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Toxicological effect of environmental pollution on honeybees

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ABSTRACT

Every year, every living species faces a fresh set of problems. Environmental pollution in the form of smog is currently a major problem. Air pollution is likely to be one component of a larger issue. Because it may impact human health in so many ways, it's only natural that it affects other animals as well. Air borne pollutants affect all types of life, even insects. The presence of pesticides in the beekeeping environment is generally recognized to be one of the most important concerns that affects the honeybee's existence. Now, environmental pollution in the form of 'smog' can be added to the list of stressors. Polluted environment has negative consequences not just for humans, but also for honeybees, who survive significantly less in such contaminated air and live a handicapped existence in which they are unable to visit the flowers as frequently as they would if the air were cleaner. Furthermore, heavy metal concentration factors for honey appear to be greater in polluted areas than in unpolluted areas. These metals presence in plant flowers is linked to their presence in associated honey and by-products. In our environment, bees play a crucial role as pollinators. Pollution is hurting the health of pollinating insects, which means ecosystems are also being impacted. There are some gaps in our knowledge about environmental pollution and honeybee keeping sector in India.

Key words: *Environmental pollution, Ecosystem, Honeybee, Insecticide, Pesticides, Toxicological*

Introduction

Over the past decade rapid urbanisation, intensive agriculture, and poor emission regulation have directed to immense increases in air pollution in the developing countries (Ahmed, 2015). According to recent estimations from the World Health Organization (WHO), India currently has nine of the world's ten most polluted cities. (WHO, Data 2019). On other side, India is one of the major cultivators of fruits and vegetable globally (FAO, Data 2022). Insect pollination accounts for 35% of all agricultural productivity and has a substantial role in the productivity of at least 75% of the world's crop species. Insects, especially bees, play the major role of this pollination. Honey bees are important pollinators of crops, flowers, and fruit trees, and they play an important role in the ecosystem. (Kennedy, 2013; van Engelsdorp, 2010; Aguilar, 2006; Klein, 2007)

Bees have unique survival properties that enable it to deal with all components of the environment such as soil, plant, water and air. they one stable in the normal environment and try to find their way into such polluted environments for survival. Various environmental factors influence honeybee population health – both directly and indirectly.

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Honeybee are the most sensitive species because they lack several certain genes that produce toxicological agent detoxifying enzymes such as cytochrome P450 monooxygenases (P450s) glutathione-S-transferases and carboxylesterases (Johnson, 2010;) Moreover, certain genetic differences between species have an impact on bees' sensitivity to such toxic pollutants (Suchail, 2001). In addition, research has shown that aged honeybees are more susceptible to environment pollutants than young bees, because large bees have levels of certain protein and antioxidants that are lower than other insects (Johnson, 2015). This may adversely affect the immune system and make honeybees more sensitive to diseases. The degradation of honey bees is a serious environmental phenomenon that ultimately leads to losses in the production of many strategic crops and which may develop negative environmental pressures. Global losses in honeybees and other pollinators have been reported during the previous decade. (Biesmeijer, 2006; Cameron, 2011; Ollerton, 2010).

Beekeepers notified the scientific community to this critical colony death since they monitor bee colonies regularly and are quickly aware of any changes to the bees' colony (Carnesecchi, 2019). This reduction has raised concerns about the natural ecosystems (Potts, 2010).

While the impact of environmental pollution on human health is well studied, mechanistic impacts of air pollution on wild systems, including those providing essential ecosystem services, are largely unknown, but directly impact our health and well-being. (Renzi, 2016; Abbo, 2017; Berg, 2018; Rabea, 2010). In this review we present findings from various studies that have investigated honey bees and environmental pollutants. We focus on main environmental contaminants, including heavy metals, airborne particulate matter, and agrochemical pesticides.

