

General Overview

WHY DID I CHOSE THIS TOPIC?

Honey bees have always played a huge part in my life since my grandfather owned a bee farm in Northern Alberta. When I was younger, I would spend a lot of time "helping" him and developing a fascination in honey bees, as seen in **Figure 1**. Honey bees tend to be only thought of as a supply of honey; however, they have numerous human applications that can and have been studied.

WHY HONEY BEES AS A BIOMONITOR FOR AIR POLLUTANTS?

The term biomonitoring means using the reactions of an organism to environmental pollution or changes to help determine the state of its surrounding environment². In a bee colony, all bees have different roles; those that stay inside the hive are called worker bees, and those that leave to collect nectar and pollen are called forager bees¹. Forager honey bees collect pollen, nectar and water, all of which can contain pollutants, from approximately 2 km away from their hive². Meaning pollutants can be carried into the hives, where samples can be taken from different components of the hive or bee and studied for pollutant concentrations within the corresponding environment. Common air pollutants detected are shown in **Figure 2**.



Figure 1

Common Pollutants Detected in Honey Bee Matter

- 1.) Polychlorinated Biphenyls (PCBs)
 - 2.) Polycyclic Aromatic Hydrocarbons (PAHs)
 - 3.) Particulate Matter (PM)
 - 4.) Heavy Metals
- = Honey bees are best at detecting

Figure 2

Different Samples to Study

Different components of a beehive and the actual bee hold different pollutants to various degrees. The four most commonly studied samples listed in the order of most accurate depiction of environmental pollutant levels to least are:

Propolis:

- ❖ sticky substance produced by worker bees, used to repair and strengthen the hive
- ❖ Most useful sample as it has shown to have highest level of heavy metals and PAHs when compared to other material⁴.

Foraging Bees:

- ❖ Bees can pick up heavy metals, PAHs, and PMs and carry them in their hair⁴.

Pollen:

- ❖ Bees must collect pollen from multiple plants over a large area, making the pollen that bees collect a stronger biomonitor than most human techniques¹.
- ❖ Pollen also tends to store high levels of lead (Pb) when it is present in the surrounding environment.
- ❖ Downside: only small amounts can be collected from the hive at a time¹.

Honey:

- ❖ A bee's mechanisms can block certain air pollutants from entering honey, making it the least accurate depiction of most air pollutants in the surrounding environment⁴.

Conclusion

Bees can be used as biomonitors for air pollutants and as filters to protect human health. The use of honey bees as a biomonitor for air pollutants is a relatively new concept, with most current studies based in Europe. Current studies regard the detection of air pollutants using different components of bees to determine how accurate the analysis of pollutant concentration is compared to the surrounding environment^{1,2,4}.

PROPOSED APPLICATION IN ALBERTA

Experimental Design:

Suppose we establish a honey bee colony within an oil sand region (< 2km) and another colony in a location where the climate is similar, but the air is less impacted by the oil sands. This setup allows us to collect samples of pollen, honey, propolis, and bees from both colonies and test for concentration levels of specifically PAHs and heavy metals.

Figure 7: Locations of Alberta oil sands



Hypothesis:

The level of PAHs found in the colony closest to the oil sands would be significantly higher than the level of PAHs in the farther colony due to the Alberta oil sands consisting of a large amount of bitumen-covered sand which contains large amounts of PAHs³.

Polychlorinated Biphenyls (PCBs)

WHAT ARE PCBs?

PCBs are a group of industrial organochlorine chemicals that remain in the environment for years as they resist breakdown by chemical and biological agents³. **Figure 3** shows the process of how PCBs form.

