Transport of Microplastics in Agricultural Soils - Analyzing Surface Water Runoff as an Environmental Pathway

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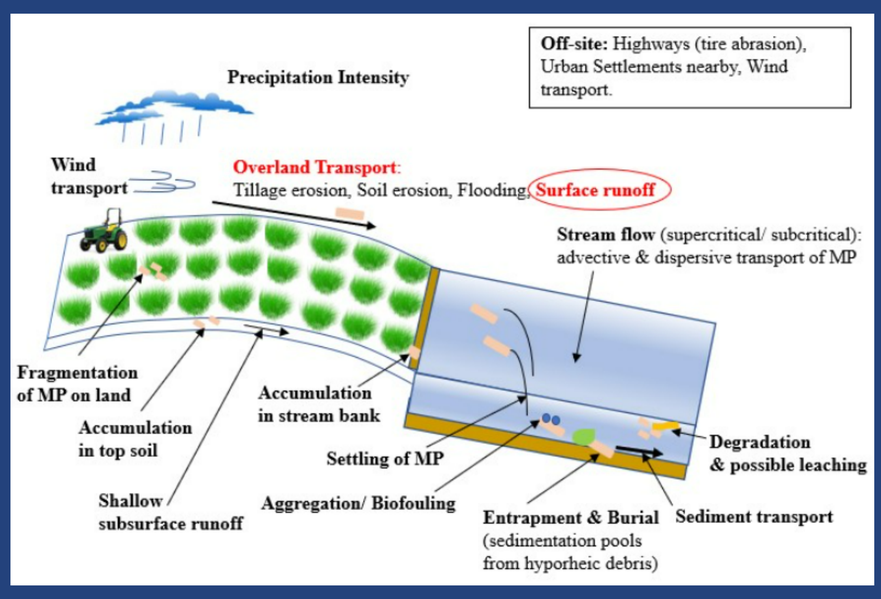


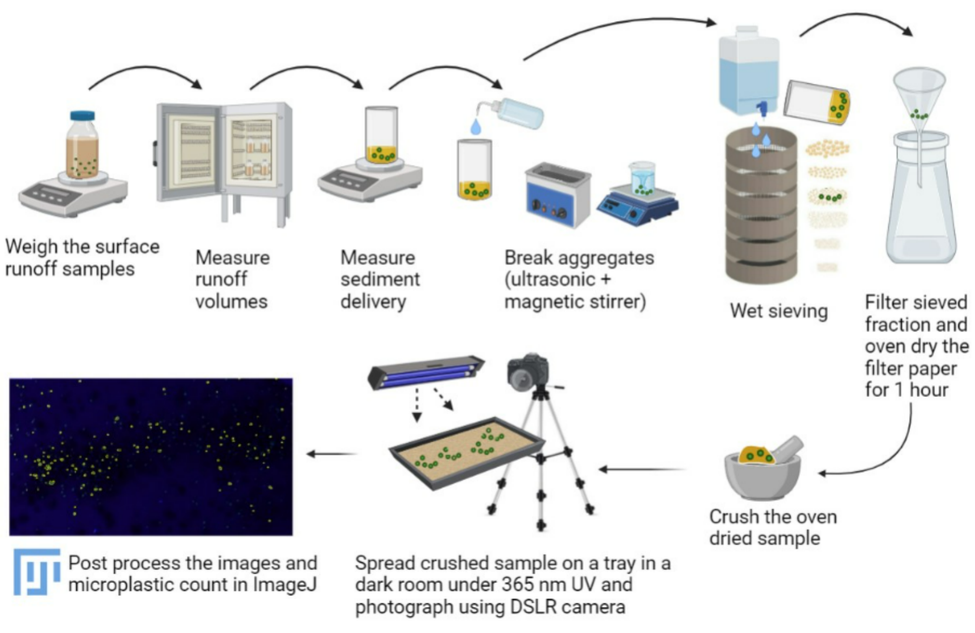
Biodegradable polylactic acid (PLA) microplastic particles showed a lack of preferential erosion from agricultural topsoil under simulated heavy rainfall on a plot scale.