Environmental pollutants

The most important source of environmental pollutants that reach the bees and its products are water as first source, the air, soil and plants are additional sources of this pollution as the bees transport the pollutants into the hive, and thus to its products causing large losses because they contain heavy metals such as cadmium, lead, mercury and other pollutants. Pesticides, illnesses, and a lack of different food sources have all contributed to the dramatic reduction of honeybees around the world. Several researches conducted over the last 40 years have confirmed the impact of air pollution on insect populations and olfactory behaviour (Alstad, 1982; Dethier, 1947). Now a days, air pollution in form of 'smog' has been added to the list of stressors.

Environmentally persistent compounds, often classified as persistent organic pollutants, are a major source of pollution around the world. These substances can move long distances in air or water and are resistant to natural degradation (Wania, 1996). The effects of diesel exhaust on *A. mellifera*, both at the level of individual foragers and the colony as a whole, were investigated in a study. According to the findings of this study, colonies exposed to diesel exhaust lost colony weight after the exposure, but control colonies gained weight near the end of the season (Christine, 2022).

According to a study of honeybees in India, air pollution impairs the pollinators' behaviour, survival, and health These impacts may not be fatal to bees. However, continuous working under heavy stress, the researchers noted that bees have sluggish daily activities in air pollution and could shorten their lives (Thimmegowda, 2020).

Bees are naturally attracted to various types of flowers, including pollen and nectar, in the quantities required for their food and brood food. When this food becomes limited and insufficient, it leads to a lack of nutrition, which in turn causes weakening of the bee immune system. This may be aggravated by inexperienced beekeepers who keep their hives near residential and industrial areas where limited plant resources. Heavy metal contamination is a big concern in densely populated areas, predominantly in regions with heavy industrial activity. Perugini (2011) used atomic absorption spectrometry to examine the metal accumulation in honeybees in urban regions and natural reserves and discovered that hives in dense metropolitan environments had the highest Pb levels.

Nicotine insecticides have been discovered to reduce crucial behaviours in sperm and food search (Williamson and Wright, 2013), as well as their impact on gene expression in honeybee larvae and increase illness levels in honeybees exposed to lethal concentrations (Steinhauer, 2014).

When comparing stationary and migratory colonies, the highest number of residues is discovered in migratory colonies, which is the main reason for hive migration as well as other variables of repetitive use of varroa mites pesticide that putting more pressure on colonies. Pollen containing pesticide residues has been attributed to the disappearance of some honeybee colonies in past years in some European countries and America.

Toxicological effects

In most reported studies, it was highlighted that the most widely investigated products were insecticides, because they were demonstrated to be harmful to non-target organisms, such as honey bees. Different authors observed that neonicotinoid insecticides, such as imidacloprid, thiamethoxam, acetamiprid, dinotefuran, thiacloprid, nitenpyram, and clothianidin, can damage honey bees olfactory learning performances, foraging activity and flight abilities (Hladun, 2012; Dai, 2010; Imran, 2019; Hladun, 2012; Hladun, 2016; Herbert, 2014; Monchanin, 2019). Honey bees are sensitive bioindicators of environmental contamination, according to all these studies.

Several studies examined the effect of insecticides including pyrethroid, deltamethrin, bifenthrin, cypermethrin, permethrin, and cyhalothrin, which appear to produce neurotoxicity by altering acetylcholine esterase activity which may be induced (Boily, 2013) or inhibited (Badawy, 2015), and by modulating carboxylesterase activity (Badiou-Beneteau, 2012; Qi, 2020; Mao, 2011; Chaimanee, 2016; Al Naggar, 2015; Carvalho, 2013; Bendahou, 1999; Bounias, 1985). These chemicals also produced other impairment like reduced learning, memory performances (Al Naggar, 2020; Sovik, 2015) and foraging activity (Decourtye, 2004) and affect honeybees locomotion and social interaction (Ingram, 2015). Variations in metabolic and detoxifying activities are also evident with this class of pesticides. (Johnson, 2009; Perugini, 2009; Bounias, 1985; Christen, 2019; Bendahou, 1999; Qi, 2020).

