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A feasible approach to dispose of soil washing wastes: Adsorptive removal of chlorobenzene compounds in aqueous solutions using humic acid modified with monoolein (HA-M)†

Yueyue Shen,[a]‡ Shilin Zhao,[ab*]‡ Yue Li,[a] Qian Liu,[a] Chongdi Ma,[a] Hui Mao,[ab] Yang Liao,[ab*] and Jun Ma[ab*]

[a] College of Chemistry and Materials Science, Sichuan Normal University, Chengdu, Sichuan 610068, P.R. China

[b] The Engineering Center for the Development of Farmland Ecosystem Service Function, Sichuan Normal University, Chengdu, Sichuan 610068, P.R. China

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*****Corresponding author: Shilin Zhao (S. Zhao), e-mail: zhaoslin@aliyun.com

*****Corresponding author: Yang Liao (Y. Liao), e-mail: liaoyang315_sicnu@163.com

*****Corresponding author: Jun Ma (J. Ma), e-mail: hxxysyzx@qq.com

‡ Y. S. (yshen028@126.com) and S. Z. (zhaoslin@aliyun.com) contributed equally.

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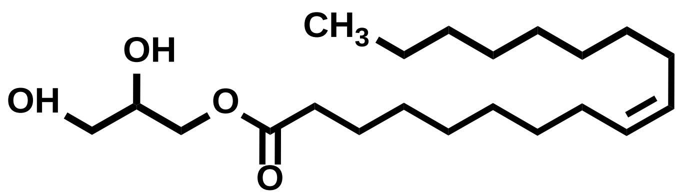

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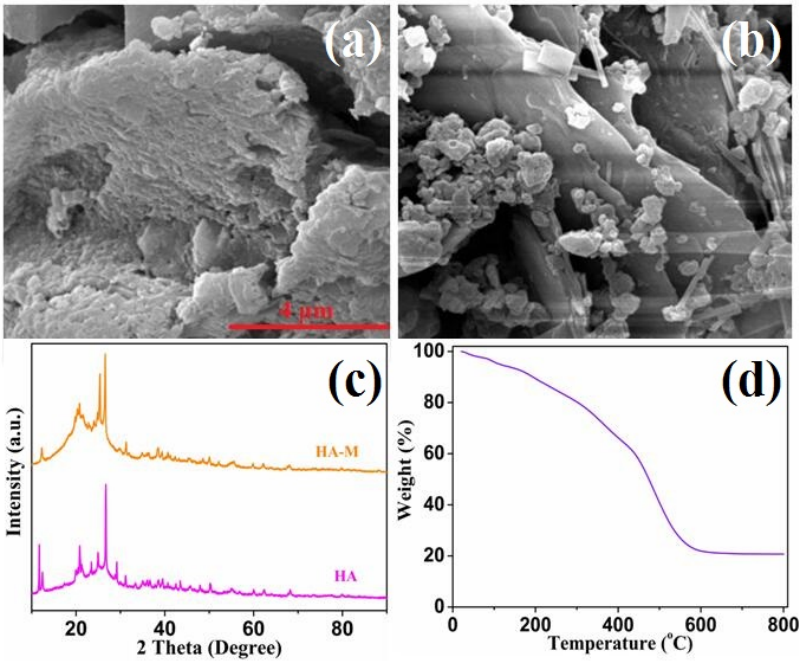

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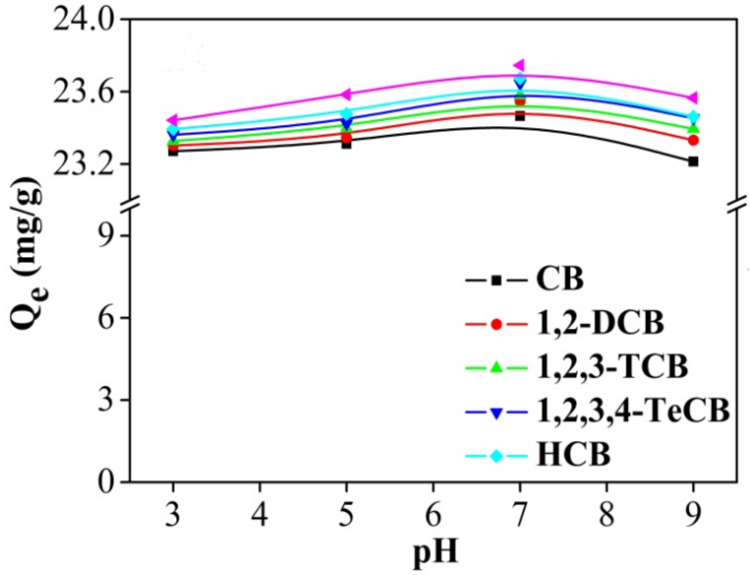

