



Article

Polystyrene Nanoplastic Behavior and Toxicity on Crustacean *Daphnia magna* Media Composition, Size, and Surface Charge Effects

Alexis Pochelon, Serge Stoll * and Vera I. Slaveykova *

University of Geneva, Faculty of Science, School of Earth and Environmental Sciences Department F.-A. Forel for Environmental and Aquatic Sciences and Institute for Environmental Sciences, Uni Carl Vogt, 66 Boulevard Carl-Vogt, CH-1211 Geneva 4, Switzerland; alexis.pochelon@asleman.org

* Correspondence: serge.stoll@unige.ch (S.S.); vera.slaveykova@unige.ch (V.I.S.)

Supplementary Materials

Table S1. Characteristics of 20, 40, 60 and 100 nm polystyrene nano-plastics (NPLs) as provided by the manufacturer.

20 nm PS NPLs		
Lot Number : 1855061	Lot Data	Specification
Density at 20°C	1.055 g/cm ³	n.a.
Refractive Index at 590 nm, 20°C	1.591	n.a.
Mean Diameter (TEM)	0.023 µm	0.01–0.03 µm
Standard Deviation of Diameter	0.005 µm	n.a.
Percent Solids w/v	4.0%	4.0 + 0.5 %
Specific surface Area	2.5 × 10 ⁶ cm ² /g	n.a.
Surface Charge Density	3.0 µC/cm ²	n.a.
Charge Groups per Particle	3.0 × 10 ²	n.a.
40 nm PS NPLs		
Lot Number : 1071753	Lot Data	Specification
Density at 20°C	1.055 g/cm ³	n.a.
Refractive Index at 590 nm, 20°C	1.591	n.a.
Mean Diameter (TEM)	0.044 µm	n.a.
Standard Deviation of Diameter	0.006 µm	n.a.
Percent Solids w/v	4.0%	4.0 + 0.5 %
Specific surface Area	1.3 × 10 ⁶ cm ² /g	n.a.
Surface Charge Density	3.4 µC/cm ²	n.a.
Charge Groups per Particle	1.3 × 10 ³	n.a.
60 nm PS NPLs		
Lot Number : 1540263	Lot Data	Specification
Density at 20°C	1.055 g/cm ³	n.a.
Refractive Index at 590 nm, 20°C	1.591	n.a.
Mean Diameter (TEM)	0.068 µm	0.05–0.07 µm
Standard Deviation of Diameter	0.008 µm	n.a.
Percent Solids w/v	4.1%	4.0 + 0.5 %
Specific surface Area	8.4 × 10 ⁵ cm ² /g	n.a.
Surface Charge Density	4.8 µC/cm ²	n.a.
Charge Groups per Particle	4.4 × 10 ³	n.a.

100 nm PS NPLs		
Lot Number : 1071755	Lot Data	Specification
Density at 20°C	1.055 g/cm ³	n.a.
Refractive Index at 590 nm, 20°C	1.591	n.a.
Mean Diameter (TEM)	0.10 µm	n.a.
Standard Deviation of Diameter	0.009 µm	n.a.
Percent Solids w/v	4.1%	4.0 + 0.5 %
Specific surface Area	5.7 × 10 ⁵ cm ² /g	n.a.
Surface Charge Density	3.2 µC/cm ²	n.a.
Charge Groups per Particle	6.4 × 10 ³	n.a.

Table S2. Ionic compositions and DOC of freshwaters sampled from Station 1 to Station 5 of transect Pointe à la Bise. The concentration are mean of 3 replicates, SD is standard deviation.