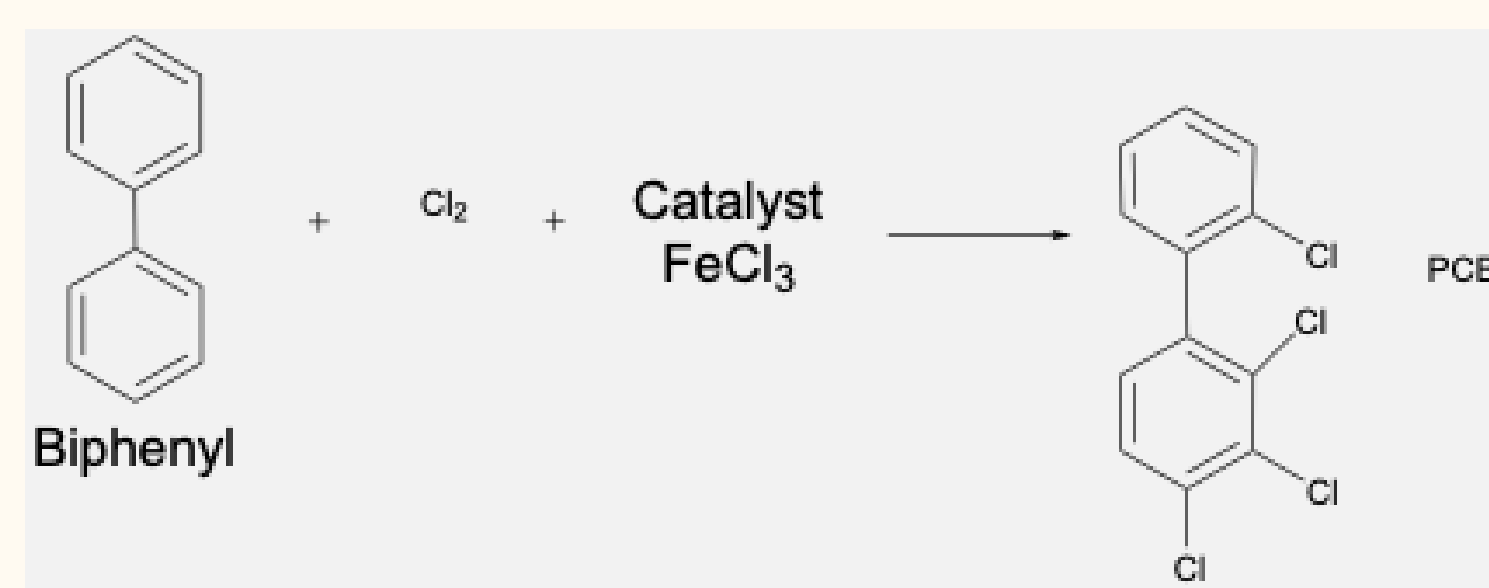


Figure 3

HONEY BEES AND PCBs

PCBs have low solubility in water, meaning they are not easily absorbed by plants, so they are rarely found in pollen or nectar. However, PCBs can attach to forager bees, which ultimately get absorbed or broken down as they are not found in honey¹.

Polycyclic Aromatic Hydrocarbons (PAHs)

WHAT ARE PAHs?

PAHs are made up of multiple aromatic rings and are formed by the incomplete combustion of carbon containing materials³.

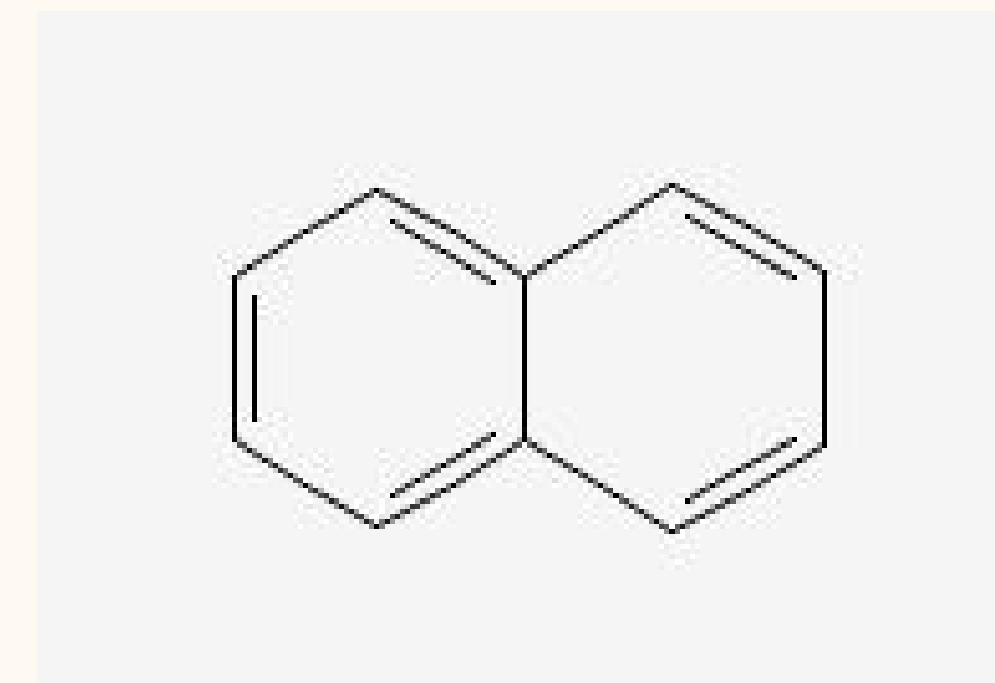


Figure 4: Example of a PAH (Naphthalene)

HONEY BEES AND PAHs?

