Supplementary Information for

Influence of inorganic nano-fertilizer on the transport and release of nano- and micro-plastics in saturated quartz sand

Yanan Liu [a], Jizhe Lu [a], Genyao Gu [a], Shenghao Liu [a], Quanyuan Chen [a], Yunfei Zhang [b], Li Cai [a, *]

[a] College of Environmental Science and Engineering, Donghua University, Shanghai 201620, P R China

[b] Natural History Research Center, Shanghai Natural History Museum, Shanghai Science and Technology Museum, Shanghai 200127, P R China

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*Corresponding author. E-mail: caili@dhu.edu.cn (Cai L.,)

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Text S1. SEM and TEM species preparation

For PS NPs and MPs characterization, SEM species were prepared by vacuum-drying 5 μL samples on silicon plates. TEM species were prepared by air-drying 5 μL samples on 230-mesh copper grids. For nano-$CaCO_3$ characterization, SEM species were prepared by vacuum-drying 10 μL solutions (200 mg L^{-1}) on silicon plates. TEM species were prepared by air-drying 10 μL samples on 230-mesh copper grids.

Text S2. Column experiment protocols

Ultrapure quartz sand (Minghai Quartz Sand Factory, Zhengzhou, China), ranging from 425 to 700 μm in size, was used as porous media for the PS NPs and MPs transport experiments. The quartz sand was cleaned by soaking in concentrated HCl for at least 24 h and 1 M NaOH solution for a further 24 h. The quartz sand was then repeatedly washed with DI water until a neutral pH was obtained. The sand was then dried at 105°C overnight and baked at 850°C for at least 8 h.

Prior to packing, the cleaned quartz sand was rehydrated by boiling in DI water for at least 0.5 h. After cooling the rehydrated quartz sand, the columns were packed with wet quartz sand that was added in small increments (~ 1 cm) under mild vibration, minimizing layering or air entrapment. An 80-mesh fabric screen was placed at each end of the column.

Text S3. Determination of the PS NPs, MPs and nano-$CaCO_3$ concentration

The concentrations of PS NPs and MPs were analyzed using a fluorescence spectrophotometer (F7000, Hitachi, Japan) with a 10 mm × 10 mm quartz cuvette. Optimum excitation/emission wavelengths of 468/508 nm were used to detect the PS NPs (both 0.51 and 1.1 μm) and the excitation and emission slits of the instrument were both set to 5 nm. The calibration results confirmed linear correlation between the concentration of NPs and MPs and the intensity of the fluorescence signals over the range of concentrations investigated (Figure S2).

The concentrations of nano-$CaCO_3$ was analyzed using a turbidity meter (WZS-188E, INESA, China). Before testing, calibration of the turbidimeter with standard liquids were performed. Then, 10 mL of the samples were taken to measure the turbidity value. Each sample were measured three times and the average value obtained as the turbidity value. The calibration results confirmed linear correlation between the concentration of nano- $CaCO_3$ and the intensity of the turbidity value over the range of concentrations investigated (Figure S3).

Table S1. Mass recovery of PS NPs or MPs without (w/o) nano-$CaCO_3$, cotransport and release with nano-$CaCO_3$, and also mass recovery of single nano-$CaCO_3$ under different experimental conditions.

	Ionic Strength	Condition	Mass Recovery (%)
PS NPs	0.1 mM NaCl	w/o nano-$CaCO_3$	73.98±0.35
		cotransport	86.16±4.86
		release	88.52±3.57
	1 mM NaCl	w/o nano-$CaCO_3$	67.17±1.46
		cotransport	88.66±0.43
		release	86.39±0.31
	10 mM NaCl	w/o nano-$CaCO_3$	72.86±0.02
		cotransport	71.10±0.32
		release	78.47±0.49
	0.1 mM $CaCl_2$	w/o nano-$CaCO_3$	90.16±0.65
		cotransport	97.46±1.98
		release	97.52±1.94
	1 mM $CaCl_2$	w/o nano-$CaCO_3$	73.96±0.12
		cotransport	90.87±0.82
		release	83.74±5.39
PS MPs	0.1 mM NaCl	w/o nano-$CaCO_3$	91.84±1.32
		cotransport	98.92±0.23
		release	95.97±0.3
	1 mM NaCl	w/o nano-$CaCO_3$	75.92±0.62
		cotransport	88.33±0.1
		release	82.11±1.3
	10 mM NaCl	w/o nano-$CaCO_3$	56.16±0.8
		cotransport	64.55±0.03
		release	56.55±1.18
	0.1 mM $CaCl_2$	w/o nano-$CaCO_3$	92.89±0.29
		cotransport	97.89±0.44
		release	95.56±0.55
	1 mM $CaCl_2$	w/o nano-$CaCO_3$	81.51±2.21
		cotransport	90.13±1.36