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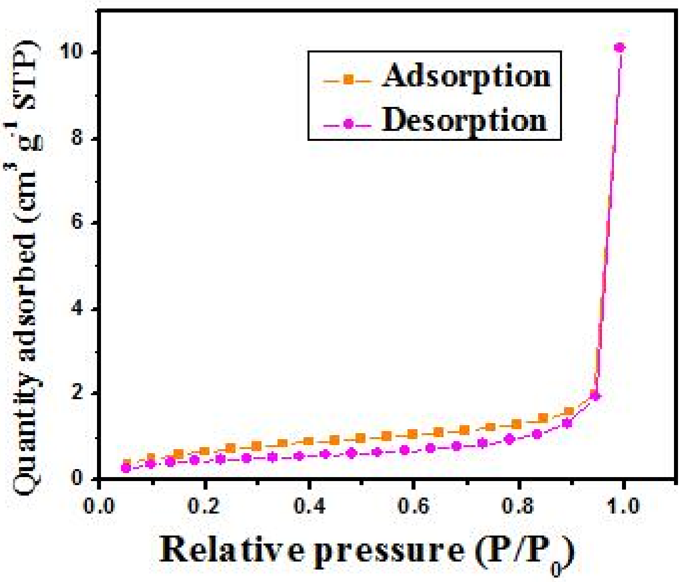

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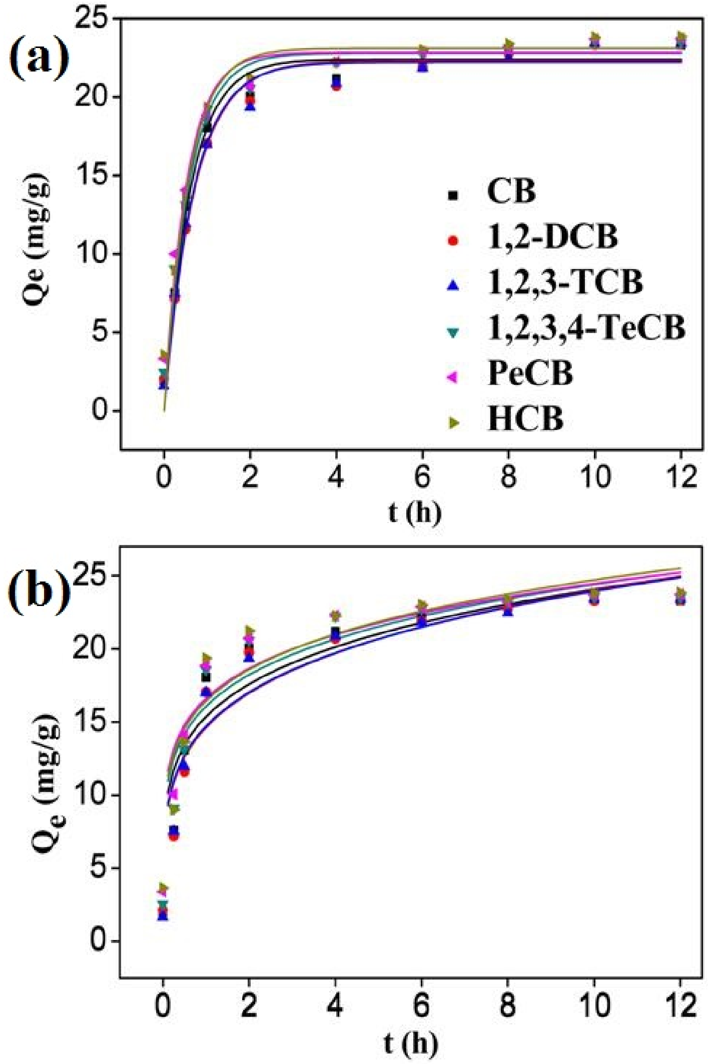

