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Review Article

Constructing a Tropical Acoustic Exposimeter with Regard to Technological Issues and Compact Exposimeter Gadget for such Measurement and Monitoring of Electromagnetic Radiation from 78 MHz to 6 GHz in Multiple Wide Zones (300 kHz)

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Abstract

The design of a tropical acoustic exposimeter utilising the strain gauge concept involves a vast amount of technical concerns. The design parameters must be carefully chosen, and modelling must be done in a way that results in a robust, affordable, portable, and sensitive device that is equivalent to existing designs. We have made an effort to modify popular radiation force balancing schemes to account for factors unique to tropical environments. Our research has shown significant differences in the specifications for an ideal liquid medium, the physical and isotropic characteristics of cantilever materials, the selection of target angle and material, as well as accurate electrical circuitry (Anson LW et al., 1981). As innovative adaptations for a prospective tropical model, it has been proposed to treat water with sodium aluminium sulphate, utilise polystyrene and duraluminum as cantilever materials, and carefully choose and attach the strain gauges. We sought to design an experimental model by utilising the technical concerns stated in this study, drawing on the expertise of other writers, and making exact alterations to the construction of appropriate cantilever arms. Our design has sensitivity of 2.13mV/watt and 1.47mV/watt correspondingly using cantilever arms manufactured of locally accessible materials, namely polystyrene and duraluminum with dimensions of 100 x 5 x 0.6mm and 100 x 5 x 0.6mm. With detection threshold of 128mW and a power range of roughly 6.1watts for both arms. Our system offers possibilities for a successful design of an acoustic exposimeter for use in tropical environments, especially with minor adjustments to the electrical circuitry and the use of locally accessible materials like polystyrene and duraluminium (Perkins MA 1989).

In order to measure the full communications spectrum and identify multiple sources of electromagnetic fields using the same communications band, a novel, compact device with spectrum analyzer characteristics has been developed. The device can record the entire spectrum from 78 MHz to 6 GHz and measure the maximum power received in multiple narrow frequency bands of 300 kHz. The suggested device enables the assessment of the cross-talk effect, which leads to inaccurate electromagnetic field estimates in traditional exposimeters. The instrument was tested against a portable spectrum analyzer in a residential area after being calibrated for far-fields in an anechoic room. A substantial connection between the two devices was discovered, and a confidence level greater than 95% was attained; this suggested that the device would be useful for studying electromagnetic fields (Phillips JL et al., 2009).

Keywords: Technical considerations, Design, Strain-gauge, Acoustic exposimeter, Cantilever arms, Exposimeter, Electromagnetic fields, Power density, Radiofrequency

INTRODUCTION

The use of diagnostic ultrasonography is widespread in almost all areas of clinical medicine, including obstetrics and gynaecology, gastrointestinal, nephrology, and paediatrics. Ultrasound has been widely accepted in Nigeria, where it is often used in a variety of contexts, such as obstetric and radiology departments, ultrasound and diagnostic clinics, private doctors' offices, and even veterinary facilities. As a result, Nigeria has seen a significant increase in the sale of new and used ultrasound devices. To the best of our knowledge, there are no records of the exposimetry of diagnostic ultrasonography probes in Nigeria or the tropics, despite the surveys of acoustic diagnostic probes that have been reported by a number of writers. Without the development of acoustic exposimeters especially suited for usage in tropical environments, this would also be challenging (Hardell L et al., 2013).

No attempts have been made to construct tropical designs, despite the fact that there are a number of acoustic exposimeter designs in the literature that take the form of radiation force detectors. In theory, the sensitivity of these earlier designs may fluctuate owing to changes in ambient temperature and environmental factors, necessitating a design that can withstand the somewhat higher temperatures that are expected to be seen in the tropics (Ruediger HW 2009).

The authors' goal was to examine current design issues and highlight distinctive technological changes required for the strain gauge-based modelling of a tropical acoustic exposimeter. The strain-gauge idea is the foundation of the acoustic exposimeter, a radiation force detector. It is based on the discovery that the vector force related to radiation pressure from an ultrasonic field is independent of ultrasonic frequency and proportional to ultrasonic power. A passive transducer that detects the variation in resistance of an electric conductor in response to a change in its geometry is the strain gauge. It precisely measures the induced strain. A length of material that acts as a cantilever arm has the strain gauge connected to it. The latter is fixed to a target that receives the radiation force produced by an ultrasonic beam by acting as a receptor (Morgan LL et al., 2015).

The cantilever arm, which is already laced with strain gauges, is subjected to this force, which results in a deflection and strain throughout the length of the arm. As a result, the strain is passed to the associated strain gauge, where it results in a resistance R. Using a Wheatstone bridge circuit, the resistance is changed from a resistance to a voltage change V. A straightforward voltmeter may be used to read the resulting voltage change. The gauge's resistance R, which in turn is proportional to the ultrasonic power being measured, determines how the voltage changes. The entire apparatus is set within a suitable container filled with liquid media. Our design is based on the aforementioned notion (Johansson O 2009).

The population is being subjected to non-ionizing electromagnetic fields in the radio frequency range (RF-EMF), which ranges between 100 kHz to 300 GHz. These frequencies are associated with wireless technologies like Wifi, mobile phones, television, radio, etc.

According to global figures compiled by the International Telecommunication Union (ITU) between 2001 and 2018, the usage of wireless technologies has been steadily increasing, raising concerns in society about potential health impacts related to RF-EMF exposures (Bhatt CR et al., 2016).

The regulating bodies set radiation limits in accordance with the recommendations of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which only take into account so-called thermal effects. The criteria used by the regulatory bodies are the maximum rate of radiation and Specific Absorption Rate (SAR), which is a measurement of the maximum RF-EMF power absorbed by living tissue.