Station 1

Name of element	Unit	Mean Value	SD
Sodium Na ⁺	mg/L	7.757	0.080
Potassium K ⁺	mg/L	2.265	0.047
Magnesium Mg ²⁺	mg/L	5.761	0.205
Calcium Ca ²⁺	mg/L	64.458	0.101
Chloride, Cl ⁻	mg/L	12.242	0.057
Phosphate, PO ₄ ³⁻	mg/L	0.099	0.001
Sulfate SO ₄ ²⁻	mg/L	43.705	0.508
Nitrate, NO ₃ ⁻	mg/L	1.710	0.012
Dissolved Organic Carbon (DOC)	mg/L	1.681	0.004

Station 2

Name of element	Unit	Mean Value	SD
Sodium Na ⁺	mg/L	7.771	0.012
Potassium K ⁺	mg/L	1.947	0.011
Magnesium Mg ²⁺	mg/L	5.817	0.040
Calcium Ca ²⁺	mg/L	62.289	0.1076
Chloride, Cl ⁻	mg/L	11.181	0.077
Phosphate, PO ₄ ³⁻	mg/L	0.112	0.001
Sulfate SO ₄ ²⁻	mg/L	44.667	0.317
Nitrate, NO ₃ ⁻	mg/L	1.506	0.017
Dissolved Organic Carbon (DOC)	mg/L	1.515	0.004

Station 3

Name of element	Unit	Mean Value	SD
Sodium Na ⁺	mg/L	7.489	0.049
Potassium K ⁺	mg/L	1.936	0.001
Magnesium Mg ²⁺	mg/L	5.437	0.088
Calcium Ca ²⁺	mg/L	58.175	0.049
Chloride, Cl ⁻	mg/L	10.786	0.009
Phosphate, PO ₄ ³⁻	mg/L	0.088	0.004
Sulfate SO ₄ ²⁻	mg/L	44.740	0.039
Nitrate, NO ₃ ⁻	mg/L	1.560	0.001
Dissolved Organic Carbon (DOC)	mg/L	1.326	0.004

Station 4

Name of element	Unit	Mean Value	SD
Sodium Na ⁺	mg/L	7.448	0.001
Potassium K ⁺	mg/L	1.887	0.008
Magnesium Mg ²⁺	mg/L	5.195	0.005
Calcium Ca ²⁺	mg/L	54.753	0.014
Chloride, Cl ⁻	mg/L	10.763	0.019
Phosphate, PO ₄ ³⁻	mg/L	0.042	0.001
Sulfate SO ₄ ²⁻	mg/L	45.271	0.251
Nitrate, NO ₃ ⁻	mg/L	1.679	0.008
Dissolved Organic Carbon (DOC)	mg/L	1.116	0.004

Station 5

Name of element	Unit	Mean Value	SD
Sodium Na ⁺	mg/L	7.785	0.006
Potassium K ⁺	mg/L	1.685	0.027
Magnesium Mg ²⁺	mg/L	5.165	0.003
Calcium Ca ²⁺	mg/L	50.275	0.144
Chloride, Cl ⁻	mg/L	10.749	0.004
Phosphate, PO ₄ ³⁻	mg/L	0.000	n.a.
Sulfate SO ₄ ²⁻	mg/L	46.194	0.171
Nitrate, NO ₃ ⁻	mg/L	2.026	0.014
Dissolved Organic Carbon (DOC)	mg/L	0.8795	0.004

