

# Unveiling the hidden threat: Paint microplastics and their extractable organics in soil

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## OVERVIEW

➤ **Aged exterior paint microplastics (MPs)** exhibited a significant **reproductive toxicity** on a **soil-dwelling nematode**, *Caenorhabditis elegans* (*C. elegans*).

➤ The toxicity of paint MPs varied based on their **size, color, and layer structure**, which were linked to the chemical composition of additives present in the particles.

➤ **Sequential extraction** followed by **biochemical analysis** revealed **alkyl amine**, a **leachable paint additive**, is a major contributor to reproductive toxicity.

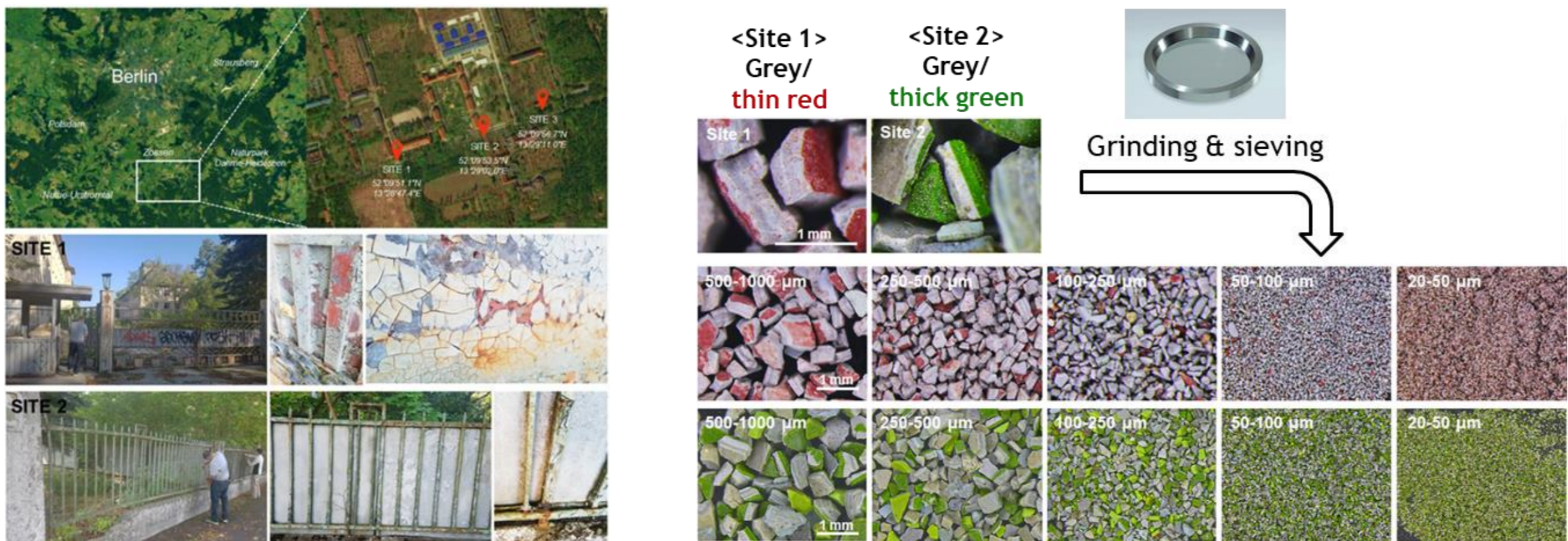
## INTRODUCTION

➤ As the **second-largest source of global MPs** [1], paint poses a significant threat to soil ecosystems. Despite widespread contamination from exterior paint coatings, the **soil toxicity** of paint MPs remains poorly understood.

