Electronic Supplementary Material (ESI) for Environmental Science: Processes & Impacts

Polyaromatic hydrocarbons (PAHs) sorption behavior unaffected by the presence of multi-walled carbon nanotubes (MWNTs) in a natural soil system

Shibin Li†* [a], Todd A. Anderson†, Micah J. Green‡, Jonathan D. Maul†, and Jaclyn E. Cañas-Carrell†

†Department of Environmental Toxicology, The Institute of Environmental and Human Health (TIEHH), Texas Tech University, Box 41163, Lubbock TX 79409-1163

‡Department of Chemical Engineering, Texas Tech University, Box 43121, Lubbock TX 79409-3121

* *Corresponding author: li.shibin@epa.gov*

[a] *Present address: Office of Research and Development, Mid-Continent Ecology Division, National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency, Duluth, Minnesota, USA*

Table S1 shows Freundlich parameters and sorption coefficients for naphthalene in various sorbents.

Table S2 shows Freundlich parameters and sorption coefficients for fluorene in various sorbents.

Table S3 shows Percent desorption for PAHs in various sorbents.

Figure S1 shows Sorption behavior of naphthalene in various sorbents.

Figure S2 shows Sorption behavior of fluorene in various sorbents.

Table S1. Freundlich parameters and sorption coefficients for naphthalene in various sorbents. Data are presented as average ± standard deviation.

Sorbent	Freundlich equation			linear equation		
	K_f [a]	1/n	r^2	K_d [b]	Log K_{oc}	r^2
MWNTs	7573 ± 637	0.32 ± 0.04	0.85 ± 0.06	1833 ± 131	5.26 ± 0.03	0.86 ± 0.08
Sand	0.31 ± 0.05	0.08 ± 0.05	0.05 ± 0.05	0.04 ± 0.01	1.55 ± 0.13	0.25 ± 0.18
Sand + MWNTs	0.88 ± 0.02	0.20 ± 0.02	0.74 ± 0.19	0.07 ± 0.04	1.34 ± 0.24	0.50± 0.44
Sandy loam	NA	NA	NA	1.84 ± 0.33	2.15 ± 0.08	0.79 ± 0.02
Sandy loam + MWNTs	4.64 ± 0.50	0.73 ± 0.08	0.45 ± 0.06	3.99 ± 0.15	2.42 ± 0.02	0.90 ± 0.08
Silt loam	10.99 ± 0.94	0.81 ± 0.09	0.85 ± 0.03	7.80 ± 0.06	2.49 ± 0.00	0.96 ± 0.02
Silt loam + MWNTs	16.01 ± 2.20	0.70 ± 0.04	0.79 ± 0.02	9.40 ± 0.70	2.54 ± 0.03	0.95 ± 0.05

[a] $\mu g^{1-1/n} mL^{1/n} g^{-1}$

[b] mLg^{-1}

NA = not available

Table S2. Freundlich parameters and sorption coefficients for fluorene in various sorbents. Data are presented as average ± standard deviation.

Sorbent	Freundlich equation			linear equation		
	K_f[a]	1/n	r^2	K_d[b]	Log K_{oc}	r^2
MWNTs	16450± 2843	0.33 ± 0.09	0.73 ± 0.09	14810 ± 1541	6.17± 0.05	0.92 ± 0.01
Sand	0.60 ± 0.16	1.30 ± 0.40	0.97 ± 0.03	0.69 ± 0.03	2.84 ± 0.02	0.80 ± 0.25
Sand + MWNTs	3.20 ± 0.57	0.56 ± 0.25	0.46± 0.13	3.71 ± 0.73	3.09 ± 0.08	0.60 ± 0.05
Sandy loam	29.82 ± 3.37	0.79 ± 0.12	0.87 ± 0.06	20.07 ± 1.99	3.19 ± 0.04	0.84 ± 0.09
Sandy loam + MWNTs	48.88 ± 3.27	0.63 ± 0.09	0.95 ± 0.01	42.62 ± 6.40	3.45 ± 0.07	0.91 ± 0.06
Silt loam	77.34 ±4.63	0.73 ± 0.03	0.95 ± 0.02	63.45 ± 4.38	3.40 ± 0.03	0.88 ± 0.04
Silt loam + MWNTs	83.50 ± 8.84	0.65 ± 0.06	0.93± 0.04	77.43 ± 12.84	3.45± 0.07	0.86 ± 0.10

[a] $\mu g^{1-1/n}\, mL^{1/n}\, g^{-1}$

[b] mLg^{-1}

Table S3. Percent desorption for PAHs in various sorbents. Data are expressed as a percentage of the mass of adsorbed PAHs.