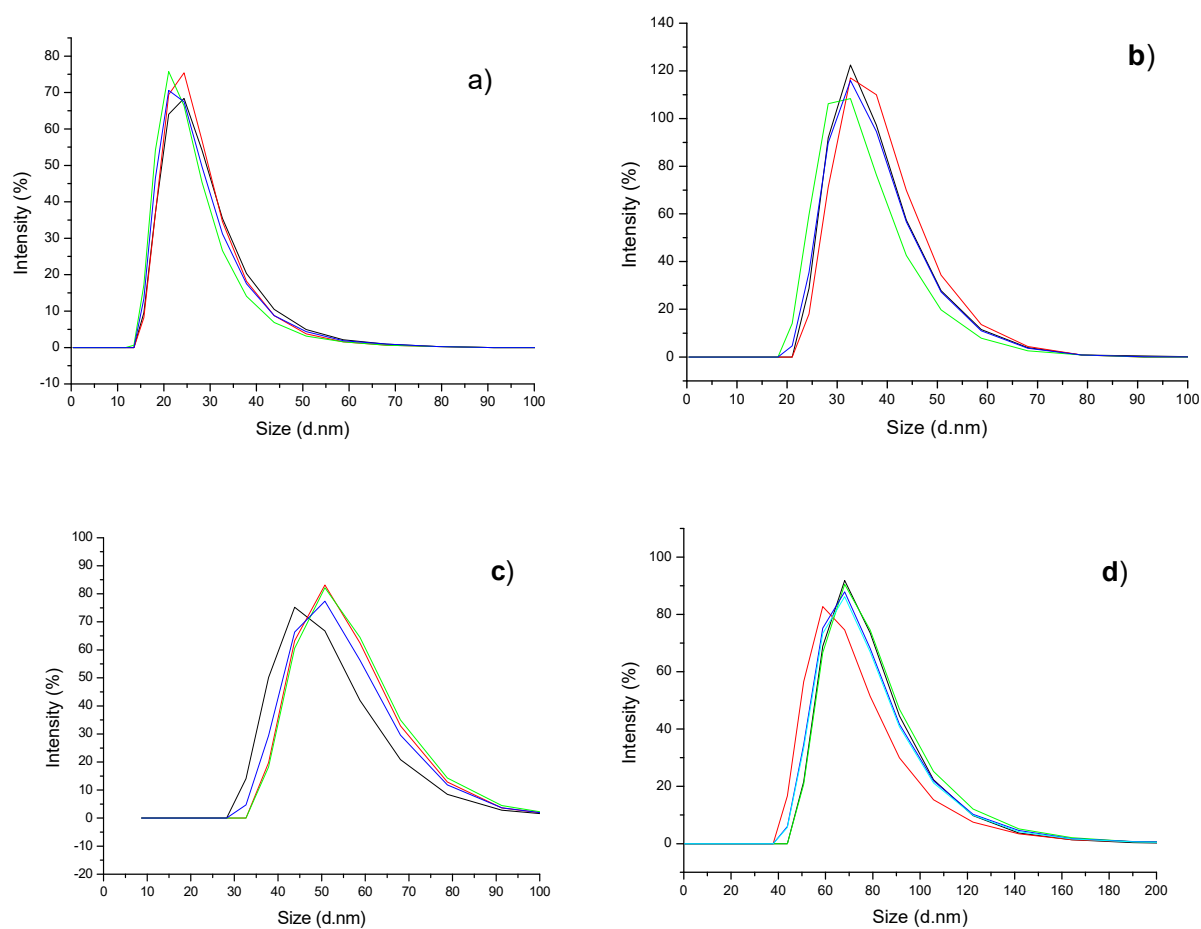


Figure S1. Intensity Particle Size Distribution measured in Ultra-Pure Water by Dynamic Light Scattering: (a) 20, (b) 40, (c) 60 and (d) 100 nm NPLs. The different colors indicate consecutively measurements (10 sub-measures for each).

