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The Effect of Cell Phone Antennas' Radiations on the Life Cycle of Honeybees

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Abstract— **As many other species, honeybees are becoming extinct in the world; this phenomenon is called the Colony Collapse Disorder. Many reasons have been proven to be behind this environmental disaster like climate changes, pesticides, fungal pathogens and others; especially, since in recent years wild life has been exposed to microwaves and radio frequencies radiation signals from various sources, including wireless phones. The claim of the research is that radiations generated by mobile phones' antennas disturb the life cycle of honeybees and affect their reproduction system and honey producing. The research involves testing the behavior of honeybees in the main lobe of the antenna at a distance of 100 meters, and another at a distance of 500 meters; and, in the back lobe of the antenna at a distance of 100 meters, knowing that the antenna is directional. The results of the experiments verified that mobile phones' antennas' radiations affect the honeybees' life system.**

Keywords: Honeybees; Mobile phone antennas' Radiatios; Colony collapse Disorder; Antenna's Patterns, Power density, main lobe, back lobe.

I. Introduction

Honey bees are sometimes called social insects; this is due to the fact that they live in colonies and they divide the jobs inside the hive among themselves. The bees' life cycle is a complex process in which a good communication is needed among them in order to survive as a whole colony [1].

Bees have different ways of communications to share information; for example, bees dance in a certain way to communicate the specific location of good food sources [2].

The claim in this research is that the radiations emitted by mobile phones antennas are possibly the reason behind a great natural disaster: the disappearance of honeybees all over the world. The mobile phones' antennas' radiations disturb the bees' navigational system, leaving them unable to find their way back to the colony; this phenomenon will lead to problems in their reproduction system, and eventually will lead to their death. This research is a complementary process to a previous paper called "The effect of cell phones radiations on the life cycle of honeybees", which has been published in July 2013 in proceeding of IEEE EUROCON 2013. It studies the effect of cell phones' radiations on the life cycle of honeybees and demonstrates that mobile phones affect honeybees' life system [3].

This project has great significance because honeybees are a very important part of the ecological system since they pollinate 80% of the flowering plants, which makes up the 1/3 of what humans eat. Pertaining to this issue, Albert Einstein predicted that if something eliminates the bees from our planet, mankind would soon perish.

The effects of colony collapse disorder can be economically significant as well since the food and agriculture industry could lose billions of dollars.

II. Background Information

A. Disapperance of honey bees

As of 1972, beekeepers started to notice that the number of honeybees is decreasing more and more; losses differ from country to country and from region to region inside the same country. During winter 2012-2013, in the south-west of England, more than 50% of honeybees' colonies perished, and in the northern part of the country 46.4% perished; on average, 33.8% of the colonies around the country did not survive. In Scotland, the Scottish Beekeepers Association predicted the loss of up to 50% of the hives during the winter of 2012-2013 [4].

The Colony Collapse Progress report, prepared by the United States Department of Agriculture (USDA) in June 2012, presents a survey of beekeepers throughout the US; this survey was conducted by the Apiary Inspectors of America and ARS, with additional assistance from the Bee Informed Partnership. The survey showed that the average loss of colonies reached 22% for winter 2011-2012; however, the losses reached 31% in late 2012 and early 2013 [5].

In Canada, the average level of losses of honeybees' colonies in the winter of 2012-2013 reached 28.6%, according to the Canadian Association of Professional Apiculturists (CAPA) national survey 2013 [6].

In Lebanon, the case is not better. In September 05, 2011, an article about honeybees' losses in Lebanon appeared in the print edition of the Daily Star; it described the catastrophic state of honeybees; the author claimed that beekeepers could discover that 20 to 80% of their bees have vanished; a fact that made the Lebanese beekeepers feel the sting as hives collapsed [7].

B. Existing Work

The topic discussed in this paper was researched in some other studies but from a different angle. They didn't analyze the buzzing sounds produced by bees when exposed to mobile phones' radiations, or study the effect of mobile phones' antenna's radiations on the life cycle of honeybees.

Sharmal and Kumar studied the effect of mobile phones on honeybees by taking into consideration the following measures: brood area, queen prolificacy, foraging which includes flight activity, pollen foraging efficiency, returning ability, and finally the colony growth, which includes bees' strength, honey stores and pollen storage [8].

