Onsite Microplastic Testing Device for Kansas Water

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Abstract

Micro- and nanoplastics are a major environmental issue found in **tap** and **bottled water**, as well as in **ponds and lakes**. Current methods for analyzing microplastics rely on complex, costly optical imaging techniques that are not readily accessible. This research aims to combine a **microfluidic chip** with **dielectrophoresis (DEP)** to **quantify**, **collect**, and **detect** microplastics in water samples. Results show the highest **concentration** when **64 V** and **1 kHz** are applied. Detection and pre-processing methods will be further explored to develop an on-site testing device.

Background

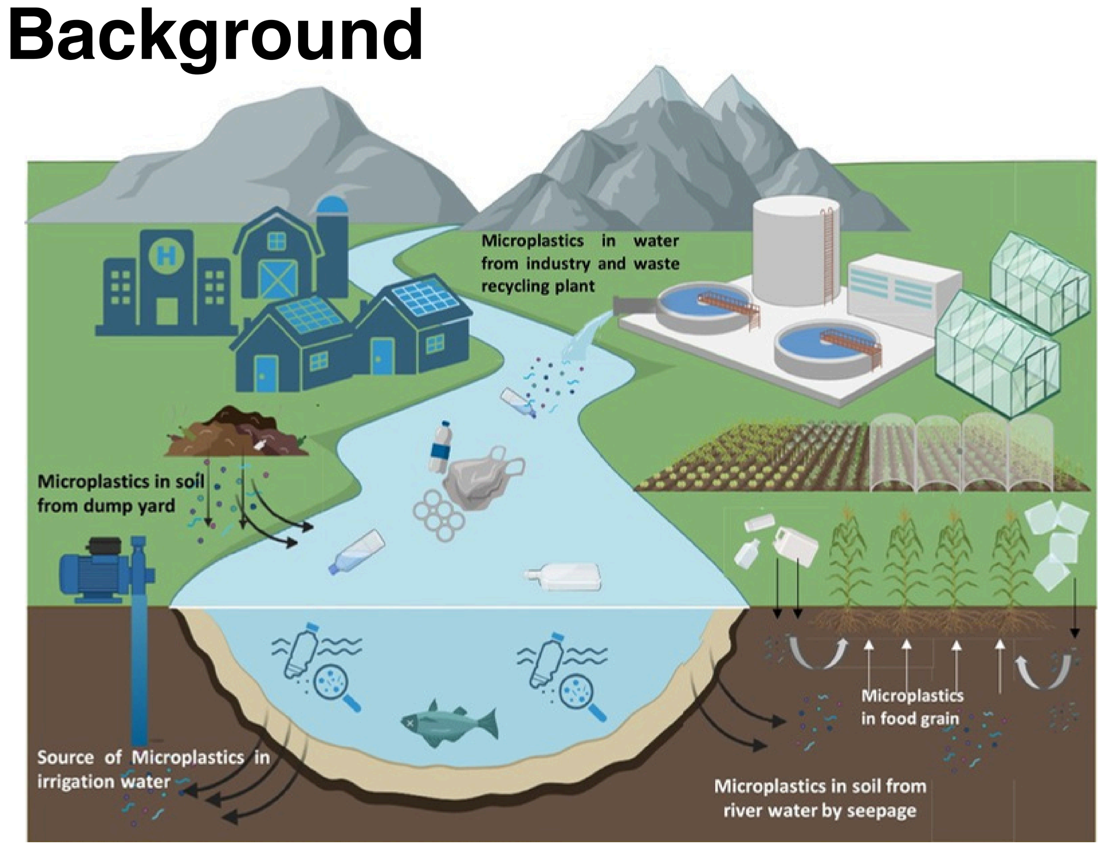

Figure 1: Microplastics are pervasive in our environment, impacting water resources in multiple ways, including **food production**, **water treatment**, and **ecosystem sustainability.**

Objectives

- Measure the concentration of plastic particles in Kansas tap water using an electrical sensor
- Concentrate large water samples of low concentration of plastic nanoparticles using dioelectrophoresis (DEP)
- Sort plastic particles by size and type when applying different flow rates

Methods

To evaluate microplastics in Kansas water samples, a microfluidic chip was designed and tested at various voltages and frequencies using DEP, as confirmed in the equations below.

