COMPRATIVE STUDY OF DIELETRIC PROPERTIES OF HEALTHY AND MALIGNANT TISSUES OF BREAST FANTOM

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ABSTRACT:-
During the last decade it has been well documented that there is variation in the dielectric properties of the healthy part and the malignant part of the human body. However, there has been no intensive study of dielectric properties of human colon tissue which is being one of the most common types of breast tumour. In order to provide information regarding this matter, the dielectric characterization of healthy and malignant tissues can give vital information about different diseases related to tumours in different parts of human bodies. It is found that, there is difference in the dielectric constants of the healthy tissues and the malignant tissues which depends on the degree of malignancy as well as the frequency of incident radiation used for probation. Findings may have a potential application in early-stage tumour detection and its diagnosis. Electromagnetic models of healthy and cancerous tissues would also be very helpful for studying the problems.

KEY WORD:-
Dielectric constant, human tissue, malignant tissue, micro wave, electromagnetic models

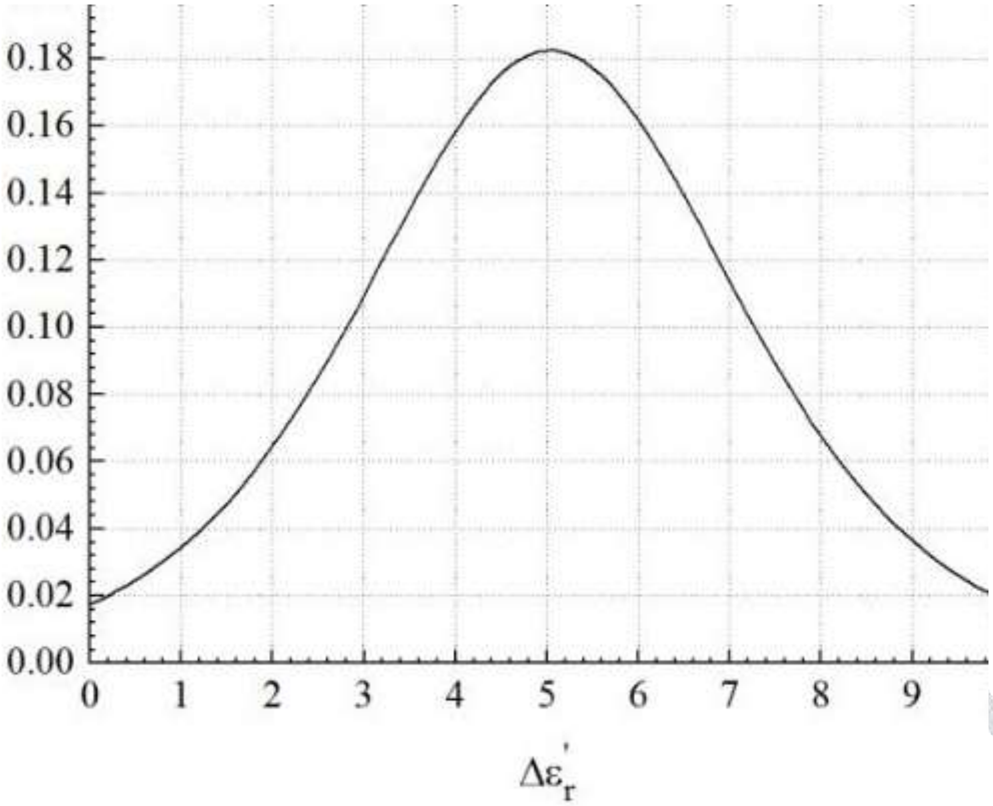
INTRODUCTION:-
Tumour has become a worldwide health problem for people of all ages in the world. Tumour has become the second most common disease in women and the third in men [1]. The early detection of this kind of tumour is crucial in order to reduce its mortality rate. Microwave techniques have been explored for tumour detection of tissues as well as for treatment procedures. In the past decades, a great number of researchers have given their contribution for the study of the interactions between biological matter and electromagnetic waves. It was discovered that malignant and healthy tissues have different interaction with microwave because proteins acquire more surface charges in malignant tumours. The attraction of these charges for water molecules results in the presence of more "bound water" [2]. It has been found that, dramatic changes take places in metabolism and adhesion properties of tumour cells. This results in the modification of the number of membrane proteins [2, 5].

It is well documented that, the absorption rate in malignant tissues is greater than that of the healthy tissues [3]. Hence, tissues characterization in terms of their electromagnetic properties (permittivity and conductivity) is crucial to determine their different absorption rates. The knowledge of these properties can be useful for the development of medical applications such as hyperthermia [4], as well as an aid in the design of devices for microwave imaging. This technique is based on the contrast in dielectric properties between a cancerous tissue and the normal cells that surrounds it. Thus, previous knowledge of the dielectric properties of the different tissues is crucial for the design of devices. An antenna conceived to detect malignant breast tissue with this method is tested in a phantom that was developed by using previously reported tissue properties [6].

Many studies evaluating these properties have been presented. The first works were mostly performed over animal tissues since their electromagnetic properties are similar to their analogous human tissues. Some tissues were measured from 2 to 4 GHz over bovine specimens [7]. Healthy and malignant canine tissues were studied to relate their dielectric properties to water content [8]. The basic concepts of dielectric phenomena in biological tissues have compiled the results of many previous works [9]. A huge quantity of healthy animal tissues was electromagnetically characterized up to 20 GHz [10]. Besides, the dependence of the dielectric properties of tissues with temperature and time was analysed over bovine liver tissue [11]. Normal and the malignant human tissue samples were measured in the 50 - 900 MHz frequency band, showing that, the electromagnetic properties of malignant tissues had larger values than those from healthy ones [12].