The results showed that the total bees' strength, the brood area, as well as the number of eggs laid, decreased due to the exposure. Moreover, the number of bees leaving and returning to the hive decreased; consequently, the total number of bees holding pollen also decreased, so did the pollen area, the nectar area and the honey storing ability [8].

In a research on the impact of mobile phones on the density of honeybees, Sahib [9] related the decline in bees' population in India to mobile phones' radiations. To demonstrate his hypothesis, the author introduced the test colonies to mobile phones' radiations of 900 MHz frequency, for 10 minutes, for ten days. He studied the bees' life cycle by observing the productivity of bees in terms of laying of eggs, flight activity, and the returning ability; i.e., the number of the bees leaving and returning back to the hive per minute, before, during and after the exposure [9].

After ten days of mobile phone's radiation exposure, the bees of the colonies under testing did not return back to the hive, and the bees' strength was reduced. In addition, the productivity of queens was reduced as compared to those of the queens of the control colonies: in the test colonies bees produced fewer eggs [9].

Mixson et al. [10] did four experiments to study the effect of mobile phones on honeybees. In the first experiment, the proboscis extension response of honeybees was studied after exposing them to mobile phone's radiations; this experiment showed that there was no effect due to GSM radiations exposure [10].

The second experiment was to study the feeding ability of bees exposed to mobile phone's radiations; the experiment showed that these radiations had no effect on the feeding ability of bees [10].

The third experiment was to study the effect of the same radiations on the flight navigation activity of forager bees. The authors said that similarly to the previous experiments, the third experiment showed that mobile phone's radiations had no effect on the bees' ability to return back to a food source that they were previously trained to visit [10].

The last experiment was to study the effect of GSM radiations on the aggression of bees. The authors said that the radiations generated by mobile phones did not increase the aggression of the bees [10].

The authors concluded that: if mobile phone's radiations affect honeybees' behavior, it should have been apparent during the experiments. Moreover, they saw that the decline in honeybees' population might have been due to reasons other than GSM radiations, like biological pathogens, agrochemicals, climate change, and genetically modified crops [10].

It is clearly noticed that the previous researchers did not take into consideration the sounds that are naturally produced by bees; as such, this study tackles the behavior of honeybees and their response to mobile phones' radiations as studied through sounds produced by bees in all modes of the mobile phone. In addition, a jammer was used to provide additional analysis' criterion; especially since the jammer transmits signals similar to the GSM signals, but with higher transmission power.

In short, as deduced from the aforementioned literature, two experiments support the hypothesis of the writers, while the last study rejects it; this discrepancy means that additional experiments are needed to utterly prove one of the claims.

III. Proposed Solution

The first step in the study, described in the first paper written by the same authors [3], was to study the effect of mobile phones radiations on the life cycle of honey bees; the claim is that such radiations disturb honeybees' life system and affect their reproduction and honey producing. In addition, a jammer was used to study the effect of mobile phones' radiations of higher power.

The behavior of bees was studied in three different settings: in their normal setting, which means without the presence of a mobile phone in the near vicinity, with the presence of a mobile phone operating in its standby mode, and finally in its active communication mode. Two hives were used, one as a reference hive which was not exposed to any mobile phones' radiations, and the experimental hive that was exposed to these radiations [3].

The results of various experiments showed that honeybees in their normal case produced sounds at lower frequencies of around 450 Hz, and with lower intensity 0.3 normalized amplitude. But, when they were disturbed by the presence of a mobile phone, they produced sounds with higher frequencies that reached 1.5 KHz, and with higher intensity that reached 0.7 normalized amplitude. The same experiments were done in Talya- Bekaa-Lebanon; the same results were obtained [3].

All experiments were executed under the same conditions, no intruders or abnormal circumstances were added; this means that the disturbance couldn't have been for any other reason than the mobile phone's radiations [3].

The time needed for bees to start being affected depends essentially on the transmission power of waves' source; this is observed after using the jammer which transmits signals similar to those of the mobile phone but with higher transmission power. For this reason, when using a jammer, bees started producing sounds with higher intensity and at higher frequencies after a shorter time than in the case of using a mobile phone alone. Moreover, bees did not return back to their normal case after turning the jammer off because they needed more than thirteen minutes to realize that the waves are not existing anymore; thus, concluding that the effect of the jammer is more harmful than that of the mobile phone [3].