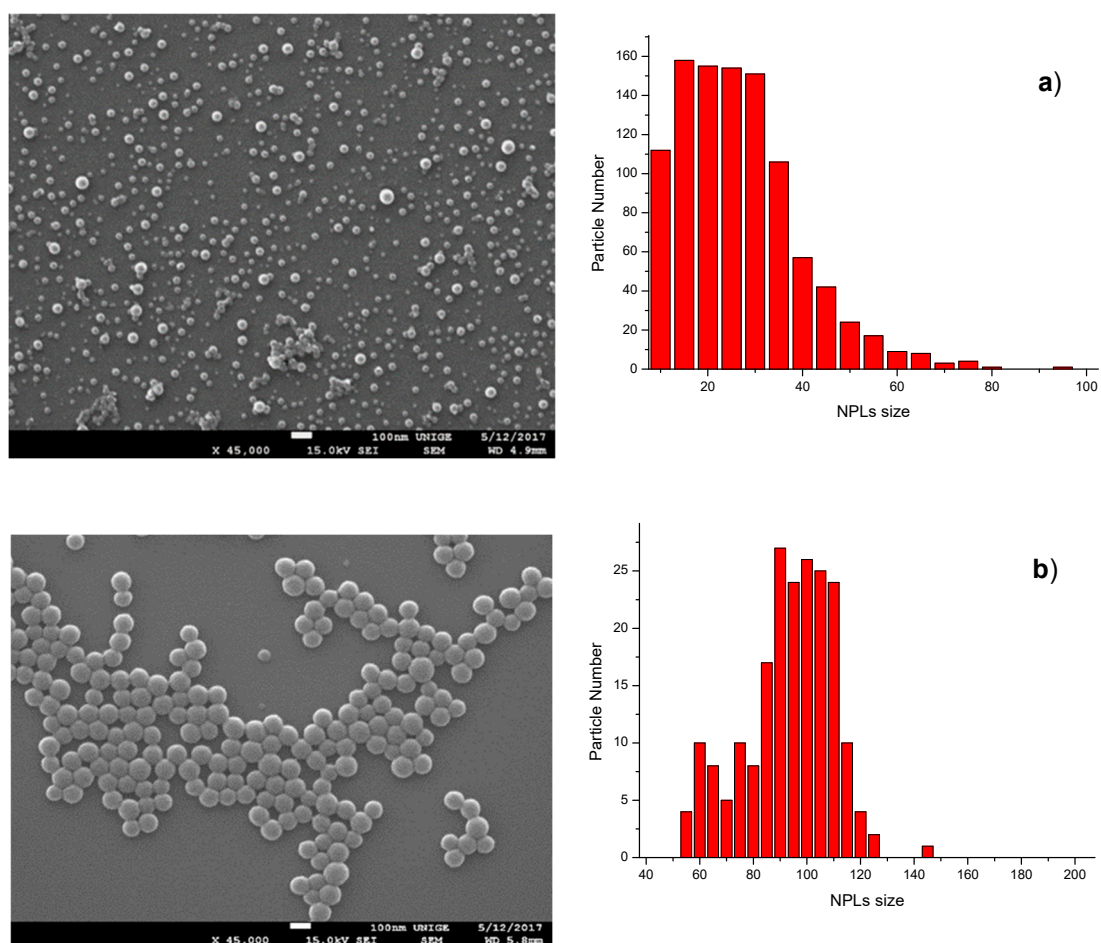


Figure S2. SEM images and results of size image analysis of (a) 20 and (b) 100 nm NPLs.