DEP Force:

$$F_{DEP} = 2\pi a^3 \varepsilon_m Re(f_{CM}) \nabla E^2$$

Clausius-Mossotti Factor:

$$f_{CM} = \frac{\varepsilon_p^* - \varepsilon_m^*}{\varepsilon_p^* + 2\varepsilon_m^*}$$

Complex Permittivity:

$$\varepsilon_{p,m}^* = \varepsilon_o \varepsilon_{p,m} - j\frac{\sigma_{p,m}}{2\pi f}$$

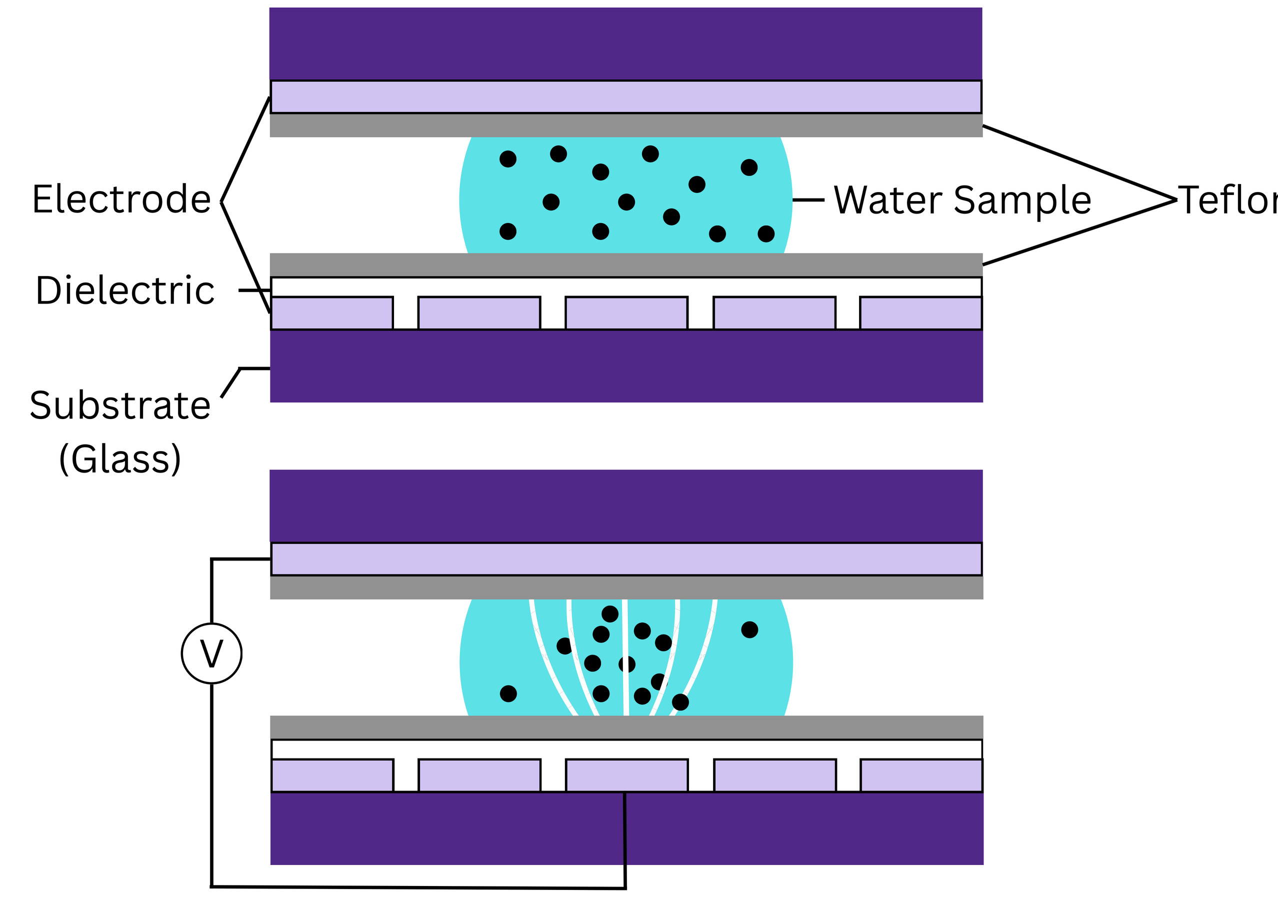

Figure 2: Cross-section of microfluidic chip containing a water sample before and after AC voltage is applied, displaying DEP.

Future Direction

- Explore pre-processing methods for large water samples
- Optimize chip pattern to improve concentration efficiency
- Experiment with different frequencies and flow rates to sort various types of plastic particles
- Detect electrical signals from plastic particles using an electrical sensor