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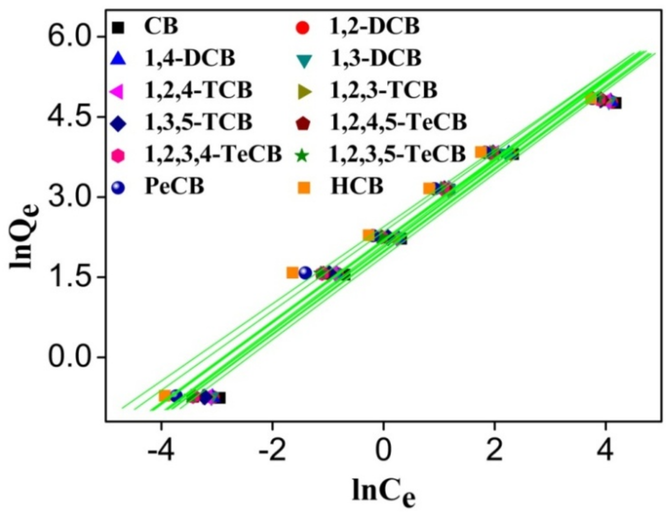


Fig. S6. Adsorption isotherm plots for adsorption of CBs onto HA-M, Freundlich model.

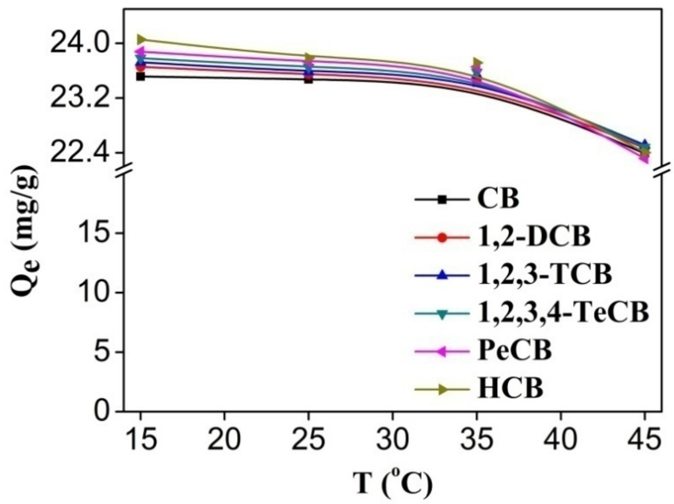
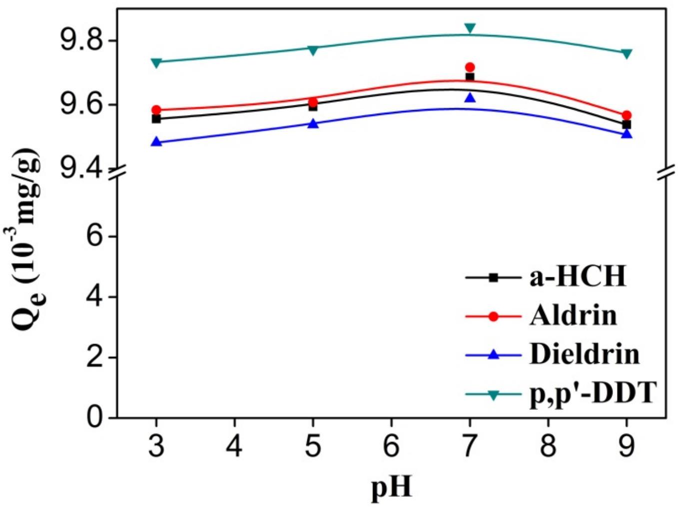


Fig. S7. The effect of temperature on the adsorptive removal efficiency of HA-M to CBs.