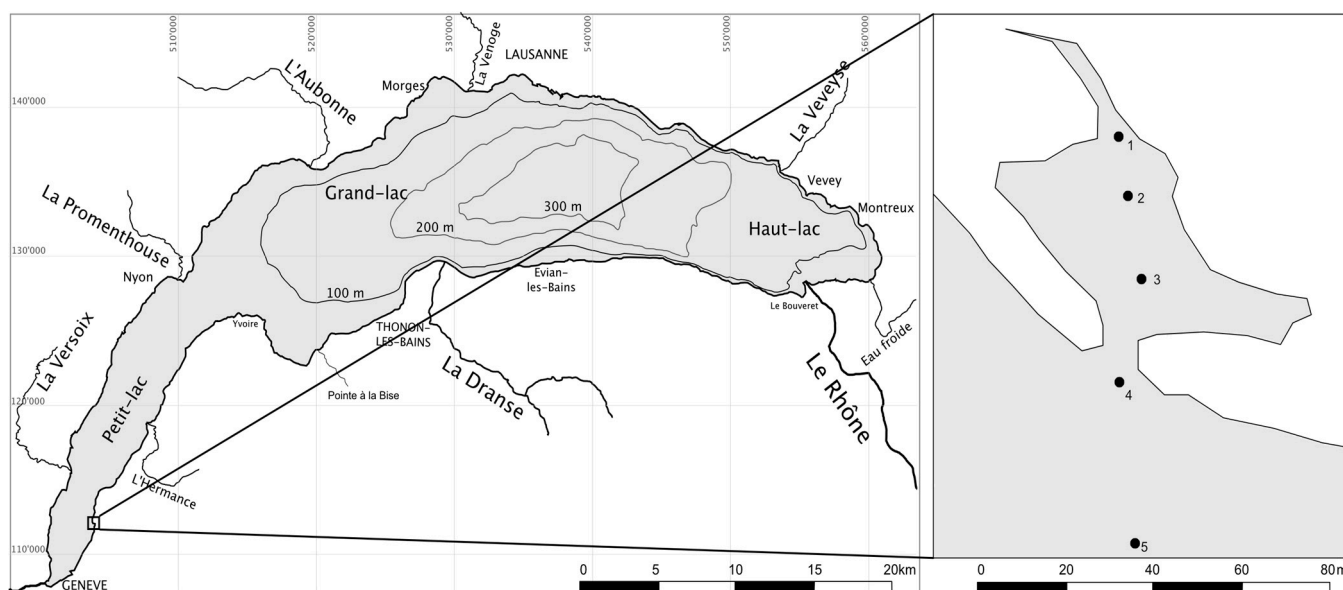


Figure S3. Lake Geneva map and location of the ‘Pointe-à-la-Bise’ marsh (left). Insert corresponds to the ‘Pointe-à-la-bise’ area and the transect is indicated by the different numbers (right).

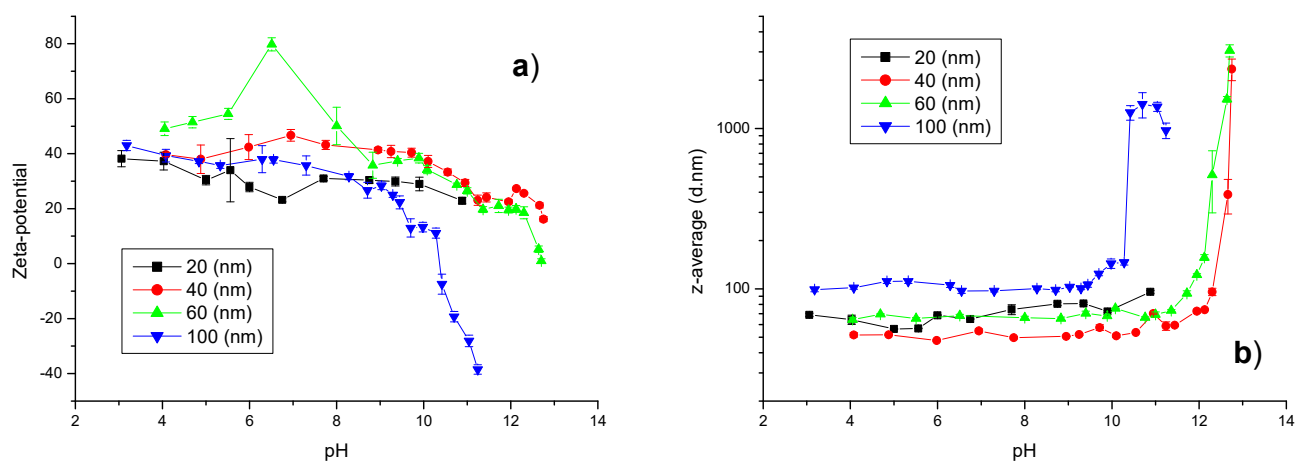


Figure S4. ζ -Potential and z-average hydrodynamic diameter (nm) variations as a function of pH obtained in ultra-pure water. .