BACKGROUND

- Current literature highlights limited quantification regarding rainfall induced erosional and transport patterns of microplastics (MP) from agricultural topsoils.
- Quantifying MP is crucial to monitor and model it's transport behaviour , however it's a time demanding task traditionally performed using expensive equipments.
- The aim of this study is to develop a simple, cost-effective technique to detect and quantify luminescent polylactic acid (PLA) particles as a tracer to examine biodegradable MPs transport in agricultural soils.

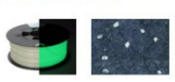
METHODS

- **PLA particles of 250 - 300 µm** were validated under a microscope and proofed for normal distribution using QQ plots.
- **Data Training Set** - To identify parameters for dark room photography and digital camera settings (1200 pictures).
- **Method Validation** - Sets of known values of MP particles were mixed with 10 g soil and photographed in the dark room to ground truth particle counts.
- **Method Evaluation** - PLA particles were added in 7 concentration gradients (0.01%, 0.04%, 0.07%, 0.1%, 0.4%, 0.7%, 1% w/w) with 10 g dry soil and recovery was analyzed (triplicates were used).
- **Field Study** - 3 plots of 1m*1m were prepared and PLA particles were mixed homogenously in top 5 cm.
- Rainfall simulation (RS) was conducted at an intensity of **59.7 ± 4.25 mm h^{-1}**. Two cycles of RS were conducted per plot – dry and wet run (30 mins each) with a gap of 15 mins
- Two scenarios were tested - Fallow plot (Day 1) and Crusted plot (Day 7)
- **4 g m^{-2}** PLA particles were added only on Day 1. Due to known properties, this corresponds to **25.2· 10^4 particles** in each plot.



RESULTS

1. MP Properties



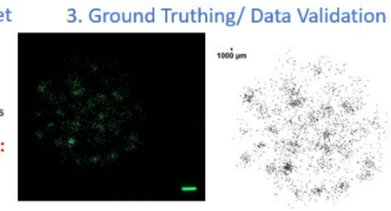
Properties	PLA
Density	1.24 g/cm³
Melting Point	160 °C
Color	Grey (Luminescent green)
Shape	Particles (Heterogenous)
Size	250 – 300 µm
Production	Dry milling and sieving

2. Data Training Set

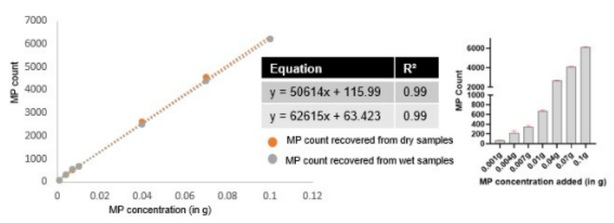
350 nm UV
Sony a6500
F 5.6
ISO 100
Exposure 2 sec
Full frame pictures