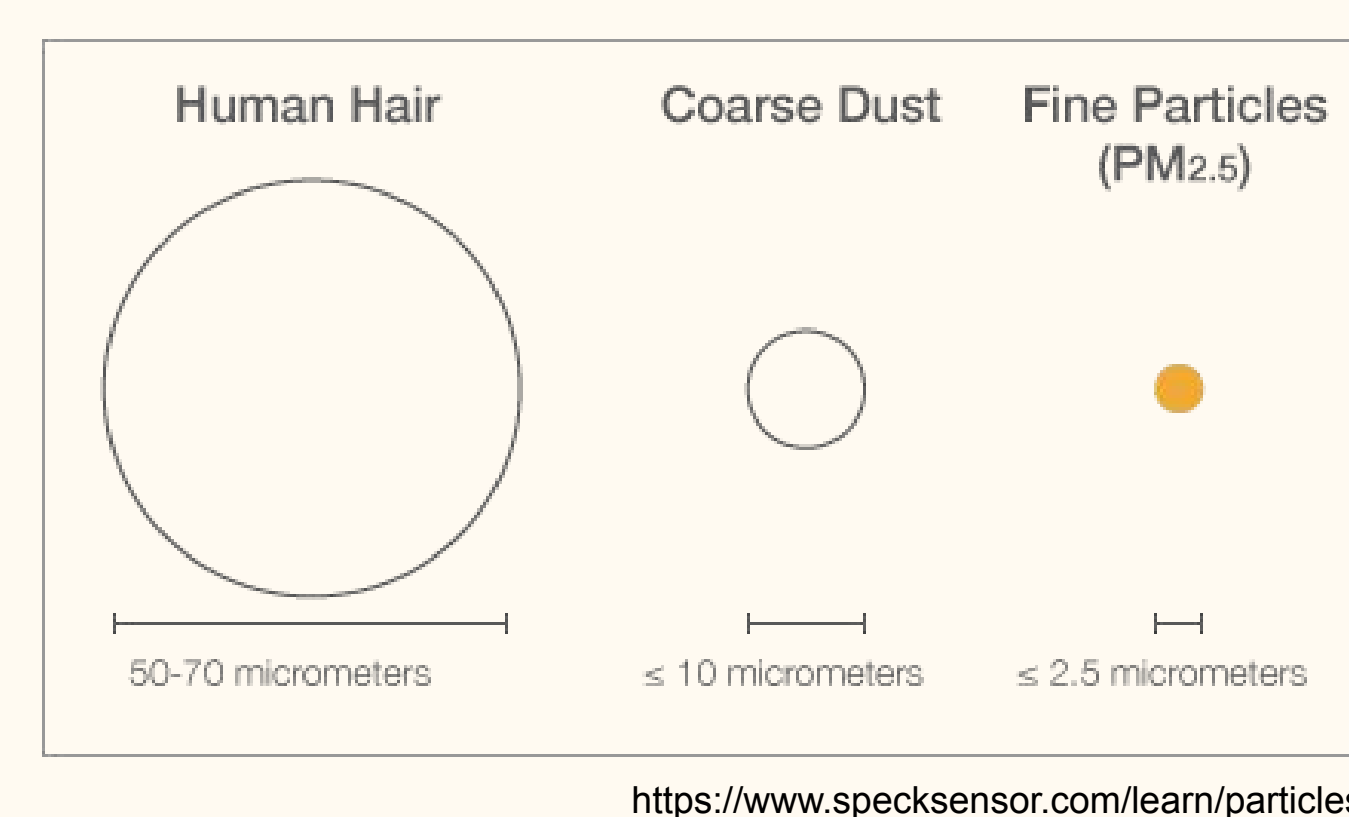
PAHs are serious water pollutants, meaning bees collect large amounts while foraging³. The forager bees then bring many PAHs back to the colony, contaminating all components, including honey.

Particulate Matter (PM)

WHAT IS PM?

PM is tiny solid or liquid particles in air. Specifically fine particles, which have a diameter $\leq 2.5 \mu\text{m}$, are called inhalable particles which are detrimental to human health as they can be absorbed into the lungs³.

Figure 5: Visualization of PM



HONEY BEES AND PM?

PM can be caught in the hair of forager bees and brought back to the hive where numerous samples can be taken. The propolis a bee produces also traps a large quantity of PM including coarse particles¹.

Heavy Metals

WHAT ARE HEAVY METALS?

Examples include lead (Pb), cadmium (Cd), mercury (Hg) and chromium (Cr), all of which are dangerous in their cations. Heavy metals typically enter the environment through combustion³.

HONEY BEES AND HEAVY METALS?

Heavy metals can adhere in the hairs of the foraging bees and although are non-toxic for the colony they can have an impact on honey production, navigation abilities and survival rates. All of which we can study to determine if high levels of heavy metals are present in the surrounding environment. Heavy metals can be found in pollen, beeswax, honey, and propolis through analysis¹.



Figure 6: Visualization of heavy metals

References

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