ADSORPTION BEHAVIOR OF CHLORINATED PHENOLS ON POLYETHYLENE IN DANUBE RIVER WATER

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INTRODUCTION

A significant amount of plastic comes into the environment, where during the time, large pieces under physical, chemical and biological processes break down into smaller ones. Plastic components detected in the environment less than 5 mm are named microplastic. Microplastics (MPs) and chlorinated phenols (CPs) are ubiquitous contaminants in aquatic ecosystems.

Since microplastics can act as vectors for the transport of different contaminants in water matrices main scope of this study was to understand adsorption behaviour of four CPs on polyethylene of different origin.

MATERIAL AND METHODS

Four chlorophenols:

- 4-chlorophenol,
- 2,4-dichlorophenol,
- 2,4,6-trichlorophenol and
- pentachlorophenol

All experiments were carried out in a Danube river water, and the initial concentration of selected CPs was 100 µg/l.

Selected microplastics:

Low density polyethylene standard substance (PEp)

PE isolated from two personal care products (PE_PCPs_1 and PE_PCPs_2)

The adsorption of selected chlorinated phenols on microplastic was determined by using kinetic and isotherm studies. Chlorinated phenols were analyzed by GC with MSD, after acurate sample preparation.

RESULTS AND DISCUSION

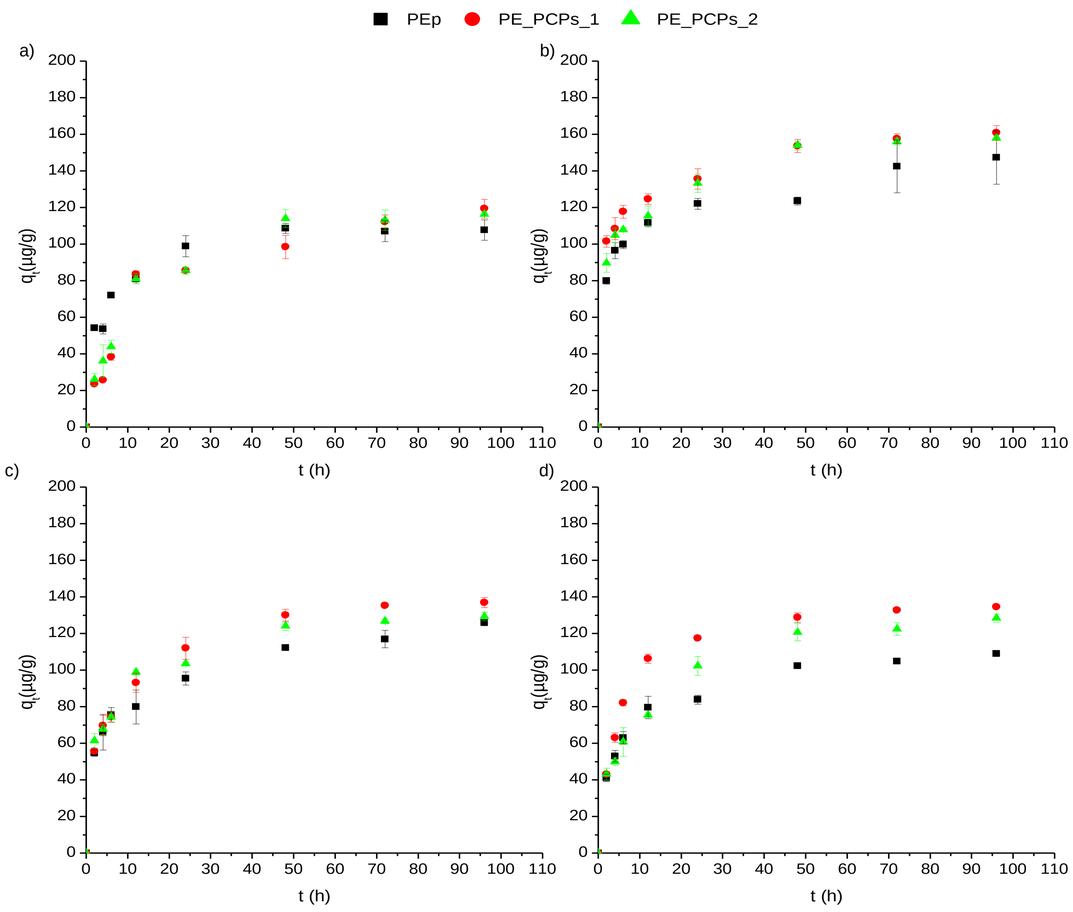

Figure 1. Experimental data (n = 3, mean value ±SD) of (a) 4-CP; (b) 2,4-DCP; (c) 2,4,6-TCP and (d) PCP on PEp, PE_PCPs_1 and PE_PCPs_2 particles in Danube water

The obtained results of the kinetic adsorption study indicated that the adsorption equilibrium between the CPs and polyethylene MPs was established after 24 h of contact time.

