Effect of TiO_2 nanoparticles on the transport of *Pseudomonas putida* in porous media

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Abstract

The transport of nanoparticles (NPs) in soil environment is controlled by their characteristics, the porous media type and structure, the solution chemistry and the presence of other contaminants and microorganisms. The scope of this study was to investigate the effect of TiO_2 NPs on the transport of *Pseudomonas putida* in porous media.

Methods

Flow-through experiments were conducted in glass columns with diameter of 2.54 cm and length of 30 cm, packed with 2-mm diameter spherical glass beads. Anatase TiO_2 NP solutions were prepared in distilled water at two different concentrations 5 and 50 mg/L. The concentration of *P. putida* solutions varied from 10^5 to 10^9 cfu/mL. Initially, transport experiments were conducted separately for *P. putida* and TiO_2 NPs, and followed by TiO_2 and *P. putida* cotransport experiments.

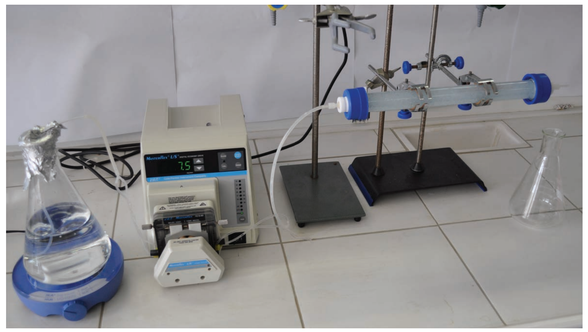

Fig. 1. Experimental setup arrangement.

The concentration of TiO_2 NPs solution was measured by a fluorescence spectrophotometer at 625 nm. *P. putida* concentrations were determined by plate counts on agar plates and optical density measurements. All experiments were conducted with two different flow rates: 1 and 2 mL/min, which correspond to interstitial velocities (U) of 0.49 and 0.98 cm/min, respectively.

Results

P. Putida transport

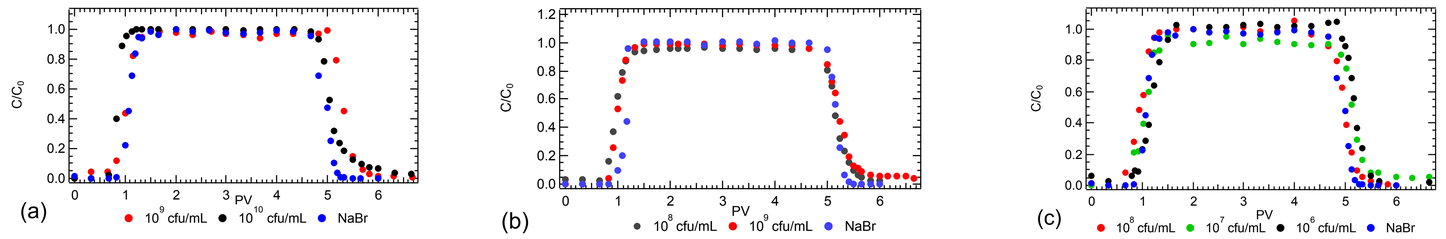

Figure 1. Experimental data for the transport of *P. putida* with U equal to: (a, c) 0.98 cm/min, and (b) 0.49 cm/min.

The transport experiments with *P. putida* exhibited similar behavior with the tracer (NaBr) indicating that there was not considerable retention. The mass recovery of *P. putida* was close to 100% in all of the transport experiments conducted.

Cotransport

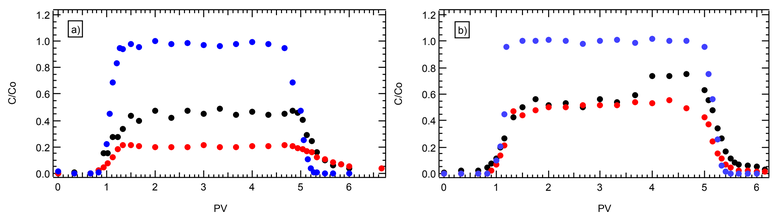

Figure 2. Experimental data for cotransport of TiO_2 NPs (5mg/L) with U equal to: (a) 0.98 cm/min, and (b) 0.49 cm/min. The blue symbols represent the tracer.

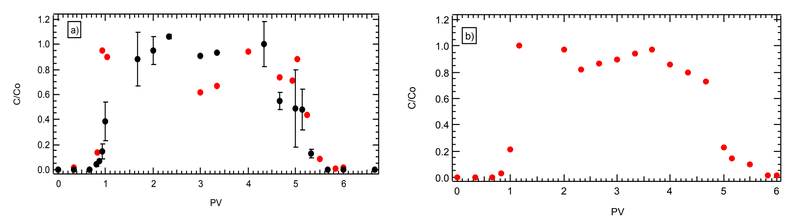

Figure 3. Experimental data for cotransport of *P. putida* (colonies) with U equal to: (a) 0.98 cm/min, and (b) 0.49 cm/min.

NaBr (mg/L)	TiO_2 NPs (mg/L)	*P. Putida* (cfu/ml)	Mass recovery (%)
Transport experiments			
		$3x10^{10}$	108.4
		$1.5x10^9$	105.5
		$3x10^8$	101.8
		$2.5x10^7$	100.5
		$7.2x10^7$	96.5
		$1x10^6$	103.3
		$1.5x10^5$	109.6
	5		57.8
25			99.5
*Cotransport experiments**			
	5	$3x10^5$	46.0
	5	-	60.2
	5	$2x10^5$	47.7
	5	$2.5x10^5$	51.3

* The values of mass recovery represent TiO_2 NPs.

Conclusions

Based on the preliminary results of the present study:

- The transport of *P. putida* was not significantly affected by the presence of TiO_2.
- The mass recovery of NPs in the transport and cotransport experiments was 46 to 60%.

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Cotransport of TiO_2 nanoparticles and Pseudomonas putida in porous media

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The scope of this study was to investigate the cotransport of Pseudomonas putida and TiO_2 nanoparticles (NPs) in porous media. Flowthrough experiments were conducted in glass columns with diameter of 2.5 cm and length of 30 cm, packed with 2-mm diameter spherical glass beads. Anatase TiO_2 NPs solutions were prepared in distilled water of at two different concentrations: 5 and 50 mg/L. The concentration of P. putida solutions varied from 105 to 109 cfu/mL. Initially, transport experiments were conducted separately for P. putida and TiO_2 NPs. Subsequently, TiO_2 and P. putida cotransport experiments were conducted. The concentration of TiO_2 NPs was measured by a fluorescence spectrophotometer and P. putida concentration was determined by plate counts on agar plates and optical density measurements. All experiments were conducted with two different flow rates: 1 and 2 mL/min. The transport experiments with P. putida exhibited similar transport behavior with the tracer (NaBr) indicating that there was not considerable retention. The mass recovery of P. putida was close to 100% in all of the transport experiments conducted. However, the transport experiments with TiO_2 NPs suggested that a significant portion of the NPs was retained in the column. Based on the cotransport experimental data, it is evident that the transport of P. putida was not significantly affected by the presence of TiO_2. It should be noted that the mass recovery of NPs in the transport and costransport experiments was between 40 and 60%.