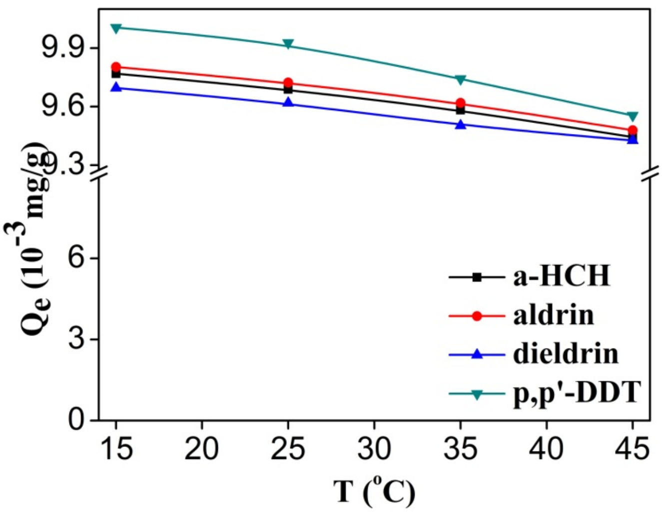


Fig. S8. The adsorption conditions of HA-M to OCPs.

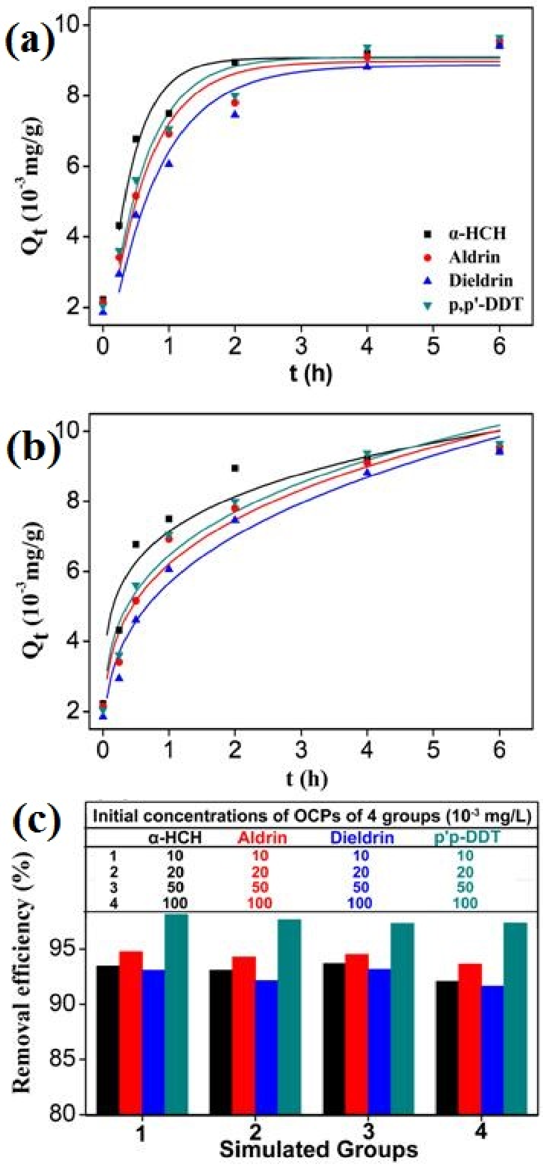


Fig. S9. Adsorption results of OCPs on HA-M. (a) Pseudo-first-order model fitting, (b) Intraparticle diffusion model fitting, (c) Adsorption efficiency of multi-compoent OCPs.

Table S1.

Fitting parameters collected from different models.

Adsorbates	*Qe(exp)*	Pseudo-first-order rate model				Pseudo-second-order rate model				Intraparticle diffusion	
	mg/g	K_1 h^{-1}	*Qe(cal)* mg/g	Error	R^2	K_2 g/(mg·h)	*Qe(cal)* mg/g	Error	R^2	K_3 g/(mg/g·$h^{-0.5}$)	R^2
CB	23.427	1.645	22.374	4.706	0.978	0.094	24.191	-3.158	0.983	15.371	0.829
1,2-DCB	23.582	1.428	22.276	5.863	0.976	0.079	24.278	-2.866	0.984	14.630	0.858
1,2,3-TCB	23.499	1.469	22.194	5.879	0.976	0.083	23.148	1.516	0.990	14.721	0.874
1,2,3,4-TeCB	23.571	1.745	22.786	3.445	0.974	0.103	24.479	-3.709	0.982	16.079	0.835
PeCB	23.769	1.948	22.826	4.131	0.954	0.118	24.401	-2.590	0.970	16.619	0.852
HCB	23.882	1.813	23.088	3.439	0.960	0.106	24.768	-3.577	0.961	16.446	0.808

Error =[*Qe*(exp)-*Qe*(cal)]/*Qe*(cal)*100; R^2, correlation coefficient.