Furthermore, detoxification and antioxidant enzymes activities (CYP450 activities) seem to be altered by other compound such as neonicotinoids (Badiou-Beneteau, 2012; Yang, 2012; du Rand, 2017; Badawy, 2010; Zaworra, 2019). Additionally, these compounds may affect the immune system by modifying the vitellogenin (Abbo, 2017; Suchail, 2001), by reducing the encapsulation response, and antimicrobial activity (Almasri, 2020), and by modulating the relative presence of several significant gut microbial molecules (Zhu, 2020). Colin *et al.* (2004) also stated that suppression of the immune system may lead to a decrease in the performance and consequently affect the population dynamics of bee colony.

Other environmental pollutants, such as hydrocarbons and trace elements, causes various adverse effects in honey bees. Various studies on trace elements pollutants, such as aluminum, cadmium, selenium, lead, and copper, are able to influence foraging behaviour (Al Naggar, 2020; Morfin, 2019) and the development time (Hladun, 2013; Zhu, 2020), to cause histopathological alterations (Dabour, 2020), to alter acetylcholinesterase, alkaline phosphatase, Glutathione-S-transferase (Caliani, 2021; Badiou-Beneteau, 2012), catalase and superoxide dismutase activities (Bounias,1999; van der Steen, 2012). Various sublethal effects, characterised by oxidative stress and the stimulation of detoxification processes, have been observed in honey bees due to the presence of neurotoxic pollutants, such as trace elements, according to Badiou-Beneteau (2013) and Nikolic (2015).

Discussion

Many pollution effects studies on bees have been conducted in areas where significant honey bee colony losses have been documented (Jacques, A2016; Steinhauer, 2014; van der Zee, 2012). This phenomenon should be investigated on a worldwide scale to truly comprehend its causes. Researchers have discovered how pollution may be affecting honeybee health in the wild. According to other studies, more than 80% of the bees taken from moderately or highly polluted locations died within 24 hours. Bees from industrial and heavily polluted areas were also discovered to be covered with minute particles comprising lead, tungsten, arsenic and a variety of other dangerous metals. Bees have become lethargic in their regular tasks as a result of hazards form of air pollution, which may be reducing their lifespan.

The most of honey bee research has been done in a lab rather than in the field, in a controlled environment, and with the specified substances (Di Noi, 2021). Most of the actual field papers were monitoring studies where accumulation of various contaminants in Apismellifera were investigated; Research papers analysed the sublethal effects of the contaminant mixtures on honeybees. (Williamson, 2013; Renzi, 2016; Prado, 2019; Dabour and Al Naggar, 2020; Schmuck, 2003 Almasri, 2020; Badiou, 2012).

The most widely studied various sublethal effects such as Morphology, Histopathology, cytology, foraging activity, Learning ability, Reproduction, Sensory effects (gustatory or olfactory), Growth and development, brood production, enzymatic and molecular responses, neurotoxicity, metabolic responses, immunity, and oxidative stress.

To determine the role of environmental pollutants and their impact on honey bees, it is essential to understand the scientific rationale of studies that have been conducted to evaluate the health status of honeybees and the decline in honey bees' colonies (Biesmeijer, 2006; Grab, 2019).

Conclusion

The current review highlighted that, there is anotable need to increase monitoring about environmental contamination patterns. Globally, insecticides are widely studied compounds compared to other classes such as e poly hydrocarbons and trace elements. Laboratory studies are useful to determine the effects of specific compounds; however, regular real-time natural environmental monitoring should be implemented, to gain a better understanding of the ecotoxicological status and to enhance monitoring strategies. Hence from regulation perspective, developing countries need more dense air quality monitoring networks in agricultural areas and more impact studies to understand how air quality is likely to impact pollinators and plants in various densely pollution contaminated regions.

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