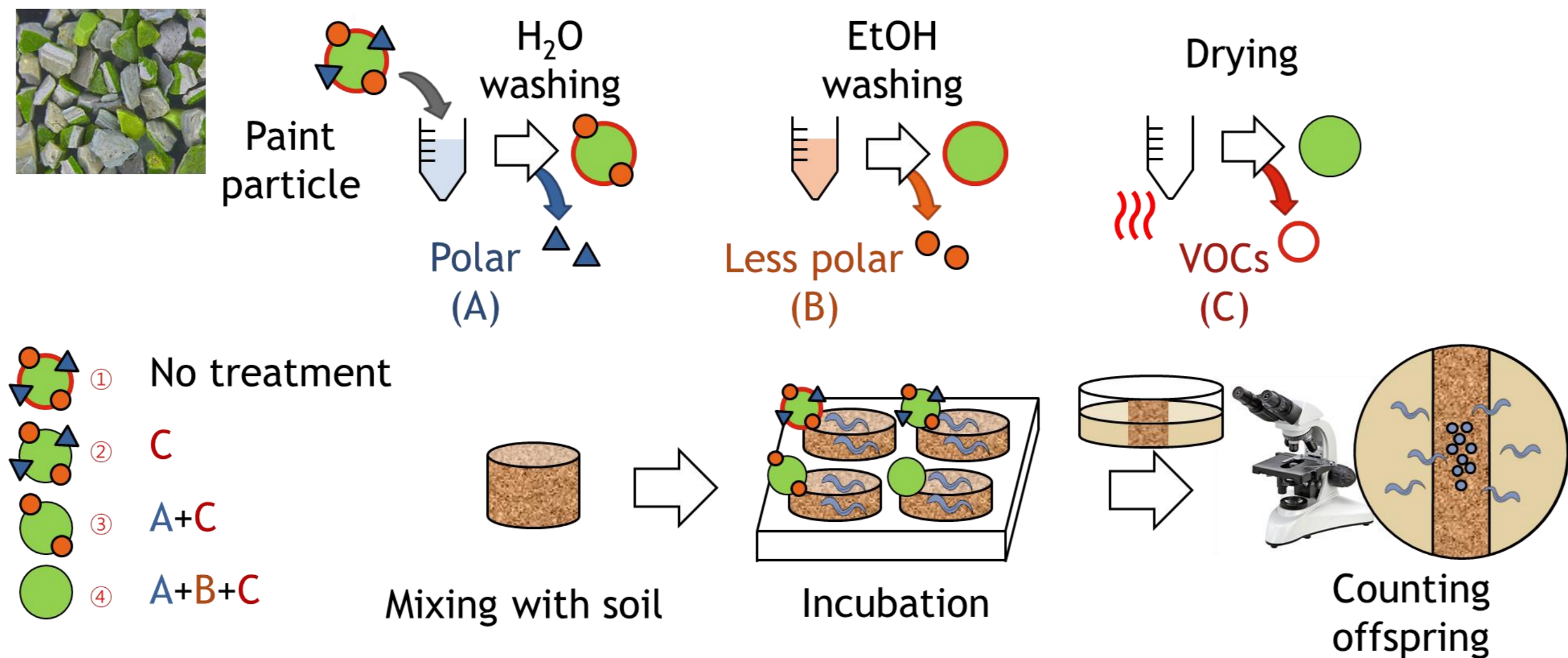
➤ This study focuses on unveiling the **impact of paint MPs and their leachable additives** on *C. elegans* by employing **sequential extraction** coupled with systematic toxicity analysis. This is followed by comprehensive chemical characterization of both **inorganic and organic additives** using **ICP-MS** and **LC-MS**, respectively [2].