Sorbent/ log k_{ow} [a]	Naphthalene/3.29	Fluorene/4.18	Phenanthrene/4.45
MWNTs	7.6	6.8	3.5
Sand	0.0	7.0	3.3
Sand + MWNTs	2.1	4.7	3.9
Sandy loam	0.0	4.3	7.9
Sandy loam + MWNTs	0.0	3.0	7.4
Silt loam	0.0	1.5	6.6
Silt loam + MWNTs	0.0	1.3	0.0

[a] ATSDR, 2005. ATSDR's Toxicological Profiles on CD-ROM, CRC Press, Boca Raton, FL.

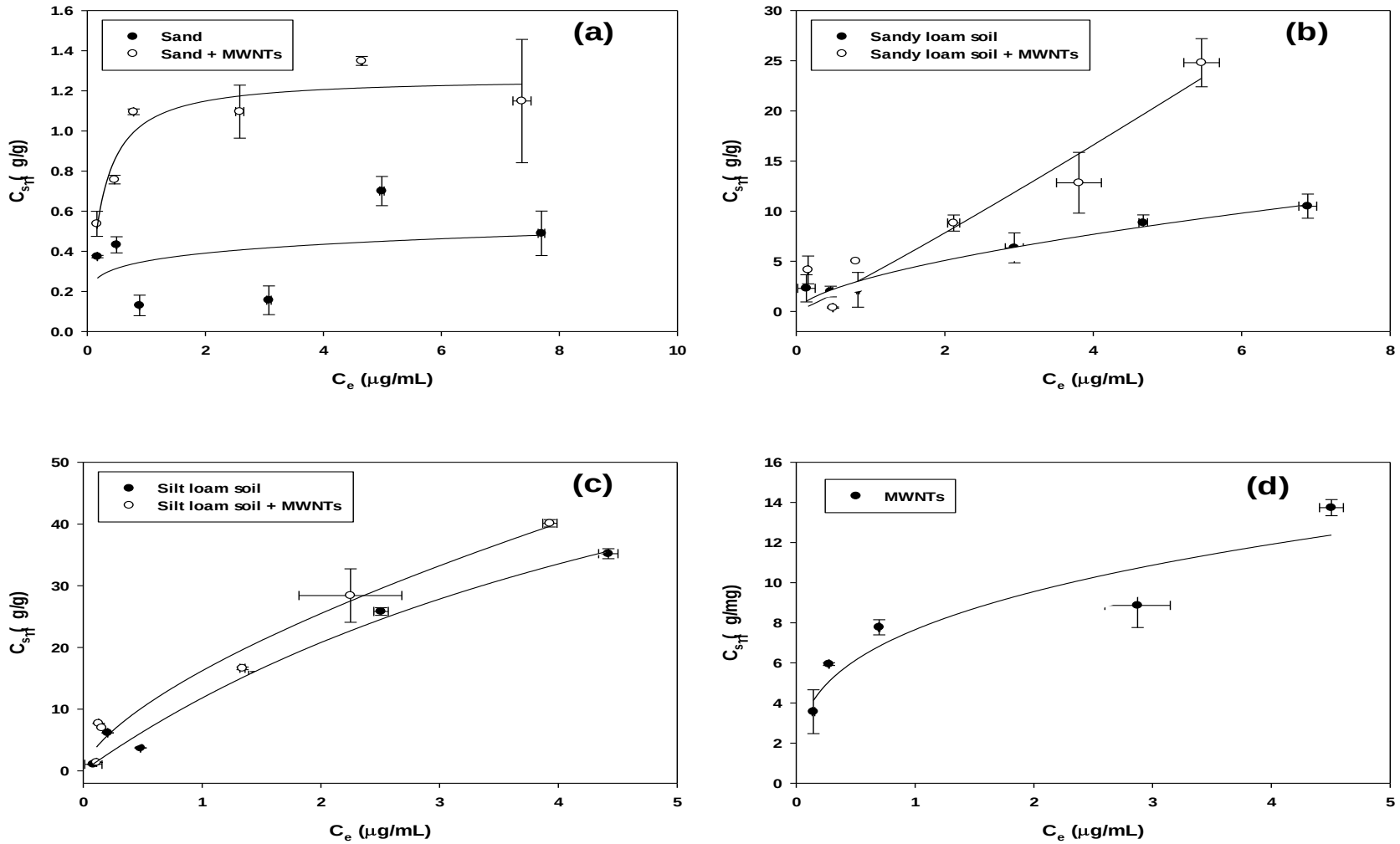

Figure S1. Sorption of naphthalene in (a) sand with or without addition of MWNTs, (b) sandy loam soil with or without addition of MWNTs, (c) silt loam soil with or without addition of MWNTs and (d) MWNTs. Data points represent means (n = 3) and error bars for both solution and sorbent concentration indicate ±1 standard deviation of the mean. The y axis unit is μg/g (except for MWNTs which is μg/mg). Solid lines are the isotherms fitted by Freundlich equation.