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In all cases, pseudo-second order kinetic model fitted data the best (R^2=0.973-0.999) indicating that chemisorption is a dominant adsorption mechanism.

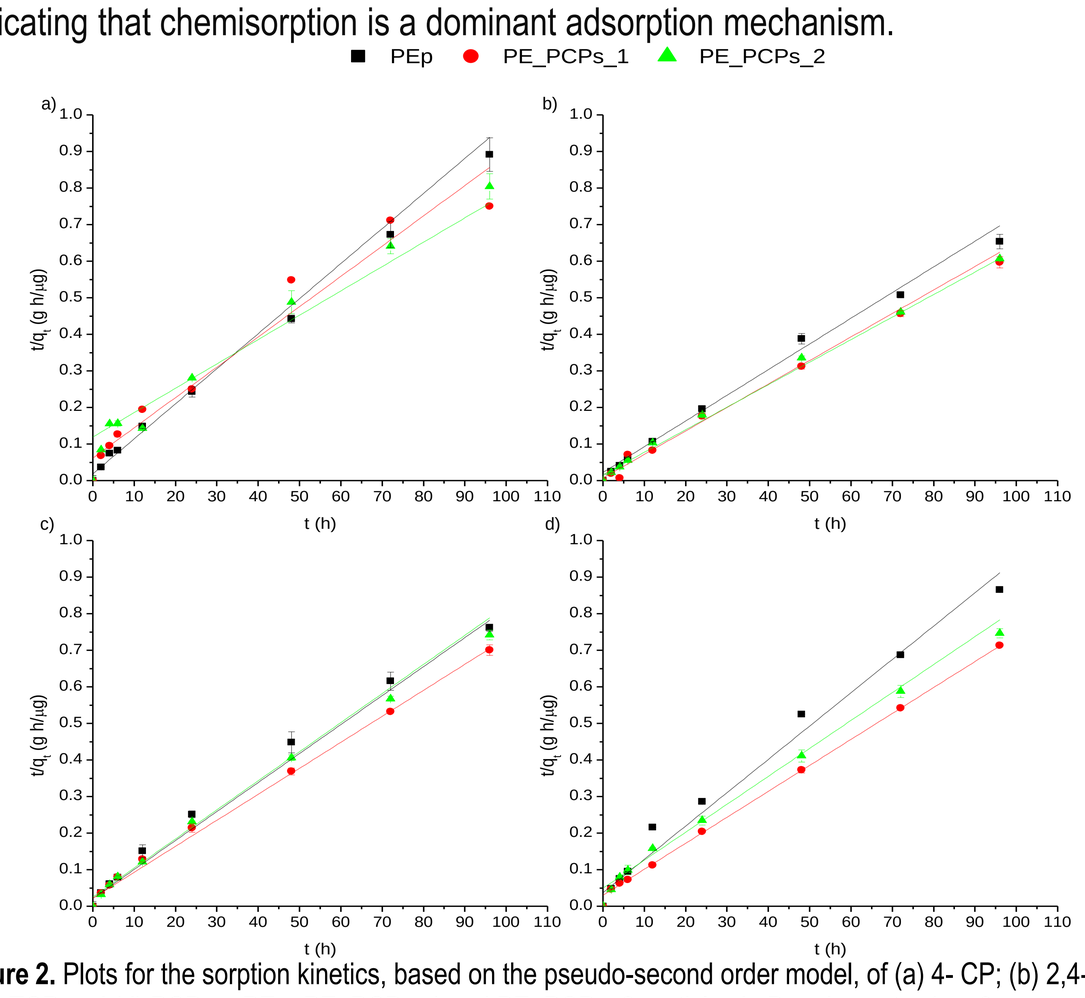

Figure 2. Plots for the sorption kinetics, based on the pseudo-second order model, of (a) 4- CP; (b) 2,4-DCP; (c) 2,4,6-TCP and (d) PCP on PEp, PE_PCPs_1 and PE_PCPs_2 particles in Danube water (n = 3, mean value SD)

Based on the obtained results Langmuir adsorption model fitted data better indicating that adsorption of the chlorinated phenols occurs at a specific site on the microplastics, with no further adsorption occurring at the same site.