## EXPERIMENTAL

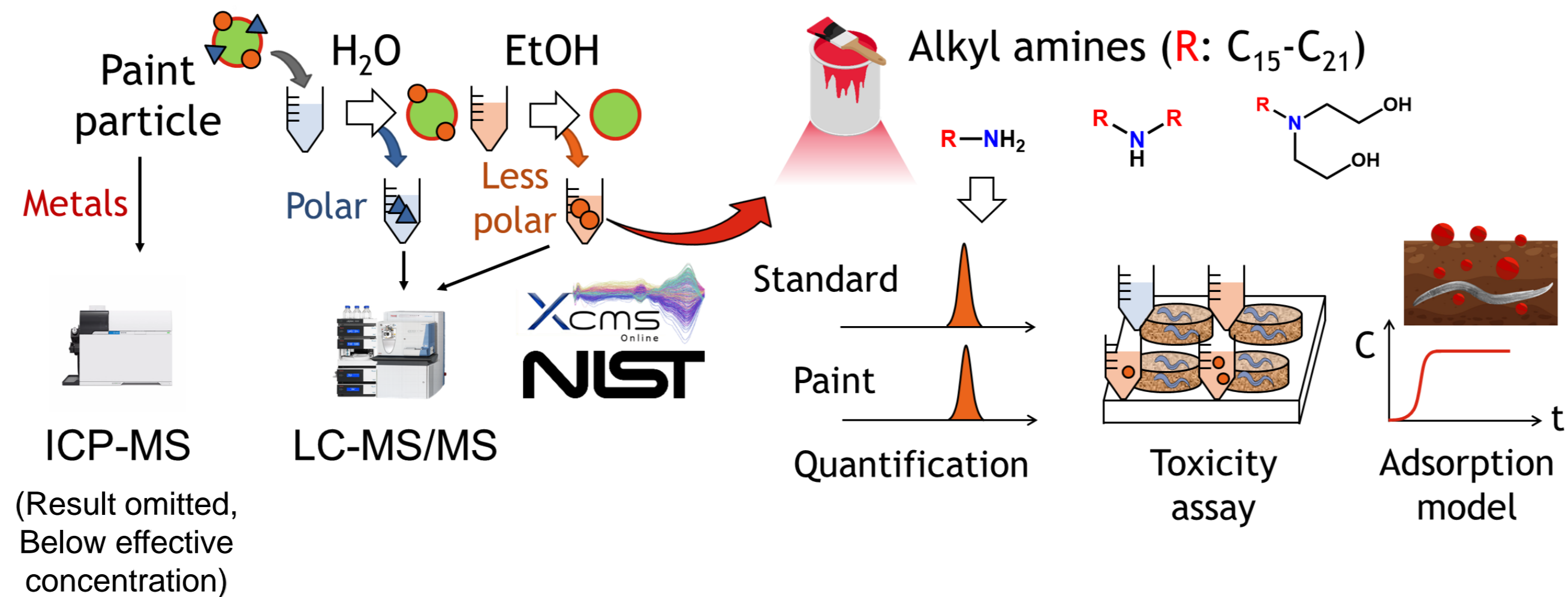
### <Sampling of exterior paint MPs>



### <Reproductive toxicity assay of paint MPs and their leachates>

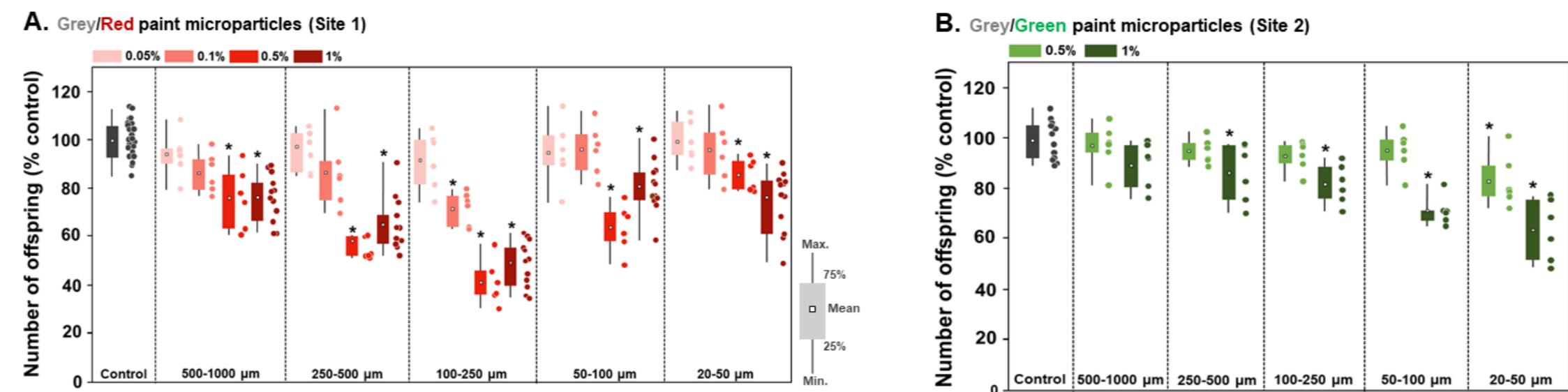


### <LC-MS analysis paint MPs and their leachates >



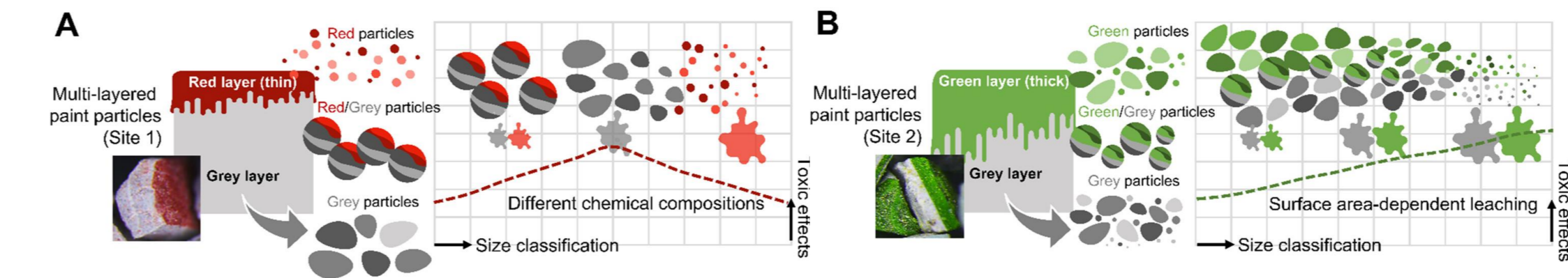
## RESULTS

### Particle size-dependent toxicity of paint MPs



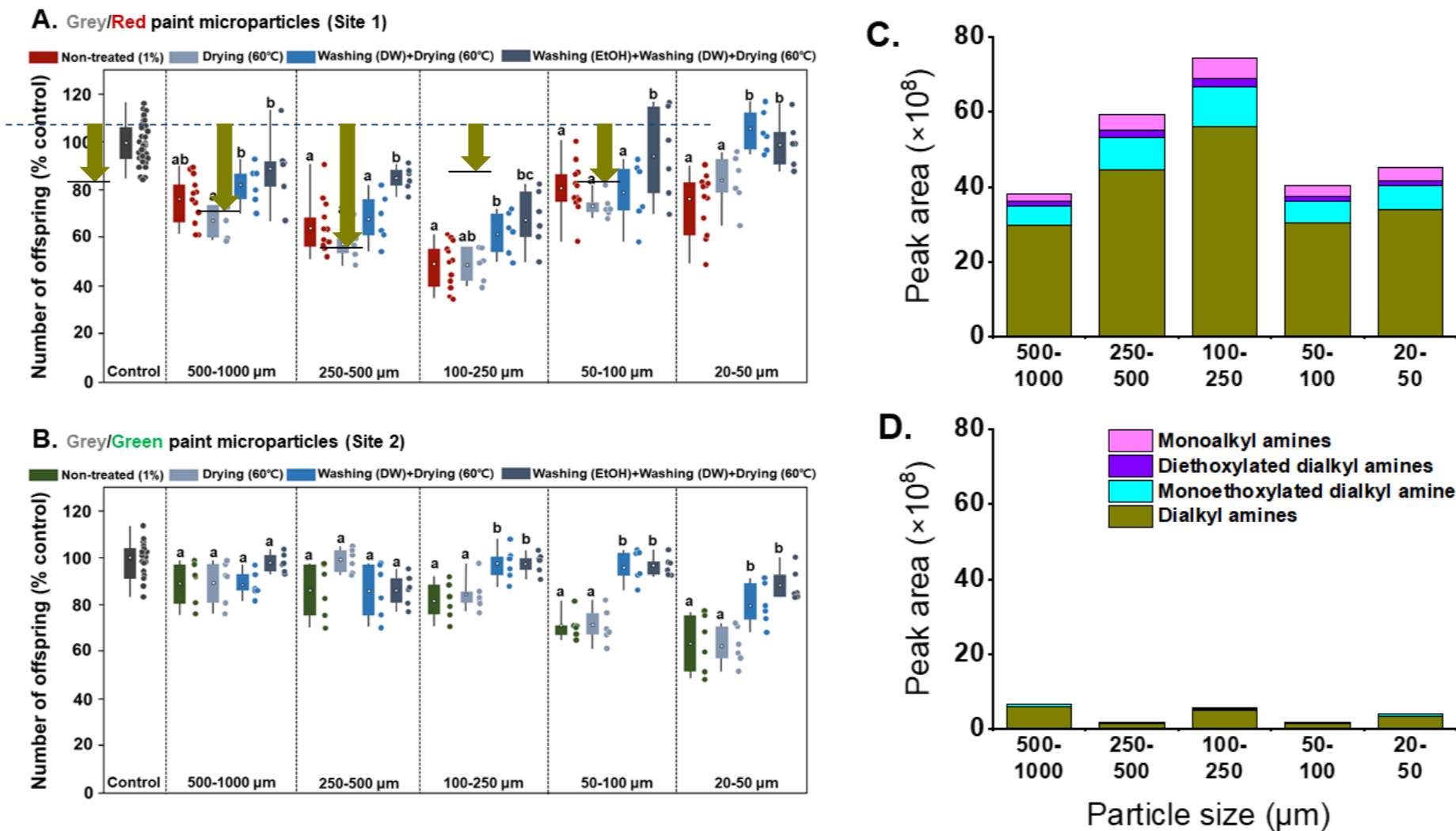
**Figure 1.** Offspring number of *C. elegans* exposed to (A) site 1 and (B) site 2 paint MPs at different concentrations. Asterisks (\*) indicate significant differences compared to the control (p < 0.05).

➤ Reproductive toxicity of site 1 paint MPs (red/grey layers) demonstrated a **U-shaped trend** within the size range of 20 to 1000 µm.



**Figure 2.** Potential fragmentation mechanisms responsible for the toxic effects of the (A) site 1 and (B) site 2 paint MPs.

➤ The variability in paint MP toxicity by particle size can be attributed to the **chemical heterogeneity of multilayered paint particles**, leading to an investigation of the **leachable additives**.  
➤ **Sequential extraction reveals chemical heterogeneity of paint MPs and their leachates by particle size**