The colon tissue has already been addressed in a few reports. Healthy and malignant human colon tissues have been reported to be measured up to 900 MHz only [12]. Normal and malignant colon tissues were cultivated using the xenograft model and measured up to 5 GHz, without presenting fitting parameters [13].The dielectric analysis is performed using the open- ended coaxial technique, which has been used by most of the studies that present electromagnetic properties of biological tissues. This method has been used in different areas, such as chemical mixture, concrete and moisture characterization etc. [14, 15, 16]

GRAPHICAL STUDY OF PROBABILITY DENSITY FUNCTION:-Statistics of the difference in dielectric constant between the healthy and the malignant tissue from the same patient: Probability distribution at 2.45 GHz.



A Kolmogorov- Smirnov test has been performed at each frequency testing several distribution functions in order to characterize the kind of distribution that better fits the difference between tissues of the same patient. The test has shown that the logistic distribution is the one that better fits this difference at most frequencies. The difference at 2.45 GHz, a logistic distribution of mean μ =5.04and a scale parameter s = 1.369

CONCLUSION:-

The dielectric constant of malignant tissue and that of the healthy tissue have been analysed over the full band of microwave frequencies. It has been observed that the dielectric constant of the malignant tissues is higher than that of the healthy one. This difference is even higher at frequencies below 4GHz.

Regarding the conductivity, the relative difference has a similar behaviour, despite that the absolute differences are much lower than in dielectric constant. From the data available in the literature it is found that, the within-patient analysis has shown greater dielectric constants from malignant tissues when compared to healthy tissues, with significant differences that appear systematically at lower end of microwave frequency band. From the graph of Probability Density Function, it is found that the difference at 2.45 GHz, a logistic distribution of mean μ=5.04 and a scale parameter s = 1.369

These results have a potential application in cancer detection and diagnosis, and can be useful in order to develop new diagnosis devices, tools for hyperthermia treatments and to create electromagnetic models of healthy and malignant colon tissues.

REFERENCES:-

(01) Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012 Int. J. Cancer 136- Ferlay J, Soerjomataram I, Dikshit R, Eser S, Mathers C, Rebelo M, Parkin D M, Forman D and Bray F, E359–86; 2014

(02) 2005 Non-invasive detection of prostate cancer by electromagnetic interaction Eur. Urol. 47- Bellorofonte C, Vedruccio C, Tombolini P, Ruoppolo M and Tubaro A 29–37; 2005

(03) Frequency-dependent absorption of electromagnetic energy in biological tissue IEEE Trans. Biomed. Eng. 31- Joines W T, 17–20; 1984

(04) Interstitial microwave hyperthermia treatment investigations J. Phys. Conf. Ser.395- Siauve N and Lormel C, 012001; 2012
(05) Non-invasive radiofrequency diagnostics of cancer. The Bioscanner-Trimprob technology and clinical applications J. Phys. Conf. Ser. 329- Vedruccio C and Vedruccio C R, 012038; 2011
(06) A single antenna based microwave system for breast cancer detection: Experimental results 2013 Loughborough Antennas and Propagation Conference, LAPC 2013(IEEE)- Zhang H, Arslan T and Flynn B, p.- 477–81; 2013
(07) Dielectric behavior of selected animal tissues in vitro at frequencies from 2 to 4 GHz IEEE Trans. Biomed. Eng. 28- Brady M M, Symons S A and Stuchly S S, 305–7; 1981
(08) Dielectric properties of tumor and normal tissues at radio through microwave frequencies J. Microwave Power, 16- Foster K R and Schepps J L, 107–19; 1981
(09) The dielectric properties of biological tissues:III. Parametric models for the dielectric spectrum of tissues, Physics Med. Biol. 41- Gabriel S, Lau R W and Gabriel C, 2271–93; 1996
(10) Compilation of the dielectric properties of body tissues at RF and M. W. frequencies Technical Report AL/OE-TR-1996-0037 Armstrong Laboratory, Brooks Air Force Base- Gabriel C, 1996a / The dielectric properties of biological tissues: I. Literature survey Phys. Med. Biol. 41- Gabriel C, Gabriel S and Corthout E, 2231–49; 1996
(11) Changes in dielectric properties of ex vivo bovine liver at 915 MHz during heating Phys. Med. Biol.461- Chin L and Sherar M, 97–211; 2001
(12) The measured electrical properties of normal and malignant human tissues from 50 to 900 MHz Med. Phys. 21- Joines W T, Zhang Y, Li C and Jirtle R L, 547–50; 1994
(13) The dielectric properties of cancerous tissues in a nude mouse xenograft model Bioelectromagnetics 25- Yoo D S, 492–7; 2004
(14) Non-invasive electrical characterization of materials at Microwave Freq. using an Open-ended Coaxial Line- A Microwave Theory Tech. 38- Misra D, Chabbra M, Epstein B R, Microtznik M and Foster K R, 8–14; 1990
(15) Design and calibration of a large open-ended coaxial probe for the measurement of the dielectric properties of concrete IEEE Trans. Microw. Theory Tech. 56- Filali B, Boone F, Rhazi J and Ballivy G, 2322–8; 2008
(16) Complex permittivity and moisture measurements of oil palm fruits using an open-ended coaxial sensor IEEE Sensors Journal 5- Abbas Z, You Kok Yeow, Shaari A H, Khalid K, Hassan J and Saion E, 1281-7; 2005

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