this study, we measured anthropometric measurements and brain-derived neurotrophic factor (BDNF) levels in pregnant rats' offspring to determine if Wi-Fi EMF also affected their growth. These data we report for the first time in this publication.Methods. Twenty Albino-Wistar pregnant rats were divided randomly into EMF and control (CON) groups, and after delivery, 12 male fetuses were randomly selected. For assessing the body growth change of offspring beginning at delivery, then at 21 postnatal days, and finally at 56 post-natal days, the crown-rump length of the body was assessed using a digital caliper. Examining BDNF factor levels, an Enzyme-linked immunosorbent assay ELISA kit was taken. Bodyweight was recorded by digital scale.Results. Outcomes of the anthropometric measurements demonstrated that EMF blocked body growth in rats exposed to EMF. The results of the BDNF test illustrated that the BDNF in the EMF liter group was remarkably decreased compared to the CON group. The results indicate that EMF exposure could affect BDNF levels and harm body growth in pregnant rats' offspring.Conclusions. The results suggest that EMF exposure could affect BDNF levels and impair body growth in pregnant rats' offspring. https://doi.org/10.4081/jphia.2023.2347

Excessive whole-body exposure to 28?GHz quasi-millimeter wave induces thermoregulation accompanied by a change in skin blood flow proportion in rats,
IJIMA E., S. KODERA, A. HIRATA, T. HIKAGE, A. MATSUMOTO, T. ISHITAKE and H. MASUDA,
Frontiers in Public Health 11 (Sep 2023),
IntroductionLimited information is available on the biological effects of whole-body exposure to quasi-millimeter waves (qMMW). The aim of the present study was to determine the intensity of exposure to increase body temperature and investigate whether thermoregulation, including changes in skin blood flow, is induced in rats under whole-body exposure to qMMW.MethodsThe backs of conscious rats were extensively exposed to 28 GHz qMMW at absorbed power densities of 0, 122, and 237 W/m2 for 40 minutes. Temperature changes in three regions (dorsal and tail skin, and rectum) and blood flow in the dorsal and tail skin were measured simultaneously using fiber-optic probes.ResultsIntensity-dependent temperature increases were observed in the dorsal skin and the rectum. In addition, skin blood flow was altered in the tail but not in the dorsum, accompanied by an increase in rectal temperature and resulting in an increase in tail skin temperature.DiscussionThese findings suggest that whole-body exposure to qMMW drives thermoregulation to transport and dissipate heat generated on the exposed body surface. Despite the large differences in size and physiology between humans and rats, our findings may be helpful for discussing the operational health-effect thresholds in the standardization of international exposure guidelines. https://doi.org/10.3389/fpubh.2023.1225896

4G mobile phone radiation alters some immunogenic and vascular gene expressions, and gross and microscopic and biochemical parameters in the chick embryo model,
ISLAM M. S., M. M. ISLAM, M. M. RAHMAN and K. ISLAM,
Veterinary Medicine and Science 9, no. 6 (Nov 2023): 2648-2659,
Background: The risks to human health have grown over the past 10 years due to the excessive use of mobile phones. Objectives: The study was designed to determine the harmful effects of 4G mobile phone radiation on the expression of immunogenic and vascular genes and gross, microscopic and biochemical alterations in the development of chicken embryos. Methods: Sixty individuals in the exposure group were subjected to mobile phones with a specific absorption rate of 1.4W/kg and a frequency of 2100 MHz positioned at a distance of 12 cm in the incubator for 60 min/night for 14 days. The histopathological examination involved hematoxylin and eosin staining, whereas cresyl violet staining was used to evaluate the condition and number of neurons in the brain. The biochemical parameters of amniotic fluid were analysed using the photometry method,

and the expression of VEGF-A and immunity genes (AvBD9, IL6) was measured using the real-time PCR (qPCR) technique. Results: Compared to the control, the exposure group's body weight and length significantly decreased ($p < 0.05$). Subcutaneous bleeding was seen in the exposure group. Urea, creatinine, alkaline phosphatase, aspartate aminotransferase and alanine aminotransferase levels were all significantly higher than in the control group ($p < 0.05$). The exposed group showed pathological lesions in the liver and degenerated neurons with lightly stained nuclei in the cerebral cortex. Hyperchromatic neurons were significantly higher in the exposure group (58.8 +/- 2.28) compared to the control (6.6 +/- 0.44) ($p < 0.05$). 4G exposure reduced lymphocyte count in the caecal tonsil (86.8 +/- 5.38) compared to the control (147.2 +/- 9.06) ($p < 0.05$). Vascular gene mRNA expression was higher, but immune gene expression was lower in the exposed group. Conclusion: Exposure to mobile phone radiation may result in gross, microscopic and biochemical changes, as well as alterations in gene expression that could hinder embryonic development.
https://doi.org/10.1002/vms3.1273