F Score/ Recovery: 0.89 ± 0.07
Recall: 0.92 ± 0.09
Precision: 0.91 ± 0.09

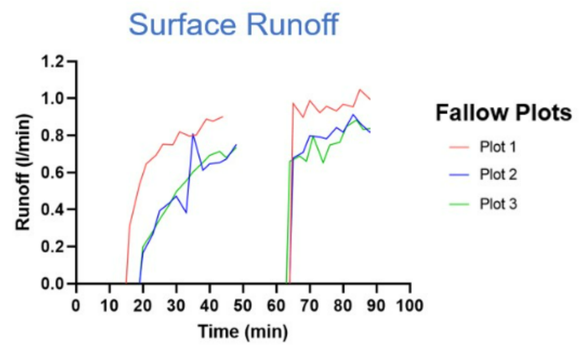
3. Ground Truthing/ Data Validation

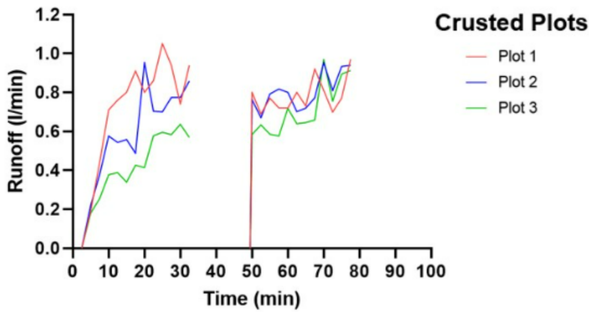


4. Data Test Set – conducted on dry and wet samples

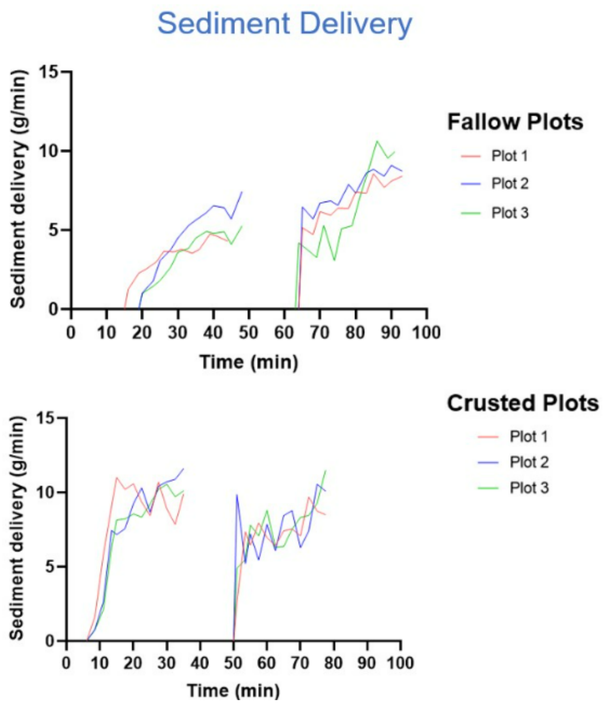


Developed protocol has a recovery rate of 89%

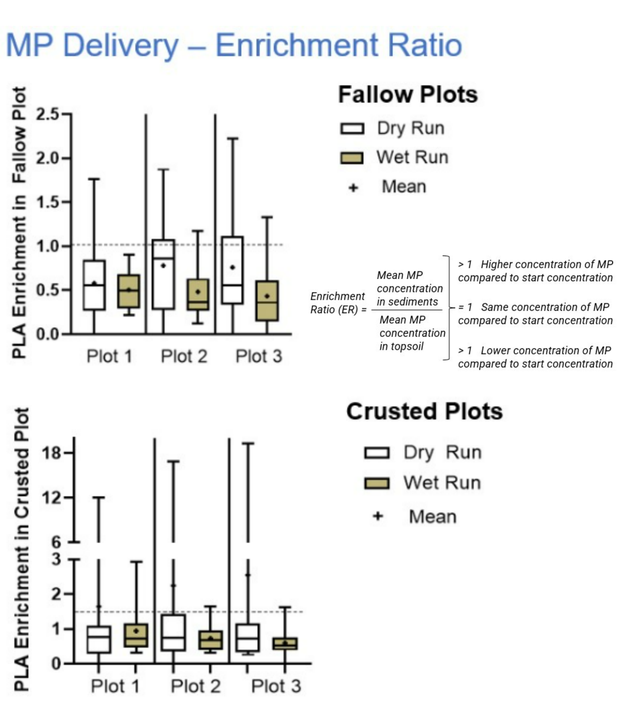




Runoff coefficients were 0.41 ± 0.13 and 0.53 ± 0.2 (n= 6) for dry and wet runs respectively



SD increased by a factor of 2.3 for dry runs between fallow and crusted plots



Mean ER for all fallow and crusted plots are 0.095 ± 0.06 and **0.21 ± 0.11** respectively (n=6)

CONCLUSION

- Cheap, convenient, and reliable protocol – applicable for a mix of heavy and low-density fluorescent polymers
- Under naturally relevant input concentration of PLA in a square meter plot only 0.04% of MP was mobilized by surface runoff
- Comparison of bio and non-bio MP polymers transport based on density, size, shape should be further investigated.

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