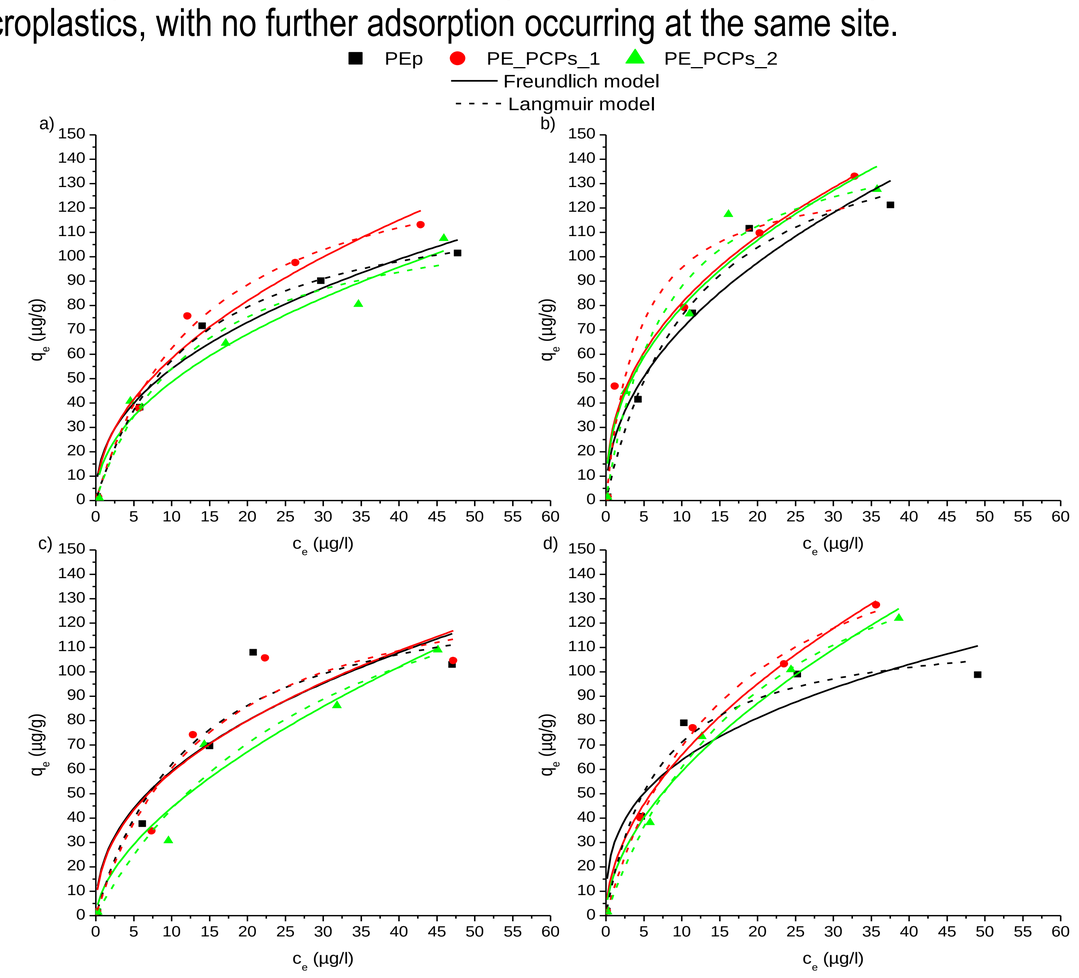

Figure 3. Sorption isotherms of (a) 4- CP; (b) 2,4-DCP; (c) 2,4,6-TCP and (d) PCP on PEp PE_PCPs_1 and PE_PCPs_2 particles in Danube water (n = 3, mean value SD)

Table 1. Values of the Freundlich and Langmuir model parameters for the sorption of 4-CP, 2,4-DCP, 2,4,6-TCP and PCP on PEp, PE_PCPs_1 and PE_PCPs_2

Compoud	Material	Freundclih model			Langmuir model		
		K_F (µg/g)/(µg/l)^n	n_F	R^2	K_L (l/µg)	q_{max} (µg/g)	R^2
4-CP	PEp_D	8.50	0.42	0.944	0.057	62.81	0.996
	PE_PCPs_1_D	18.9	0.49	0.948	0.069	153.3	0.988
	PE_PCPs_2_D	15.8	0.49	0.948	0.077	124.7	0.932
2.4-DCP	PEp_D	23.8	0.47	0.929	0.064	218.1	0.980
	PE_PCPs_1_D	30.9	0.42	0.946	0.230	138.8	0.902
	PE_PCPs_2_D	29.5	0.43	0.913	0.130	152.4	0.949
2,4,6-TCP	PEp_D	22.0	0.43	0.819	0.080	138.1	0.901
	PE_PCPs_1_D	21.2	0.44	0.830	0.069	148.3	0.906
	PE_PCPs_2_D	11.1	0.60	0.928	0.030	191.7	0.938
PCP	PEp_D	28.8	0.35	0.863	0.148	119.1	0.969
	PE_PCPs_1_D	19.5	0.53	0.990	0.062	181.5	0.996
	PE_PCPs_2_D	16.3	0.56	0.983	0.047	189.0	0.998

Maximum adsorption capacities determined by the Langmuir adsorption model also indicated that phisyco-chemical properties of the organic compound have the highest impact on adsorption behaviour in the case of chlorinated phenols toward microplastic.

CONCLUSION

The highest adsorption capacity was determined for 2,4-DCP (q_{max}=218.1µg/g) and the lowest for 4-CP (q_{max}=62.81 µg/g). The results of this study also indicated that polyethylene MPs can serve for the transport of the chlorinated phenols through freshwater bodies.