Preliminary Results

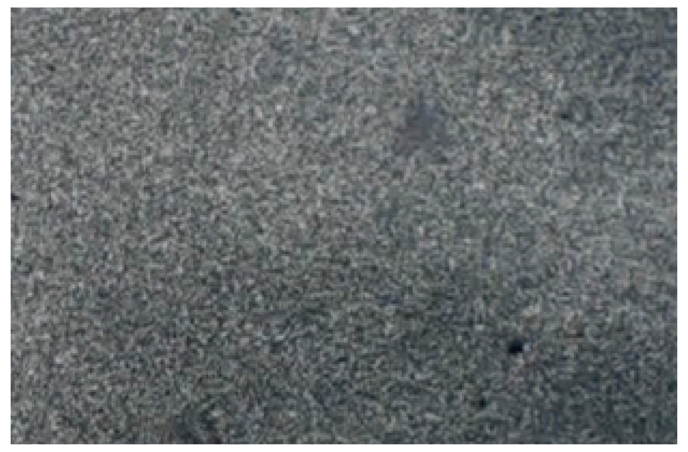

Figure 3: No voltage or frequency applied to 3 μm Polysterene beads

Figure 4: Initial influence of DEP when 40 V and 1 kHz is applied

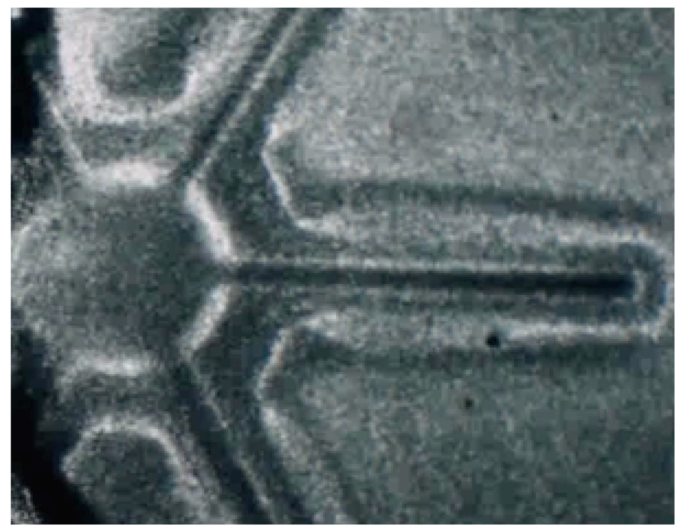

Figure 5: Higher concentration when 40 V and 9 kHz applied

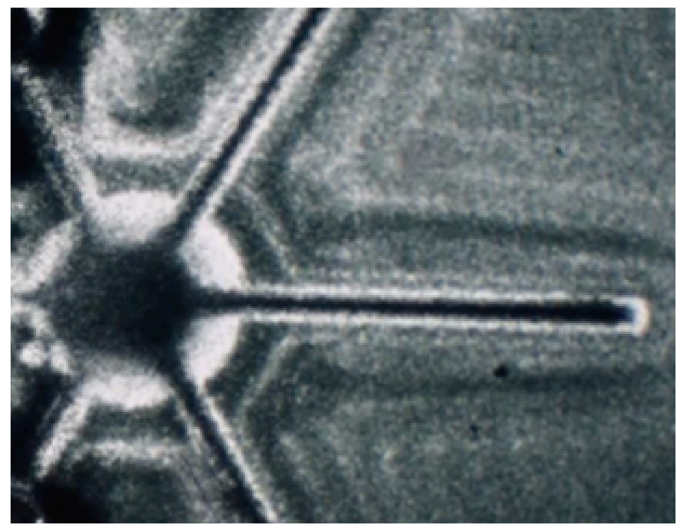