After verifying the effect of mobile phones on the life cycle of bees, it is important to study the effect of mobile phones' antennas' on them. Three honeybees' hives were placed at different distances from a mobile phones' antenna, two in the main lobe of the antenna, and one in the back lobe (see Fig. 1).

"Fig. 1" represents the basic design of the experiments with the antenna and the three hives:

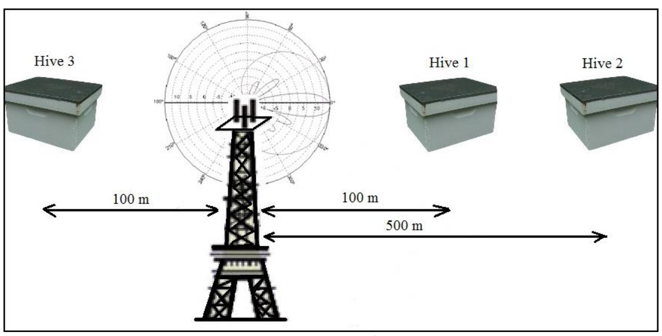

Fig. 1. The basic design of the experiments

In this study, an Aaronia Spectrum Analyzer is used as the measurement instrument that gives a representation of the signals transmitted by mobile phones' antennas. The 2G bands available in Lebanon are GSM 900 with 890-915 MHz uplink band and 935-960 MHz downlink band, and GSM 1800 with 1710-1735 MHz uplink band and 1805-1880 downlink band; while, the 3G bands are UMTS900 with 880-915 MHz uplink band and 925-960 MHz downlink bans, and UMTS2100 with 1920-1980 MHz uplink band and 2110-2170 MHz downlink bands [11].

IV. Antenna

A. *What is an antenna*

An antenna (or aerial) is an electrical device which converts electric power into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter supplies an oscillating radio frequency electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals that is applied to a receiver to be amplified. Antennas can be designed to transmit or receive radio waves in all directions equally (omnidirectional antennas), or transmit them in a beam in a particular direction, and receive from that one direction only (directional or high gain antennas) [12].

Every antenna is verified with the following parameters: Radiation pattern, Horizontal beam width, Elevation beam width, Electrical tilt angle, Front-to-back ratio, First upper side lobe suppression, First null fill below horizon, Vertical beam squint, XPD (cross polarized antennas only) – Tracking, Vertical Nullfill, Gain, Power handling, Return loss, Lightning protection, Mechanical durability, and Intermodulation products [13].

B. *5780.00 Triple Broadband Cross Polarized Powerwave antenna*

To do the analysis required for the study, 5780.00 Triple Broadband Cross Polarized Powerwave antenna owned by Alfa-Lebanon, and implemented in Kfeir – Hasbaya- South Lebanon was used, it has the following important specifications [14]:

- It is a triple broadband cross polarization antenna.
- It has the following frequency ranges:
  - 824-960
  - 2x1710-2170 MHz
- The frequency bands are:
  - 824-896/870-960 for the first frequency range.
  - 1710-1880/1850-1990.1900-2170 for the second frequency range.
- The gain is between 14.1 and 14.8 dBi, or 12 and 12.7 dBd.
- Horizontal beam width, -3 dB (°), is between 62 and 71, depending on the frequency band.
- Power handling average per input is 300 W for the first frequency range, and 250 W for the second frequency range.
- Total power handling average is 600 W for the first frequency range, and 500 W for the second frequency range.

"Fig. 2", "Fig. 3" and "Fig. 4" represent the radiation patterns for 900 MHz, 1800 MHz and 2100 MHz respectively [14].

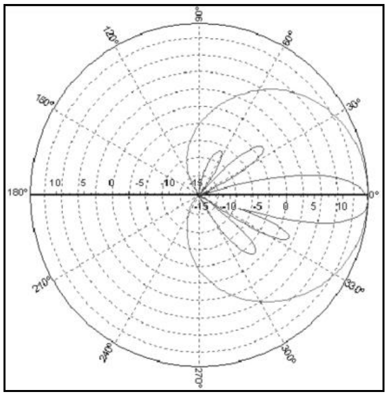

Fig. 2. 900 MHz antenna patterns.