nano-$CaCO_3$	0.1 mM NaCl	release	86.45±0.27
		cotransport	56.39±4.32
	1 mM NaCl	release	41.80±0.72
		cotransport	42.55±6.52
	10 mM NaCl	release	36.66±1.97
		cotransport	41.37±0.82
	0.1 mM $CaCl_2$	release	47.79±5.78
		cotransport	48.80±5.53
	1 mM $CaCl_2$	release	36.38±0.55
		cotransport	58.22±6.07
		release	46.75±4.63

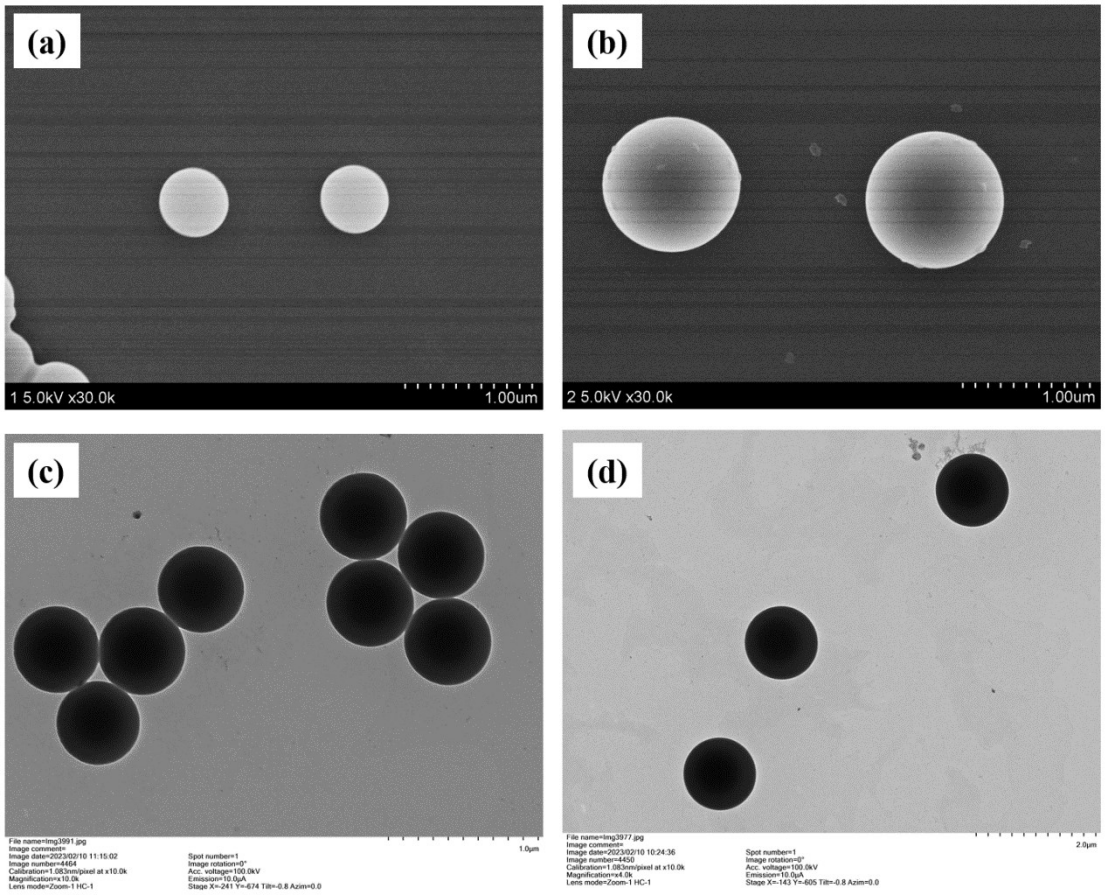

Figure S1. SEM images of PS NPs(a) and PS MPs (b); TEM images of PS NPs (c) and PS MPs (d).

