Investigations on the Effects of Electromagnetic Radiation on Indian Flora

Abstract

With the widespread deployment of wireless communication infrastructure, electromagnetic radiation is steadily increasing in the open environment over multiple frequency bands – in fact, electromagnetic radiation is omnipresent all around the globe. Presence of enormous water and ion substances in the majority of living tissues contributes to reasonably high permittivity (ε_r') and electrical conductivity (σ). Therefore, biological objects are quite capable of absorbing electromagnetic energy over wide frequency spectrum. Till date, scientists and researchers have majorly investigated electromagnetic energy absorption rates in several human models along with associated biological effects – however, similar investigations on prototyped fruit and plant models are rarely available. Furthermore, all existing global and national electromagnetic exposure regulatory standards have been prescribed entirely based on immediate thermal effects of electromagnetic radiation on humans. As a consequence, prescribed reference power density and Specific Absorption Rate (SAR) limits have been set only for humans. However, arguments can be put to investigate SAR values for fruit, flower and plant structures as those get exposed to uninterrupted electromagnetic radiation at multiple frequencies from the radiating antennas. Besides, higher surface-to-volume ratio of plant structures makes increased interaction with incident electromagnetic field possible. Therefore, in addition to investigating SAR data and spatial distributions, periodic (long duration) as well as one-time (hours long) electromagnetic irradiation induced plant responses should also be investigated at physiological and molecular levels. This thesis entitled "**Investigations on the Effects of Electromagnetic Radiation on Indian Flora**" aims at such investigations of complex dielectric properties (ε_r) of fruit and plant tissues, SAR distributions in prototyped fruit and plant models, tissue equivalent phantom liquids for SAR measurement, and periodic (long duration) as well as one-time (hours long) electromagnetic irradiation induced physiological and molecular responses in plants. In this thesis, a chapter is dedicated to the fundamental concepts of material dielectric properties (ε_r)

and broadband dielectric properties (ε_r) characterization of fruit and plant tissue specimens. Furthermore, a novel technique to determine multi-tissue layers equivalent homogeneous phantom liquid formulation (for practical SAR measurement) has also been discussed in the same chapter. SAR data and associated spatial distributions in several tropical fruit models have been demonstrated in the next chapter. The dependence of SAR data and spatial distributions in fruit and plant models on electromagnetic exposure regulatory guidelines, frequency of operation, angle of incidence and wave polarization has also been demonstrated. Reported findings indicate towards the necessity of harmonizing global and national electromagnetic exposure regulatory standards worldwide. The following chapter covers fruit and plant tissue equivalent homogeneous phantom liquid preparation for performing practical SAR measurement in future. Custom-made phantom liquid recipes have been prepared for twenty fruit and plant tissue layers at 947.50 MHz, 1842.50 MHz and 2450.00 MHz. In this thesis, the subsequent chapters by and large report induced plant responses under electromagnetic irradiation. The immediate next chapter covers investigations on electromagnetic propagation loss due to presence of plants inside an anechoic chamber and initial plant responses under long duration cell phone radiation. Being motivated by the initial plant responses, further investigations have been carried out to investigate periodic (long duration) as well as one-time (hours long), controlled and deterministic electromagnetic irradiation induced physiological and molecular plant responses in two subsequent chapters. Periodic electromagnetic irradiation (1837.50 MHz, 2.75 mW/m^2) induced physiological and molecular responses have been investigated in two rice variants (*Oryza sativa*) at different growth stages – inside a simple electromagnetic reverberation chamber. Reduced rice seed germination rate, photosynthetic pigment concentration levels and upregulated stress-sensitive gene expressions were noted under the periodic electromagnetic irradiation. Furthermore, investigations have been conducted to examine molecular responses in rice plants following one-time electromagnetic irradiation for 2 h 30 min. Transcript accumulations of selected stress-sensitive genes have been noted even following this one-time electromagnetic irradiation. Thus, reported findings indicate that plants in general perceive electromagnetic irradiation as an abiotic stress. Reported outcome in this thesis can lead to potential planning for minimizing electromagnetic energy absorption in fruits and plants along with associated biological effects without compromising sustainable telecommunication development.