However, according to ICNIRP, the effects that may be regarded as non-thermal are not supported by the scientific data. The ICNIRP's recommendations set the maximum radiation levels at 450 W/cm2. However, the BioInitiative working group and other researchers contend that unfavourable health impacts can be seen at exposure levels as low as 0.1 W/cm2. Studies indicate that RF-EMF exposures with powers below the ICNIRP recommendations have effects related to changes in brain activity, affecting cognition and motor function, infertility issues in the male reproductive system, DNA damage, association with various brain tumours, and intensity of RF-EMF, and having a greater effect in children and teenagers than in adults. These findings imply that RF-EMF exposure should be taken into account as a "possible carcinogen," which the International Agency for Research on Cancer has placed in category 2B. (IARC). On the other hand, they advise that RF-EMF exposures should be classified by the IARC as "probably carcinogenic" using the same evaluation standards (Lucas-Lenard JEAN et al., 1971).

Due to the potential negative health implications of ongoing exposure to these electromagnetic fields, it is more concerning that the population's exposure to RF-EMF radiation remains unknown. Utilizing devices that enable the detection and characterisation of RF-EMF, such as spectrum analyzers and exposimeters, is the current answer to this issue. The measurements made with a spectrum analyzer are the most suitable for the characterization of RF-EMF because they are made continuously, allowing the power intensity to be measured and discriminating between each frequency corresponding to the RF-EMF emission sources. This is in accordance with the criteria of the International Telecommunication Union (ITU). The usage of exposimeters is seen to be the best alternative despite the fact that it is a costly approach and also requires professionals for the proper use and interpretation of the equipment's data. Broadband measurements made by various exposimeters prevent accurate frequency discrimination and, as a result, the accurate identification of the RF-EMF emission sources. It is obvious that the general public needs access to a small, inexpensive expometer that can monitor the peak-to-peak maximum electromagnetic radiation levels of the entire radioelectric spectrum in a number of precise frequency bands in order to distinguish between various sources using the same telecommunications band (Lengyel P et al., 1969).

CONCLUSION

Without sacrificing the benefits of traditional exposimeters, a small exposimeter system has been presented. This system can be an effective instrument for electromagnetic field investigations that assess a far-field. The proposed exposimeter has passed the testing phase when compared with spectrum analyzers with a significant factor of 0.948 for Student's t-test and a correlation factor of 0.9682 between the measurements of both devices. It measures the received power in the spectrum between 78 MHz and 6 GHz with a resolution bandwidth of 300 KHz, measuring roughly 19,500 narrow bands. The suggested exposimeter has a lower sensitivity to fluctuations in electromagnetic fields since it takes one second to measure the whole radioelectric spectrum. By limiting the measurements to the relevant communication bands, this might be made better, but then data from the remainder of the radio spectrum would be lost. It is crucial to specify the link between the measurement of the communication bands and the sensitivity to changes in the electromagnetic field over time. In next study, it is anticipated that some of the suggested devices would be employed in electromagnetic field surveys to cover residential areas and offer data as an electromagnetic field sensor network to be used in the deployed area's epidemiological investigations.

A tropical acoustic exposimeter has several complex technological requirements. The design parameters must be carefully chosen, and the modelling must be carried out to develop a robust, affordable, portable, and sensitive device that is equivalent to existing designs. Our research has highlighted significant differences in the specifications for an ideal liquid medium, the physical and isotropic characteristics of the cantilever materials, and the selection of target angle. The employment of customised electrical circuitry (wheatstone bridge design), careful selection of strain gauges with tropical adaptability, and different improvements to cantilever design—all while building on the expertise of earlier authors—are of the utmost significance. We have made an attempt to create an experimental model using the technical issues discussed in this work, with positive results. We think that the groundwork has been done to properly develop and then simulate a tropical acoustic exposimeter.

The ICNIRP rules were not adhered to in this investigation, which relied on measurements of maximum received power levels (not the average). The BioInitiative working group and other researchers suggest that adverse health effects are observed at low levels of exposure and that using the SAR criterion alone is not the most appropriate method for this purpose because the non-thermal effects are not taken into account in the establishment of the exposure limits. Because their resolution bandwidth is determined by the entire desired frequency band to be measured, conventional exposimeters are not suitable for differentiating between multiple electromagnetic field sources, preventing the detection of the sources that contribute the most electromagnetic fields. When energy peaks are found, it is thought that the biological consequences of extended RF radiation exposure will become more pronounced. The suggested technology complies with the ICNIRP mandate to measure the full radioelectric spectrum in less than one second. The switching between each fractal antenna takes 901.29 ms, and it has no effect on the observations in terms of delay or uncertainty. However, as shown in Table 6, the sweeping time could be what caused the variations in the power measurements between the spectrum analyzer and the suggested exposimeter. On the other hand, limiting measurements to the base station's communication bands will greatly enhance the sample rate and produce a more accurate estimate of the received power. The remaining radioelectric spectrum may lose information, though. Conventional exposimeters may measure up to 20 frequency bands, thus the sweeping time is a highly important topic.

The frequency ranges that fall within the recorded maximum power ranges. Demonstrating that there is a strong connection at each point of measurement. The spectrum analyzer's and the suggested exposimeter's various resolution bandwidths, however, are to blame for certain frequency disparities. The designed system measures the entire radioelectric spectrum in multiple narrow bands (300 kHz), allowing the identification of various sources of electromagnetic fields, even within the same communications band. For instance, if there are two slots occupied in the same frequency band, the proposed expometer will be able to detect both sources, and it will also provide information of the rest of the spectrum in order to detect the cross-talk effect, which in conventional systems results in interference between the sources.

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