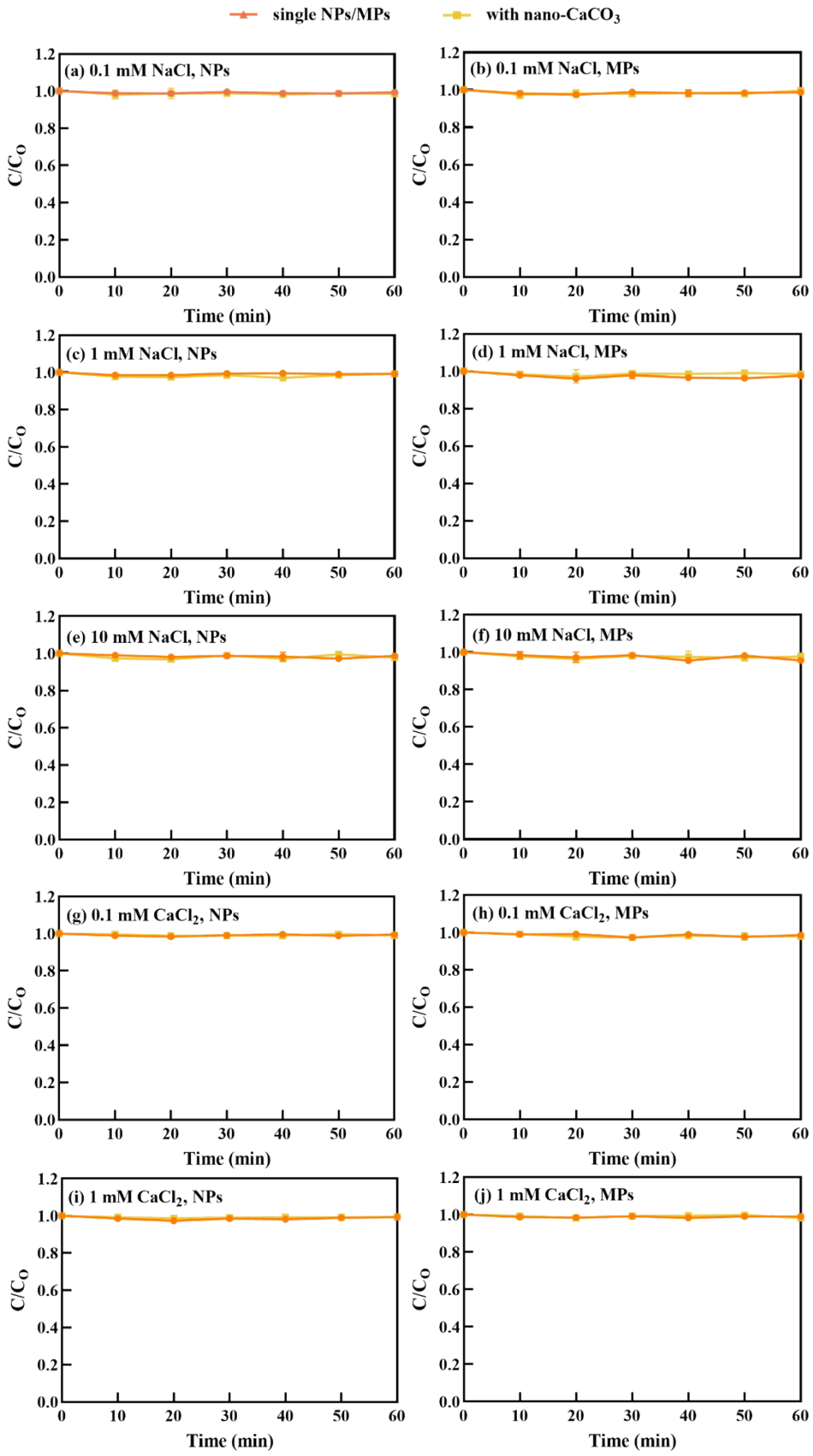

Figure S2. The variation of PS NPs and MPs concentration within 1 h.

