Contribution ID: **126** Contribution code: **S1 Physics Innovation** Type: **Poster Presentation**

Measurement and analysis of sound frequencies in beehive with smart electronic sensor systems for health status monitoring and specific behavioral study from native bees (Apis cerana Fabricius, 1758) for non-migratory beekeeping in the safe agricultural area

Bees are well known as social insects with divisions of labor. In a dark beehive, it was long thought that communication within the hive was based on chemical signals. However, specific sound signals have been identified, and science is beginning to decode what the bees are signaling in the beehive. This work has developed a sound frequency monitoring system from native bees (*Apis cerana Fabricius, 1758*) based on the Arduino board and NB-IoT module. Sound samples have been acquired using mini microphones and placed inside the beehive with some environmental parameters acquisition, such as temperature and humidity at the same time. The signal voltage in the time domain was received and converted to the frequency domain using a fast Fourier transform (FFT) and sent data to cloud storage every minute for a week. The range frequencies of the acoustic signals produced by a honey bee colony are in the range of 10 to 1 kHz. The first (1^{st}), second (2^{nd}), and third (3^{rd}) frequencies of sound have been studied. However, most of the sound frequencies may change with time, temperature, and humidity, probably owing to specific behavior. Finally, the sound produced by ventilating workers as a function of the period time, temperature, and moisture has been identified. As a result, this intelligent electronic sensor system could be potentially applied for health status monitoring for non-migratory beekeeping on farms.

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Session Classification: Poster: S1 Physics innovation

Track Classification: Physics Innovation