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## HONEY CAN BE USED AS AN INDICATOR OF ENVIRONMENTAL POLLUTION -A REVIEW

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Honey bees (*Apis mellifera*) collect nectar and pollen using an area of approximately 5 km in diameter. At the same time, they actually take biological samples from thousands of points of this land. Therefore, honey samples can be used as an important biomarker to detect environmental pollution. Because the content of honey also reflects the quality of the soil, water and air in the region where the bee lives. The determination of the following chemical substances in honey provides important data about environmental pollution. Pesticides and Chemicals: Pesticides and other chemicals used in agricultural areas may leave residues in plant nectars and soil. When bees produce honey using these nectars, traces of these chemicals may be present in the honey. Analysis of honey with pesticide residues can be helpful in demonstrating the level of environmental pollution. Heavy Metals: Heavy metals can accumulate in the environment because of air, water, and soil pollution. Bees can get these heavy metals through nectar and plants they collect. High heavy metal levels in honey can be an indicator of environmental pollution. Nectars collected by bees from flowers may contain such substances. In addition, changes in the smell and taste of honey can be used as an indicator of environmental pollution. Because environmental pollution can affect vegetation and soil, this can change the smell and taste of nectar collected by bees. Monitoring the odor and taste profile of honey can be an indicator of environmental changes. Particularly in regions where large-scale wars take place, chemical substances emitted by weapons, heavy metals, and toxic substances released due to environmental destruction are transmitted to soil and water. For this reason, the extent of environmental pollution can be determined by taking honey samples from various regions and analyzing them.

**Key words:** Honey, environmental pollution, biomarker, toxic substance, heavy metal

### Introduction

Environmental pollution is among the most important problems of today (Appannagari, 2017). Many harmful substances released as a result of industrialization and the widespread use of vehicles (Conrad and Wastl, 1995), urbanization with increasing population (Briggs, 2003), chemicals used to increase productivity in agriculture (Tudi et al., 2021), wars or regional conflicts (Weir, 2014) are released into the air, water and soil and threaten living things (Weldeslassie et al., 2018; Vardhan et al., 2019). This situation is even more serious in low-income countries (Zurbrugg, 2002). Because serious resources need to be allocated to prevent or reduce environmental pollution. However, determining the extent of environmental pollution is also a very important issue. For example, early detection of heavy metals, pesticides, or polycyclic aromatic hydrocarbons released for various reasons is important for measures to be taken to clean up the environment (Cunningham et al., 2022). Many methods exist for the detection and traceability of these substances (Gavrilescu et al., 2015). In our review, we will talk about studies on monitoring environmental pollution using bees and bee products.

### Honey bees as bioindicators of environmental pollution

Honey bees interact strongly with the vegetation, air, soil, and water around the hive. They collect nectar and pollen in an area of about 7 km<sup>2</sup> around the hive (Celli & Maccagnani, 2003). When bees leave their hives in search of food, they come into contact with many plants and are exposed to the contaminants present in them (Martinello et al., 2021). Not only are they exposed to contaminants during nectar collection, but their body feathers and wings are also exposed to pollution in the air as they fly, providing us with valuable information about pollution in their environment (Al Naggari et al., 2013). Although they are susceptible to these contaminants individually, as a whole, bees in the hive

are highly resistant (Cunningham et al., 2022). In this way, they cause the accumulation of harmful contaminants in bee products and provide long-term monitoring (Bogdanov, 2006). Since they are numerous, we can take enough samples. Bee products are also suitable samples for studies. Hives that are lighter and cheaper to manufacture than traditional wooden hives can be preferred for monitoring stations. Such hives are used as mating hives in bee breeding (Bargańska et al., 2016). Beehives located in contaminated areas can provide a wide range of data for continuous monitoring of emitted pollutants and indication of their sources (Matin et al., 2016).

### **Heavy metal pollution: a dual concern for human health and bee populations**

The effects of heavy metal pollution in areas with dense human populations and especially industrial activities are of great concern (Hu et al., 2013). Major anthropogenic sources of heavy metals include exhaust gases, fossil fuel combustion, and agricultural chemical use. The resulting heavy metals are highly toxic (Alloway, 2013). Studies have shown that heavy metals trigger various types of cancer in humans, cause neurological disorders, damage to kidney function, and disruption of the endocrine system (Rehman et al., 2018). Heavy metals can be detected in bee products such as honey, pollen, propolis, and beeswax, or the bees themselves (Conti & Botrè, 2001). Although heavy metals in the environment can negatively affect offspring production, orientation, and survival of bees (Burden et al., 2019), they often do not result in colony death (Cunningham et al., 2022). This creates an opportunity for environmental bioavailability. For example, honey bees and hive products (pollen, propolis, and beeswax) sampled in areas of high vehicular traffic have been found to have higher levels of heavy metals compared to non-urban areas (Conti and Botrè, 2001).