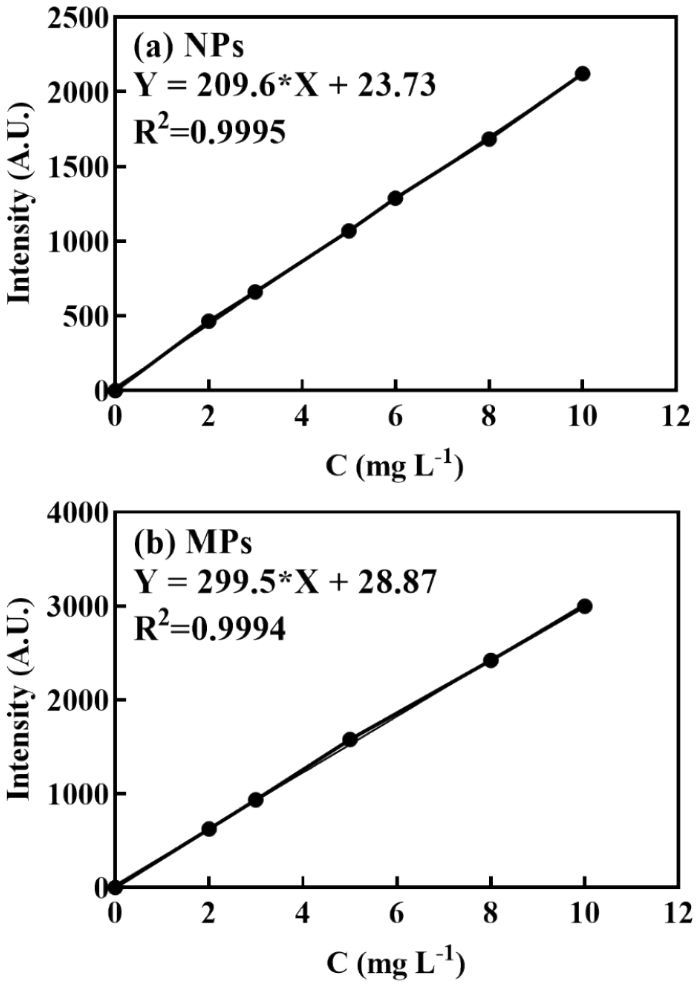

Figure S3. Calibration curves of PS NPs and MPs with fluorescence spectrophotometer.

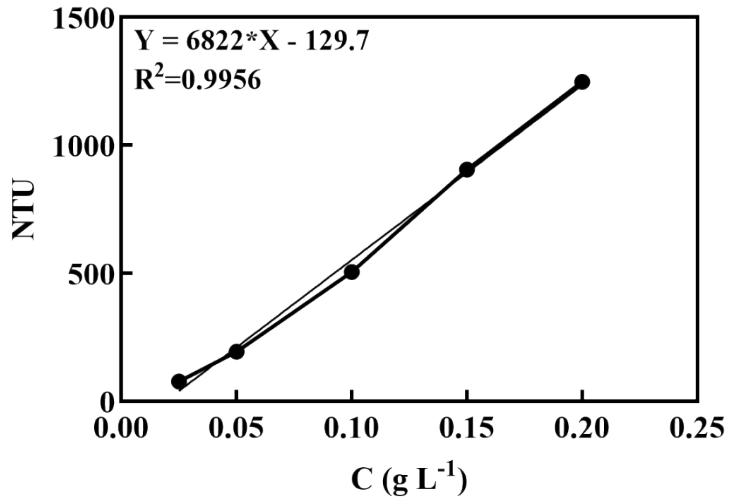

Figure S4. Calibration curves of nano-$CaCO_3$ with turbidity meter.