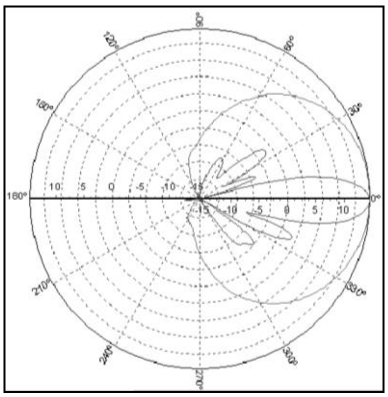

Fig. 3. 1800 MHz antenna patterns.

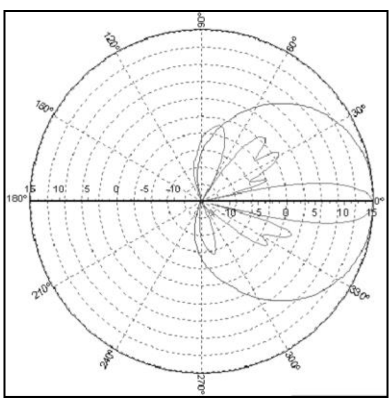

Fig. 4. 2100 MHz antenna patterns.

C. Power density

Power density is the amount of power per unit of volume. Cell-phone towers can be isotropic (transmit uniformly radiations in all directions) or non-isotropic (radiations are not uniform in all directions). For the first type of towers, the power density at a specific distance from tower is the same; however, for the second type, power density at a specific distance is dependent on the propagation direction of the tower. The power density at the aperture of the antenna can be calculated by multiplying the power input of the antenna by the antenna's power gain and dividing the result over the surface area of a sphere [15].

$$\boldsymbol{S} = \frac{\boldsymbol{PG}}{\boldsymbol{4\pi R^2}} = \frac{\boldsymbol{ERP}}{\boldsymbol{4\pi R^2}}$$

S: Power density in appropriate unit, e.g. mW/cm^2, W/m^2, mW/m^2, etc.

P: Power input to the antenna in appropriate unit, e.g. mW, W, etc.

G: Power gain of the antenna.

R: Distance to the center of radiation of the antenna in appropriate unit, e.g. cm, m, etc.

V. EXPERIMENTS

In order to study the effect of mobile phone antennas' radiations on honeybees, three healthy colonies were used. Since the antenna is directional and non-isotropic, it implies that there is another factor that affects power density at a specific point other than the distance from the antenna: it is the angle according to the origin, which is the antenna. Non-isotropic antennas, in general, have a main lobe (front lobe), side lobes and a back lobe. The first experimental hive is placed in the main lobe, at an angle 0° and a distance of 100 meters from the antenna, the second hive is placed also in the main lobe and at an angle 0°, but at a distance greater than 500 meters from the antenna; and, the last hive is placed in the back lobe, at an angle 180° and a distance of 100 meters.

The three hives have the same characteristics, the same wooden boxes, same frames' types; so they are all with 8 frames and approximately with the same number of bees. The performance of the three hives was observed, including number of bees, area of wax, and larvae and eggs state.

The experiment started on June 25, 2013. The beekeeper stated that the weather was very appropriate for bees to live, and all environmental conditions in the experiment region were normal. In addition, the three hives were treated against viruses and mites. The beekeeper claimed that the hives were well protected and would survive normally.

On July, 13, it was discovered that the hive placed at a large distance from the antenna was performing very well, and no changes were noticed. The hive placed in the back lobe of the antenna was also performing well, but the number of eggs and larvae was a bit smaller than the first one; the beekeeper estimated the difference not to be more than 10%. The most important thing that was observed was that the hive which was close to the antenna (100 meters) was noticeably affected. Three out of eight frames were kept without either eggs or larva or wax. Thus, the beekeeper estimated that the number of bees inside the hive had been decreased by approximately 40%.

On July 22nd, it was discovered that the hive placed close to the tower was going to be lost; it was kept with only workers, no foragers bees returned back to the colony; so there was no choice but to transfer the queen to a new healthy hive, or else the queen would be lost also since no pollen or water were being fed to the said hive. Moreover, only two out of eight frames remained active. The losses were estimated to be 75% for the number of bees inside the hive, and 80% for the eggs and larvae area as compared to those of the healthy hive. However, the hive placed at larger distance survived normally, with no noticeable decrease neither in number of bees or in larvae and eggs area. For the hive in the back lobe, the number of bees did not decrease, and the 10% difference in eggs and larvae area as compared to those of the healthy hive, is not an important factor.