Table S2.

The Langmuir and Freundlich model parameters of the adsorption of CBs on HA-M.

Adsorbates	Langmuir			Freundich		
	Q_{max}(mg/g)	K_4(L·mg^{-1})	R_1^2	1/n	K_5	R_2^2
CB	235.8491	0.0215	0.9798	0.5449	10.3947	0.9747
1,2-DCB	251.8892	0.0213	0.9804	0.5566	10.6031	0.9776
1,4-DCB	253.8071	0.0213	0.9789	0.5586	10.6169	0.9780
1,3-DCB	265.2512	0.0207	0.9742	0.5665	10.6635	0.9795
1,2,4-TCB	271.0027	0.0218	0.9655	0.5653	11.2533	0.9757
1,2,3-TCB	277.0083	0.0216	0.9607	0.5686	11.3399	0.9771
1,3,5-TCB	280.1120	0.0225	0.9615	0.5702	11.6450	0.9788
1,2,4,5-TeCB	284.0909	0.0226	0.9579	0.5699	11.8703	0.9838
1,2,3,4-TeCB	287.3563	0.0229	0.9533	0.5719	12.0313	0.9836
1,2,3,5-TeCB	290.6977	0.0229	0.9512	0.5738	12.1214	0.9837
PeCB	301.2048	0.0270	0.9509	0.5611	13.4374	0.9842
HCB	306.7485	0.0287	0.9011	0.5788	13.7986	0.9875

Table S3.

The adsorption performances of other sorbents to CBs.

Adsorbates	Adsorption performance of other sorbents					Ref.
	Sorbent	**Adsorption capacity (mg/g)**	**Temp. (°C)**	**Time (h)**	**Medium**	
HCB	HA-M	23.882	25	12	deionized water(methanol as cosolvent)	This work
CB	Marine Sediment	< 19	25	~6.6	deionized water	1
1,2,4-TCB	Graphene oxide	< 3	23±1	24	deionized water	2
1,2,4,5-TeCB	Carbon Nanotube	~12	Room temperature	3	deionized water(methanol as cosolvent)	3
HCB	Carbonaceous material	0.992	25	24	methanol	4

Table S4.

Thermodynamic parameters for the adsorptive removal of CBs on HA-M.

Sorbates	T (K)	ΔG^{O} (KJ/mol)	ΔH^{O} (KJ/mol)	ΔS^{O} (J/K·mol)	Log K_d
CB	288	-2.052	62.21	0.675	0.857
	298	-2.122			0.856
	308	-2.190			0.855
	318	-2.210			0.853
1,2-DCB	288	-2.071	61.88	0.653	0.865
	298	-2.138			0.863
	308	-2.205			0.861
	318	-2.227			0.842
1,2,3-TCB	288	-2.126	62.21	0.675	0.888
	298	-2.194			0.885
	308	-2.265			0.884
	318	-2.287			0.865
1,2,3,4-TeCB	288	-2.183	67.21	0.682	0.912
	298	-2.253			0.909
	308	-2.235			0.908
	318	-2.343			0.887
PeCB	288	-2.349	80.36	0.706	0.981
	298	-2.424			0.978
	308	-2.502			0.977
	318	-2.516			0.951
HCB	288	-2.453	84.75	0.734	1.024
	298	-2.526			1.019
	308	-2.608			1.018
	318	-2.627			0.994

Table S5.

The effect of coexisting organic matters on the adsorption removal CBs on HA-M.

CBs (Removal efficiency)	Coexisting organic matters		
	Benzene	Trichloroethylene	Blank
1,3,5-TCB (%)	95.86 [a]; 91.00 [b]	95.63 [a]	94.29

[a] Conceraction of coexisting organic matters, 0.5 g/L;
[b] Conceraction of coexisting organic matters, 1.0 g/L;
Conditions: Temp., 25 °C; Time, 12 h; 1,3,5-TCB, 10 mg/L.