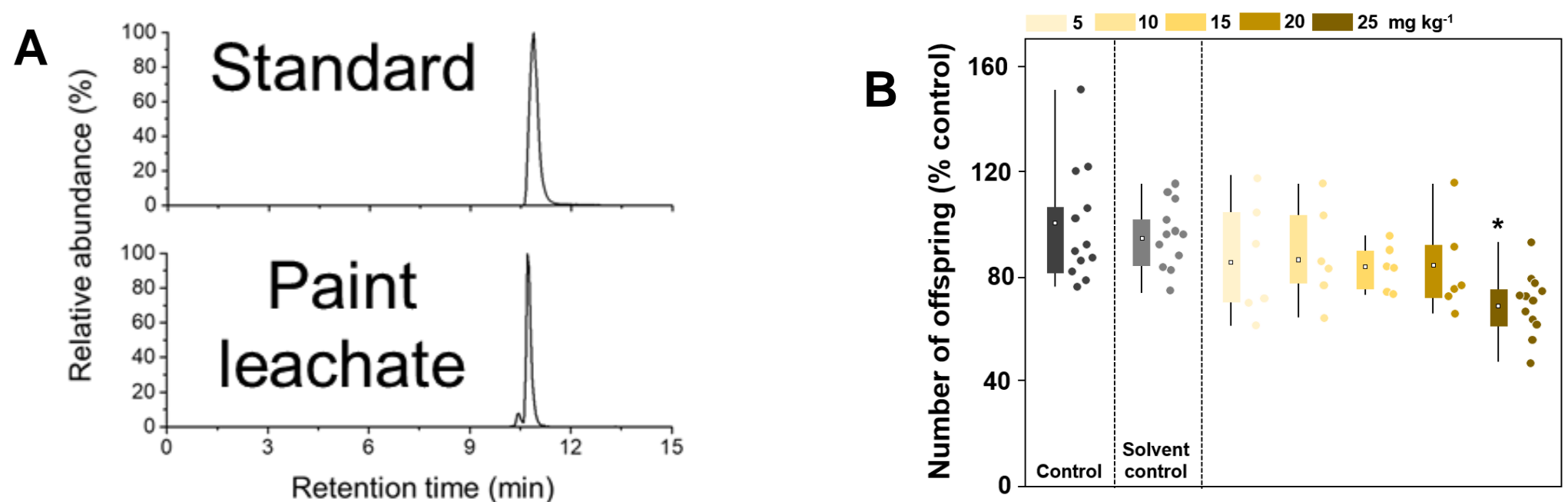


**Figure 3.** Offspring number of *C. elegans* exposed to (A) site 1 and (B) site 2 paint MPs after four different stepwise treatments. EIC peak areas of four alkyl amines in ethanol leachate of (C) site 1 (D) site 2 paint MPs.

➤ Abundances of **alkyl amines** in the ethanol leachate was **strongly correlated with the toxicity** of the paint particles, depending on their sizes.

## RESULTS

### Toxicity of Alkyl Amines in Aged Paint Particles



**Figure 4.** (A) Extracted ion chromatogram of octadecylamine standard (25 mg/kg) and paint MP leachate and (B) reproductive toxicity of octadecylamine standard at 5 to 25 mg kg<sup>-1</sup>.

➤ Toxicity of alkyl amine was confirmed using an **authentic standard**, with an EC<sub>50</sub> of **25 mg/kg** alkyl amine at a paint MP concentration of 1.2% in soil.

➤ By applying Langmuir isotherm adsorption kinetics & dynamics model from Xie et al. [3], **alkyl amine** is anticipated to **spontaneously & quickly** (99% at 0.52 min) **adsorb to soil** from 1% paint MPs at a leachable concentration of 20.2 mg/kg.

## CONCLUSIONS

➤ Even after decades of application, **paint MPs** generated through the weathering of **exterior coatings** can remain **highly toxic to soil nematodes**.  
➤ Toxic effects of **aged exterior paint MPs** on soil nematodes are primarily driven by **leachable organic additives**, influenced by both **particle sizes** and paint **layer structures**.

## ACKNOWLEDGEMENT

➤ We acknowledge support by the National Research Foundation of Korea (2019R1A2C1007170 and 2022R1A2C2005955), ERC Advanced Grant (694368), PAPILLONS (No. 101000210), and Capes-Humboldt Research Fellowship (1203128-BRA-HFSTCAPES-E-Finance code 001).

## REFERENCES

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[2] S. W. Kim and W. Y. Song et al., Toxicity of Aged Paint Particles to Soil Ecosystems: Insights from *Caenorhabditis elegans*, Environ. Sci. Technol. 2024, 58, 1, 231–241  
[3] Xie et al., Investigation of the inhibition mechanism of the number of primary amine groups of alkylamines on the swelling of bentonite, Appl. Clay Sci. 2017, 136, 43– 50