"Fig. 5" represents the results obtained for the experiment related to the first hive (main lobe, distance 100 m); values are in proportions.

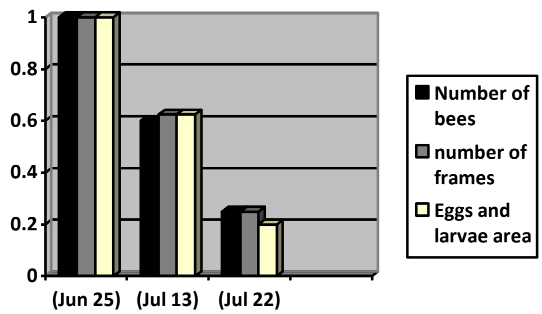

Fig. 5. Variations for hive in main lobe (distance 100 m).

"Fig. 6" represents the results obtained for the experiment related to the second hive (main lobe, distance 500 m); values are in proportions.

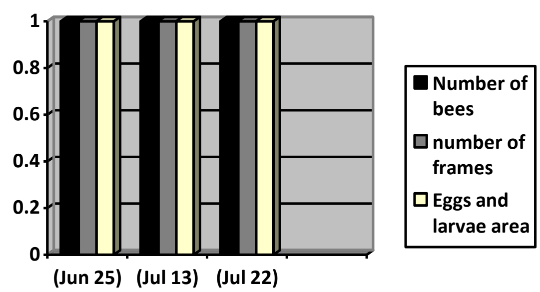

Fig. 6. Variations for hive in main lobe (distance 500 m).

"Fig. 7" represents the results obtained for the experiment related to the third hive (back lobe, distance 100 m); values are in proportions.

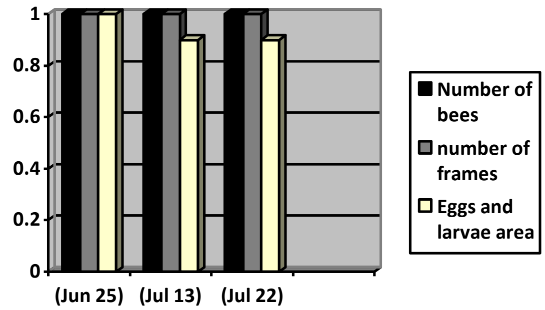

Fig. 7. Variations for hive in back lobe (distance 100 m).

VI. Discussion

In the first paper [3], it was verified that mobile phones' radiations affect the life cycle of honeybees, the next step was to verify that mobile phones antennas' radiations have an effect also, and even more than mobile phones. The results obtained after exposing three different hives at different locations to the antenna show that at a close distance the antenna's radiations do affect the life systems of the bees. Forager bees did not return to the hive that was close to the antenna, meaning that the bees had either lost their way back, or they had felt unsafe in the hive. A decrease by 75% of the number of bees inside the hive, and 80% for the eggs and larvae area as compared to those of the healthy hive is an important sign that the hive exposed to high power of antenna's radiations could not survive.

Concerning the hive at 500 meters, it was not affected. This makes sense since the power density at this location is 25 times less than that at 100 meters with the same angle. And for the hive in the front lobe, it made sense also not to be affected since the power radiation pattern showed that no radiations were propagating in the back lobe.

Less than one month is an interesting duration for a hive to perish, as the beekeeper claimed, he stated that even when the colony catch a disease it takes more time to be completely lost. This result helps verify that antennas' radiations have an important effect on the life cycle of honeybees.

In Lebanon, different types of antennas are used for GSM communications; the most used antennas are Powerwave Technologies' products, or Commscope antennas. The choice of the antenna depends on the region's needs: antennas in mountains differ from those in cities; the coverage area of the antenna is also different. In high-traffic locations, Commscope Argus antenna is usually used. For locations where a focused beam is needed, SmartBeam antenna is used, while isotropic Powerwave antennas are used in plains.

Whatever the antenna's brand and specifications are, a certain power density will affect the honeybees' colonies; however, this difference is related to the existing distance between the antenna and the hive. Thus, if a power density of the 5780.00 Triple Broadband Cross Polarized Powerwave antenna is proven to have affected the honeybees, then any similar power density coming from any other antenna at this said specific distance will affect the bees.