Detrimental effects of radiofrequency electromagnetic waves emitted by mobile phones on morphokinetics, oxidative stress, and apoptosis in mouse preimplantation embryos,
KOOHESTANIDEHAGHI Y., M. A. KHALILI, F. FESAHAT, M. SEIFY, E. MANGOLI, S. M. KALANTAR, S. A. NOTTOLA, G. MACCHIARELLI and M. G. PALMERINI,
Environmental Pollution 336 (Nov 2023),
Due to the increasing use of smart mobile phones, the impact of radiofrequency electromagnetic radiation (RFEMR) on reproductive health has become a serious concern. This study investigated the effect of mobile phone RF-EMR with frequency 900-1800 MHZ on the mouse embryo morphokinetics and genotoxic effect in laboratory conditions. After ovarian stimulation in mice, the MII oocytes were collected and underwent by in vitro fertilization (IVF) method. The generated zygotes were divided into control and exposed groups. Then, the zygotes with 30 min of exposure to mobile phone RF-EMR, and the control zygotes without exposure, were incubated in the time-lapse for 5 days. The intracellular reactive oxygen species (ROS) level, morphokinetic, embryo viability rate, and Gene expression were evaluated. Exposure of zygotes to RF-EMR by inducing ROS caused a significant decrease in blastocyst viability (87.85 & PLUSMN; 2.86 versus 94.23 & PLUSMN; 2.44), delay in cleavage development (t3-t12) and also increased the time (in hours) to reach the blastocyst stage (97.44 & PLUSMN; 5.21 versus 92.56 & PLUSMN; 6.7) compared to the control group. A significant increase observed in mRNA levels of Hsp70 in exposed animals; while Sod gene expression showed a significant down-regulation in this group compared to the controls, respectively. However, there was no significant change in the transcript level of proapoptotic and antiapoptotic genes in embryos of the exposed group compared to the controls. RF-EMR emitted by mobile phone with a frequency of 900-1800 MHZ, through inducing the production of ROS and oxidative stress, could negatively affect the growth and development as well as the transcript levels of oxidative stress associated genes in the preimplantation embryos of mice.
https://doi.org/10.1016/j.envpol.2023.122411

Impact of GSM-EMW exposure on the markers of oxidative stress in fetal rat liver,
SALAMEH M., S. ZEITOUN-GHANDOUR, L. SABRA, A. DAHER, M. KHALIL and W. H. JOUMAA,
Scientific Reports 13, no. 1 (Oct 2023),
The current study investigated the effects of 24 h/day prenatal exposure to global system for mobile communication electromagnetic fields (GSM-EMFs), 900 MHZ-induced electromagnetic radiation (EMR), on oxidative stress (OS) status, apoptotic, and inflammatory changes in liver of rats during their fetal development period. Fifty-two Sprague-Dawley pregnant rats were equally divided into control and exposed groups. Whole embryos were removed at 7.5 dpc (days post coitus), while liver tissues were extracted from embryos at 11.5, 15.5, and 19.5 dpc. For exposed animals, results showed an increased OS reflected by high levels of malondialdehyde (MDA), a

decrease in cytosolic superoxide dismutase (cytoSOD) activity, in mitochondrial superoxide dismutase (mitoSOD) levels and catalase (CAT) mRNA expression but also in hepatic nuclear factor erythroid 2-related Factor 2 (Nrf-2), protein kinase B (Akt1), and intercellular adhesion molecule-1 (ICAM-1) mRNA expression at 15.5 dpc. Moreover, GSM-EMR exposure was shown to significantly decrease mitoSOD and CAT activities at almost all studied ages. Thus, rat embryos may be protected by their mothers from OS, apoptotic, and pro-inflammatory responses till a sensitive developmental stage, during a continuous prenatal EMR exposure. This protection could be then created from the embryos themselves. https://doi.org/10.1038/s41598-023-44814-z