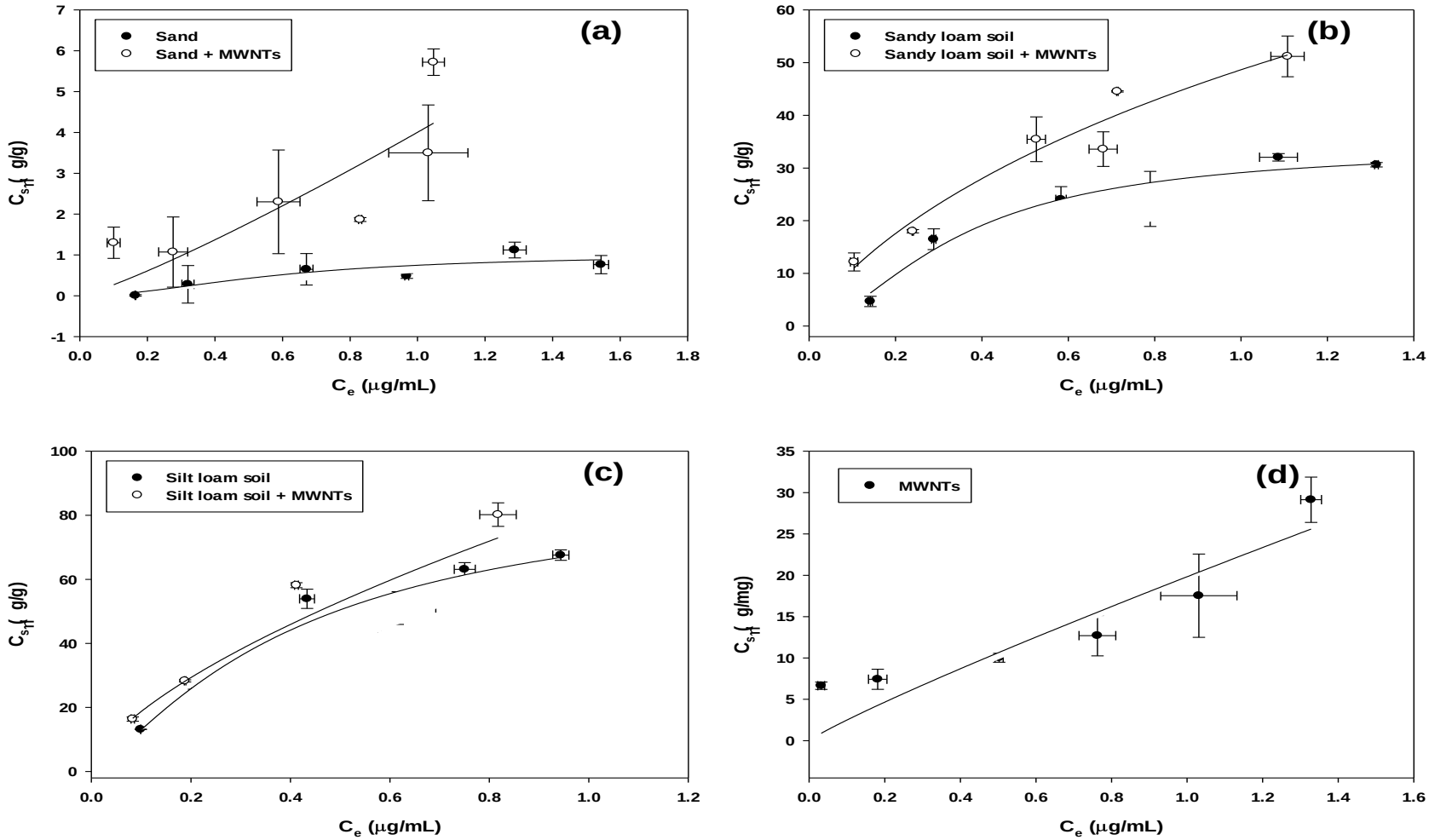

Figure S2. Sorption of fluorene in (a) sand with or without addition of MWNTs, (b) sandy loam soil with or without addition of MWNTs, (c) silt loam soil with or without addition of MWNTs and (d) MWNTs. Data points represent means (n = 3) and error bars for both solution and sorbent concentration indicate ±1 standard deviation of the mean. The y axis unit is μg/g (except for MWNTs which is μg/mg). Solid lines are the isotherms fitted by Freundlich equation