Microplastics Losses in Runoff Following Biosolids Application

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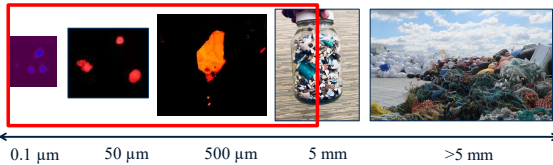*University of Kansas*

Background

Microplastics
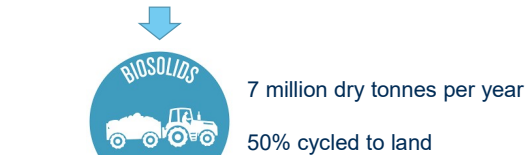
0.1 μm   50 μm   500 μm   5 mm   >5 mm

Primary sources   Secondary sources

60% MPs removed in primary clarifier

36% MPs removed in secondary treatment

Not biodegraded but retained in sludge Only 4% MPs in effluent

BIOSOLIDS

7 million dry tonnes per year

50% cycled to land

Objective: understand the fate of microplastics in soil and runoff after biosolids application.

Experiment Setup

Simulate rainfall events on plots with biosolids application

Eight 1m x 1m plots:
Two control plots without biosolids application
Three spreading plots: spread biosolids on the soil surface
Three incorporating plots: incorporate biosolids into the soil
Application rate:
720 g biosolids (class B, 30% water content, 110 MPs/dry g)

Simulated rains:
1st 2nd 3rd simulation: 0.6 inch/ 10 min
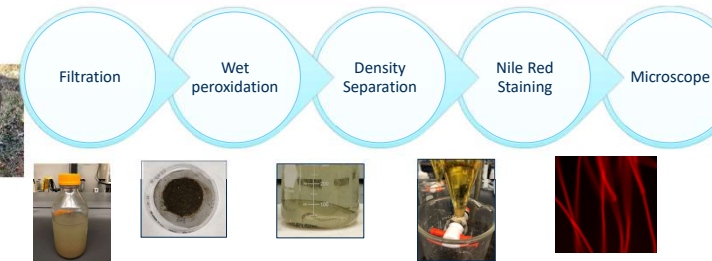4th 5th simulation: 0.6 inch/ 5 min
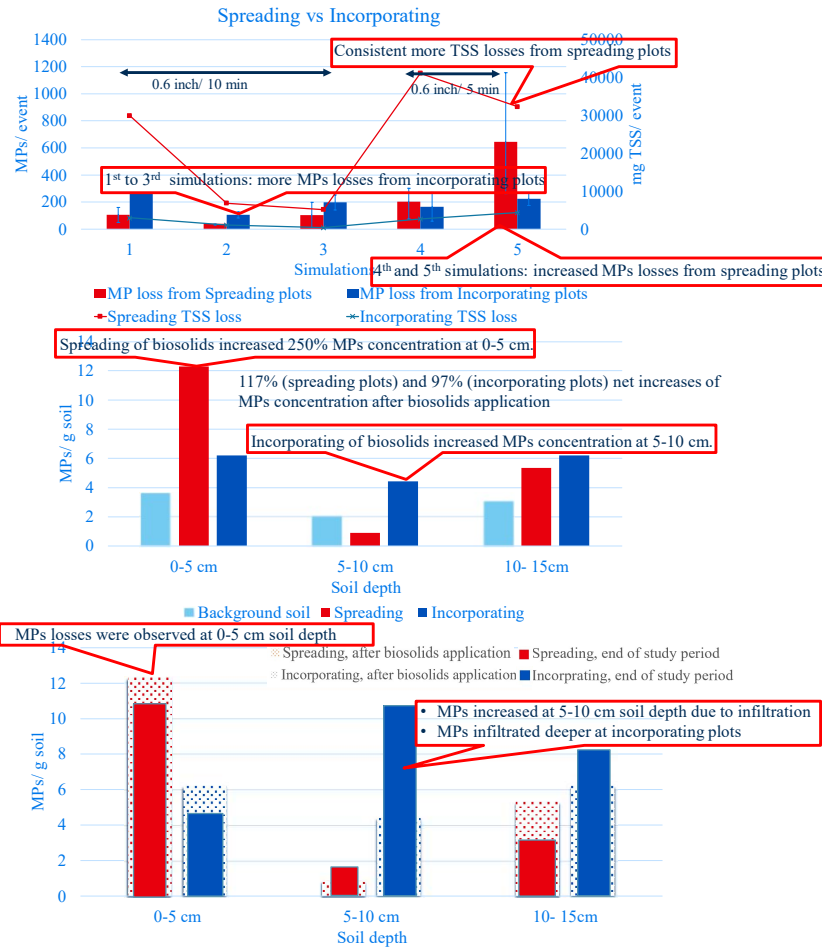
Sampling Methods

Runoff samples:
• Collected during each simulation by ISCO auto samplers
Measurements:
• Runoff volume
• MPs
• TSS

Soil samples:
• Collected one day after each simulation by coring tool from
• 0-5 cm, 5-10 cm, and 10-15 cm soil depth
Measurements:
• MPs

Extraction and Quantification

Filtration → Wet peroxidation → Density Separation → Nile Red Staining → Microscope

KU is an EO/AA institution.

Spreading vs Incorporating

Consistent more TSS losses from spreading plots

0.6 inch/ 10 min   0.6 inch/ 5 min

1st to 3rd simulations: more MPs losses from incorporating plots

Simulation

4th and 5th simulations: increased MPs losses from spreading plots

■ MP loss from Spreading plots   ■ MP loss from Incorporating plots
Spreading TSS loss   Incorporating TSS loss

Spreading of biosolids increased 250% MPs concentration at 0-5 cm.

117% (spreading plots) and 97% (incorporating plots) net increases of MPs concentration after biosolids application

Incorporating of biosolids increased MPs concentration at 5-10 cm.

Soil depth

■ Background soil   ■ Spreading   ■ Incorporating

MPs losses were observed at 0-5 cm soil depth

Spreading, after biosolids application   ■ Spreading, end of study period
Incorporating, after biosolids application   ■ Incorprating, end of study period

• MPs increased at 5-10 cm soil depth due to infiltration
• MPs infiltrated deeper at incorporating plots

Soil depth

Conclusion

In runoff:
• More runoff volumes and more TSS losses from spreading plots
• At low rainfall intensity, incorporation of biosolids into soil increased MPs losses compared to spreading application method;
• At high rainfall intensity, runoff volume increased and MPs losses from spreading plots increased;
• Explanation:
Incorporation created much more contact surface and provided the opportunity for runoff to flush the microplastics retained in the relative deeper layer. During the 4th simulation, rain at high intensity ruined the flat surface layer of spreading plots thus losing more microplastics, and the surface continued to be ruined during the 5th simulations thus releasing even more.

In soil:
• The huge impact of biosolids application on MPs concentration in soil was confirmed: 117% (spreading plots) and 97% (incorporating plots) net increases
• Infiltration was confirmed by the increase of MPs concentration at 5-10 cm soil depth
• Incorporing of plots accelerated infiltration

Future Directions:
• Relationship between TSS losses and MP losses
• Estimate of MPs weight and report concentration in mg MPs/ g soil or L runoff