Protective effect of juglone on electric field-induced apoptosis and inflammation in liver and kidney tissue in rats,
SENOL N., M. SAHIN and U. SAHIN,
Research in Veterinary Science 164 (Nov 2023),
Electric field (EF) has been shown to cause tissue damage mainly through oxidative stress, inflammation, and apoptosis. Thus, juglone (5-hydroxy-1,4-naphthoquinone) (JUG), which has antioxidant and antiapoptotic properties, is thought to be effective against electric field-induced damage. We aimed to investigate whether 50 Hz alternating current (AC) triggers inflammation and apoptosis in rat liver and kidney tissues and evaluate the JUG supplement's estimated protective effect.Twenty-four adult male wistar albino rats were divided into control, EF and EF + JUG groups, each containing eight rats. The EF and EF + JUG groups were exposed to EF while no EF exposure and JUG were applied to the control group. At the end of the experiment, liver and kidney tissues were collected for histological (H&E, caspase-3 and TNF-alpha for immunohistochemical staining), and genetics (SOCS, caspase-3 and TNF-alpha, PCR analyses). After routine histological procedures, sections stained with H&E showed significant changes in liver and kidney tissues in the EF group compared to the control group ($p < 0.05$). Significant protective effects were observed in the building volumes and histopathology in the EF + JUG group ($p < 0.05$). Our gene expression results increased the expression of caspase-3 and TNF-alpha in the EF group ($p < 0.001$). Juglone increased SOCS expression ($p < 0.001$). These findings were consistent with the anti-apoptotic and anti-inflammatory effects of JUG treatment. We reasoned that exposure to EF damaged rat liver and kidney tissues and administration of JUG alleviated the complications caused by 50 Hz EF.
https://doi.org/10.1016/j.rvsc.2023.104987

Effects of 0.4 T, 3.0 T and 9.4 T static magnetic fields on development, behaviour and immune response in zebrafish (Danio rerio),
TANG L. S., C. Z. QIU, H. Y. ZHANG and D. L. REN,
Neuroimage 282 (Nov 2023),
Magnetic Resonance Imaging (MRI) is widely applied in medical diagnosis due to its excellent non-invasiveness. With the increasing intensity of static magnetic field (SMF), the safety assessment of MRI has been ongoing. In this study, zebrafish larvae were exposed to SMFs of 0.4, 3.0, and 9.4 T for 2 h (h), and we found that there was no significant difference in the number of spontaneous tail swings, heart rate, and body length of zebrafish larvae in the treatment groups. The expression of development-related genes shha, pygo1, mylz3 and runx2b in the three SMF groups was almost not significantly different from the control group. Behavior tests unveiled a notable reduction in both the average speed and duration of high-speed movements in zebrafish larvae across all three SMF groups. In addition, the 0.4 and 3.0 T SMFs increased the migration of neutrophils in caudal fin injury, and the expression of pro-inflammatory cytokines was also increased. To explore the mechanism of SMFs on zebrafish immune function, this study utilized aanat2-/-mutant fish to demonstrate the effect of melatonin (MT) involvement in SMFs on zebrafish immune function. This study provides experimental data for understanding the effects of SMFs on organisms, and also

provides a new insight for exploring the relationship between magnetic fields and immune function. https://doi.org/10.1016/j.neuroimage.2023.120398

Brain-implanted conductors amplify radiofrequency fields in rodents: Advantages and risks, VÖRÖSLAKOS M., O. YAGHMAZADEH, L. ALON, D. K. SODICKSON and G. BUZSÁKI, *Bioelectromagnetics* (2023 Oct 2023),
Over the past few decades, daily exposure to radiofrequency (RF) fields has been increasing due to the rapid development of wireless and medical imaging technologies. Under extreme circumstances, exposure to very strong RF energy can lead to heating of body tissue, even resulting in tissue injury. The presence of implanted devices, moreover, can amplify RF effects on surrounding tissue. Therefore, it is important to understand the interactions of RF fields with tissue in the presence of implants, in order to establish appropriate wireless safety protocols, and also to extend the benefits of medical imaging to increasing numbers of people with implanted medical devices. This study explored the neurological effects of RF exposure in rodents implanted with neuronal recording electrodes. We exposed freely moving and anesthetized rats and mice to 950 MHz RF energy while monitoring their brain activity, temperature, and behavior. We found that RF exposure could induce fast onset firing of single neurons without heat injury. In addition, brain implants enhanced the effect of RF stimulation resulting in reversible behavioral changes. Using an optical temperature measurement system, we found greater than tenfold increase in brain temperature in the vicinity of the implant. On the one hand, our results underline the importance of careful safety assessment for brain-implanted devices, but on the other hand, we also show that metal implants may be used for neurostimulation if brain temperature can be kept within safe limits. https://doi.org/10.1002/bem.22489