Consequently, upon studying the effect of an antenna on honeybees, it is imperative that the “safe zone”; i.e. the location where the power density is below the level whereby the bees are affected, is to be identified.

The question here is how those radiations are affecting bees? If we consider the biological structure of living organisms, radiation can be divided into non-ionizing radiations and ionizing radiation. Ionizing radiations are those whose energies are high enough to break the chemical bonds of water; however, non-ionizing radiations are not that high to do so. To make it clearer, all non-ionizing radiations have energy per photon less than 12 electron volts (eV), and their wave lengths are greater than 100 nanometers (nm), and frequencies less than 3×10^{15}Hz [16].

Mobile phones antennas’ radiations are an example of non-ionizing radiations; nevertheless, they might be causing the hives to overheat; or, bees might be affected in their memories, since foragers did not return back to their colonies. Another possibility is that electromagnetic radiations are affecting the magnetic reference of bees, since they have a specific organ to sense the magnetic radiations at the hive’s position in order to know how to return back to it.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has developed guidelines for RF exposure limits. For frequencies between 400 and 2000 MHz, the limit for power density is f/200 W/m^2 for general public, where f is in MHz, and f/40 w/m^2 for occupational. For frequencies between 2000 and 300000 MHz, the limit for power density is 10 w/m^2 for general public and 50 W/m^2 for occupational [17].

“Fig. 7” represents the power density “S” due to the experimental antenna in function of distance from antenna “d” at an angle 0° for the hive at 100 meters, the power density is 4.091 mW/m^2; while, at the second hive, which is at 500 meters, the power density is 0.1636 mW/m^2.

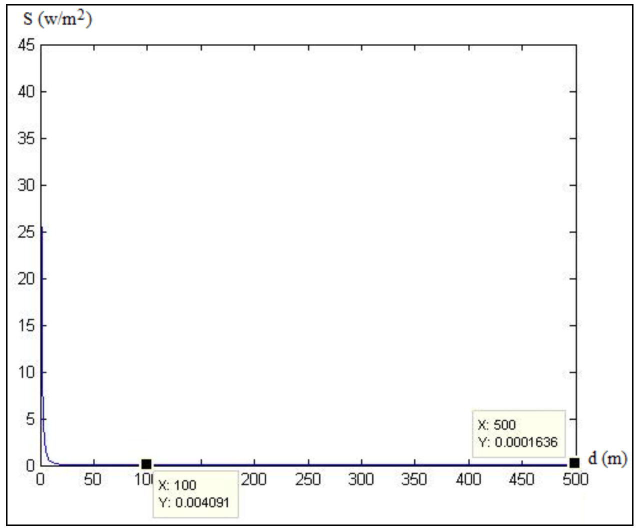

Fig. 7. Power density vs. distance.

ICNIRP levels are protective for human beings, but this does not mean that they are protective for bees; for example, 4.091 mW/m^2 is not dangerous for human beings, but it may be harmful for bees.

Whatever the way they are being affected, honeybees are in danger, and an urgent solution must be found in order to save honeybees in particular and the globe in general.

VII. CONCLUSION

In this paper, the effect of cell phones’ antennas’ radiations on the life cycle of honeybees has been studied. Three hives were placed at different locations from a triple broadband cross polarization antenna, one in the main lobe at an angle 0° and distance of 100 meters from the antenna, the second also in the main lobe at angle 0° and distance 500 meters, and the last one in the back lobe at an angle 180° and a distance of 100 meters.

After less than one month from starting the study, the first hive was left with only the queen and workers, losses reached 75% of the number of bees inside the hive, and 80% of the eggs and larvae area. The second hive was not affected, and the last one recorded a 10% loss in the eggs’ number and larvae area.

The study verified that mobile phones antennas’ radiations have an important role in colony collapse disorder, thus, the research could be extended into several branches: the effects of the mobile radiations could be studied on different animals like birds, ants, bats and other animals, since bees are not the only animals which are becoming extinct; the electromagnetic fields may be the reason behind this decline. Also the effects of the electromagnetic fields on the human beings could be analyzed, because in the last few years the rate of people affected with brain cancer has been increasing and the electromagnetic fields may be the reason. In addition, a research may be done on the ways to protect both the animals and the humans from these harmful radiations;

the specific waves that may affect the human species and animals in a negative way may be measured.

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