Towards a Better Understanding of the Lifecycle of the Pesticides in the Atmosphere

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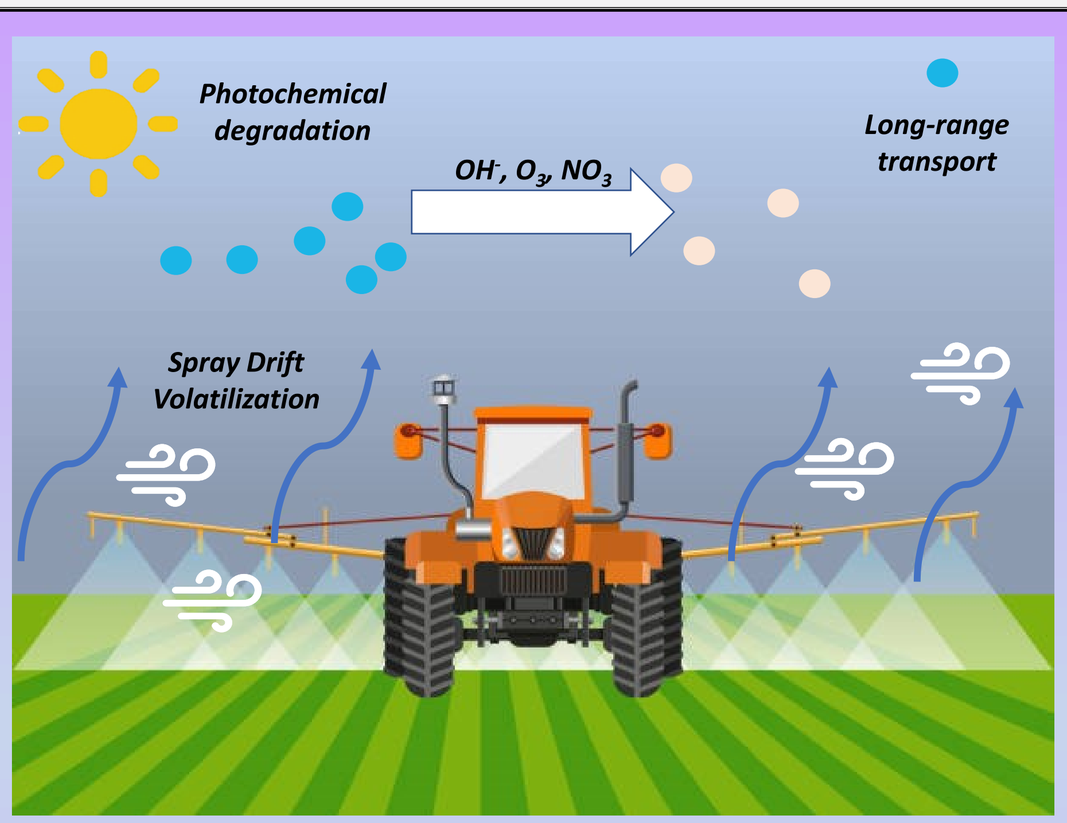
1. Background

- **Pesticides** are chemical compounds that are used to kill/prevent harmful **pests**, including insects, **rodents**, **fungi** and **unwanted plants** (weeds).
- Agriculture contributes to feeding 8 billion people & 4% global GDP[3]
- **Global consumption** of pesticides is around 2.66 million metric tons/year[2]
- Can accumulate in atmosphere in particle phase which contributes towards **higher persistence** and **slower degradation** in the atmosphere[7]
- **Persistence** is highly dependent on vapour pressure, Henry's constant, and dry and wet deposition[1,6]
- Pesticides documented as **Endocrine Disruptor compounds** and can be lethal[5]



2. Statement of Problem

- Limited understanding of **physio-chemical** properties of pesticides, their **transportation** mechanism, their conversion reactions, their persistence in the environment
- Limited techniques for characterization for direct surface **volatilization**
- Limited knowledge of **biosphere-atmosphere** exchange, governing factor in atmospheric oxidation processes and long-range transport

3. Aim

The aim of this study is to determine **fluxes** of pesticides from the point of application to the **regional** scale, with the development of **eddy correlation** (EC) system for both **particle** and **gas** phase characterization, including **HR-TOF-CIMS** in conjugation with the sonic anemometer.

4. Objectives

Objective 1: Development of system for **simultaneous** measurement of **scalar** quantity from HR-TOF-CIMS and the **vertical wind speed**
Objective 2: Development of an eddy correlation system for both particle and gas phase species
Objective 3: Deployment into the field at field scale first which can then be scaled to regional scale and for different range of environmental conditions and under **specific farming practices**. **Regional burden** of the pesticides may be examined.

5. Methodology

Eddy covariance flux measurements based on determining **correlation** between changes in **vertical wind velocity** and deviations in scalar quantity such as mixing ratio of a trace gas or air temperature[8]

$$F_c = \frac{1}{n}\sum_{i=1}^{n}(w_i - \overline{w}).(c_i - \overline{c})$$

Sonic Anemometer (SA) with an operating frequency of 10 Hz in conjugation with CIMS would provide the Eddy Correlation fluxes, which needs further correction based on the time lag of measurement, surface roughness and canopy height

Fig. Eddy correlation system for gas measurement

CIMS (Chemical Ionization Mass Spectroscopy) capable of measuring pesticides in gas and particle phase because of its **reproducibility**, **minimum sample handling**, **high mass resolution** (m/Δm~4000-6000), **high time resolution** (1-10 Hz) allowing measurements of reactive compounds[4]

Consists of five main components:

- Ion molecular Reactor (IMR)
- Two radio frequency (only quadrupoles)
- An ion lens focusing region
- TOF mass analyzer

(I⁻ CIMS ionization mechanism) $I(H_2O)_n^- + M \rightarrow n(H_2O) + I(M)^-$

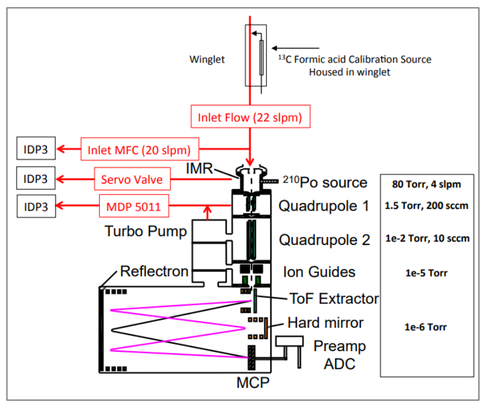


Fig. Basic schematic of the HR-ToF-CIMS[4]

6. Responsible Innovation & Policy Impact

- With development of the flux system researchers would be able to understand how **real time exchange** of pesticides happen and that could change the perception of researchers towards understanding how **lifecycle** of pesticides is influenced various **meteorological** parameters at local and regional scale.
- **Policies** and **regulations** can be formed on the regional scale to curb the influence of emissions and **atmospheric models** may be modified accordingly.

7. Foreseeable Challenges

- Operating CIMS in conjugation in with SA, as both devices run at different operating frequencies.
- Influence of change in **nocturnal boundary layer**, which affects the turbulent mixing of the air parcels,
- Identifying optimal **ion reagent** for the CIMS, as its efficiency to ionize the reactant molecule is highly dependent on the ion being used.
- Influence of near **field application** of pesticides in the measurement
- Influence of geographical location for e.g., **roughness** of the surface, **canopy** above which instrument should be placed.
- Influence of atmospheric **oxidant** leading to conversion of pesticides into their different oxidation products, which can influence long measurement cycle.

References

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