### **The impact of pesticides on bees and agricultural products**

Fertilizers and pesticides are frequently used to increase the productivity of agricultural products (Sharma and Singhvi, 2017). Pesticides contribute to the growth of vegetables and fruits in nature without harm. However, their uncontrolled use threatens the health of humans and other living organisms (Baweja et al., 2020). Depending on the dose of pesticides, the colony can survive. In this way, bees and their associated matrices allow short- and long-term monitoring of pesticides (Teeters et al., 2012). One study measured the concentration of 64 types of pesticides in in-hive bees, freshly stored pollen, and beeswax. Beeswax was the matrix with the highest concentration of agrochemicals, while pollen contained the greatest diversity of pesticide species. This study revealed that pesticide content in pollen was higher in intensive agricultural environments compared to rural or grassland environments, suggesting that pesticides in stored pollen may reflect spatial differences in environmental pesticide contamination (Calatayud et al., 2018).

### **The threat of persistent environmental pollutants to human health and bee ecosystems**

Air pollution from persistent chemicals, particulate matter, and other pollutants in the environment threatens human health by causing various respiratory diseases (Bălă et al., 2021). Persistent organic pollutants are important pollutants that attract attention worldwide. These compounds remain in the environment for a long time due to their ability to disperse over long distances and their resistance to degradation (Ma et al., 2011).

Polychlorinated biphenyl (PCBs), a group of persistent pollutants, are released into the environment from landfills containing old electrical equipment, evaporation from contaminated lakes, and incineration of municipal waste (Cunningham et al., 2022). PCBs accumulate in human tissues and suppress the immune system. They are also a source of concern worldwide as they cause an increased risk of cardiovascular diseases and cancer (Carpenter, 2006). Studies have shown that PCBs accumulate in the bees themselves, then in honey, and to a lesser extent in pollen (Cunningham et al., 2022).

Polycyclic aromatic hydrocarbons (PAHs) are naturally occurring air pollutants found in coal, crude oil, and gasoline (Låg et al., 2020). Industrial activities such as the production of iron, steel, aluminum, cement, coal tar pitch, paint, rubber, asphalt, fungicides, or pesticides are the main sources of PAHs. Exhaust emissions from refineries and energy production also contribute to PAH emissions (Patel et al., 2020). The detection of PAHs in bees or bee products is one of the best indicators of environmental pollution. In a study conducted in Italy, various levels of PAHs were detected in honey and honey bees collected from two different regions (Perugini et al., 2009). In a study conducted in France, the presence of PAHs was detected in pollen, honey, and the bees themselves and was associated with environmental pollution (Lambert et al., 2012).

### War-induced environmental pollution: a prolonged global concern

In addition, war also has serious effects on environmental pollution that last for years. This is not only a pollution that occurs during war. It is an environmental threat that starts before the conflict and continues after the conflict. For example, vehicles, airplanes, ships, or facilities used in pre-conflict preparation and training increase the consumption of petroleum-based energy, resulting in the release of excessive amounts of CO<sub>2</sub> and harmful gases (Bradford and Stoner, 2017). In addition, many toxic substances are released into the environment from weapons and explosives used during exercises (Ceobs, 2023). This situation continued to increase during the war. Heavy metals such as lead, cadmium, titanium, and mercury (Skalny et al., 2021), toxic gases such as carbon monoxide, formaldehyde, hydrogen cyanide vapor, or various nitrated compounds (nitrite oxide, nitrogen oxide, nitrous oxide) cause pollution (Harada et al., 2022). Environmental pollution in war zones is not only caused by the weapons or explosives used. During conflict, strategically important places such as military structures, industrial facilities, warehouses, infrastructure facilities, oil refineries, or power plants are also targeted (Weir, 2014). Urban areas are also bombed from time to time. Depending on the nature of the destroyed structures, many chemicals are released into the environment. Moreover, because of the destruction of forested areas during the war, the environment.

### Conclusion

Bees and bee products provide us with valuable information about the level of environmental pollution. As a result of these studies, we can identify regional risk factors that cause environmental pollution and take early measures. We can identify the causes of global bee deaths and prevent the decline of bee colonies. We can create effective solutions to protect the health of humans and all other living things.

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