Figure 6: 64V and 1kHz provided the most efficient concentration of microplastics

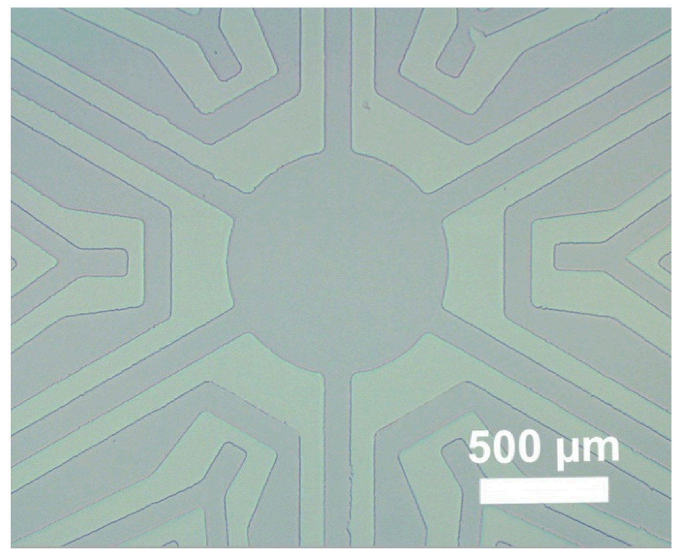

Figure 7: Measurements of the patterned electrode (Dark). Units are in micrometers.

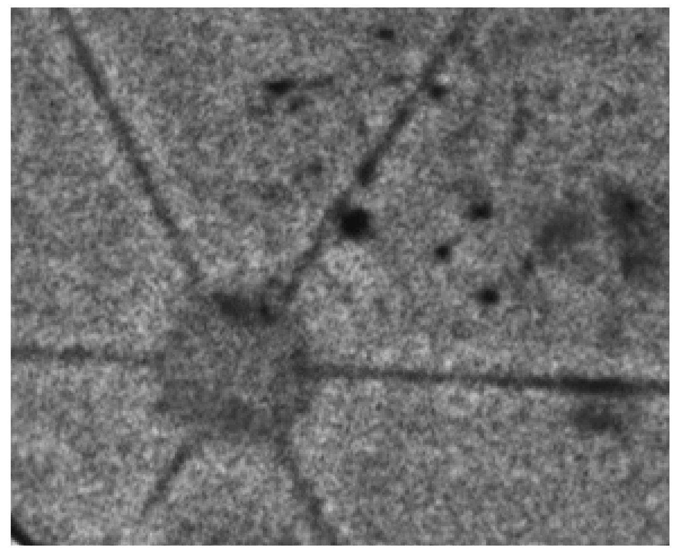

Figure 8: Concentration when 72 V and 1 kHz is applied

References

Microplastics in the soil–water–food nexus (2024). Science of the Total Environment, vol 946.