Table S6.

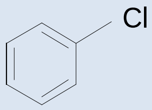
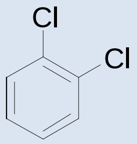
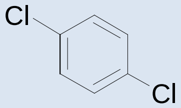
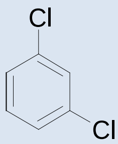
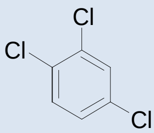
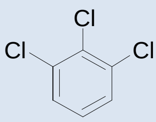
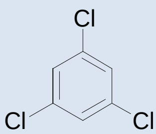
Fitting parameters collected from different models of OCPs adsorption removal.

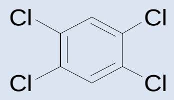
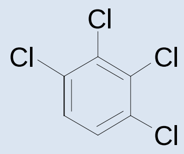
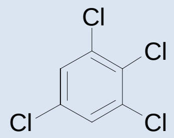
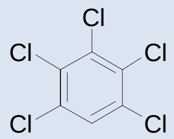
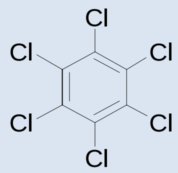
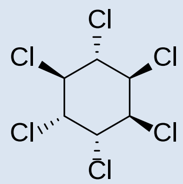
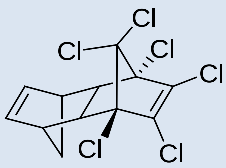
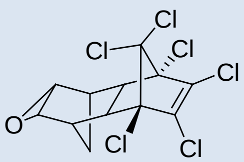
Adsorbates	*Qe(exp)*	Pseudo-first-order rate model				Pseudo-second-order rate model				Intraparticle diffusion	
	μg/g	K_1 h^{-1}	*Qe(cal)* μg/g	Error	R^2	K_2 g/(μg·h)	*Qe(cal)* μg/g	Error	R^2	K_3 g/(μg/g·h$^{-0.5}$)	R^2
α-HCH	9.681	2.477	9.073	6.701	0.939	0.461	9.831	-1.526	0.999	7.130	0.819
Aldrin	9.791	1.620	8.970	9.153	0.940	0.243	10.12	-3.270	0.999	6.200	0.928
Dieldrin	9.632	1.286	8.858	8.738	0.944	0.202	10.05	-4.159	0.998	5.660	0.955
p,p'-DDT	9.842	1.753	9.094	8.225	0.929	0.283	10.16	-3.123	0.999	6.450	0.923

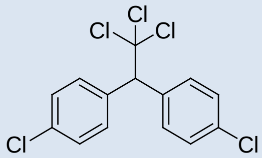
Error =[*Qe*(exp)-*Qe*(cal)]/*Qe*(cal)*100; R^2, correlation coefficient.

Table S7.

Physicochemical properties of CBs and OCPs.

CBs &OCPs	CAS Registry number	Molar mass ($g \cdot mol^{-1}$)	lgKow	Ref.	Molecular structure
CB	108-90-7	112.56	2.84	5	
1,2-DCB	95-50-1	147.00	3.38	6	
1,4-DCB	106-46-7	147.00	3.38	6	
1,3-DCB	541-73-1	147.00	3.48	6	
1,2,4-TCB	120-82-1	181.45	3.98	6	
1,2,3-TCB	87-61-6	181.45	4.04	6	
1,3,5-TCB	108-70-3	181.45	4.02	6	

1,2,4,5-TeCB	95-94-3	215.9	4.51	6	
1,2,3,4-TeCB	634-66-2	215.9	4.55	6	
1,2,3,5-TeCB	634-90-2	215.9	4.65	6	
PeCB	608-93-5	250.3	5.03	6	
HCB	118-74-1	284.8	5.47	6	
α-HCH	319-84-6	290.83	3.80~4.44	7	
Aldrin	309-00-2	364.9	5.31	8	
Dieldrin	60-57-1	380.91	4.30	9	

p,p'-DDT	50-29-3	354.48	6.36	10	

lgKow, the octanol-water partition coefficient.

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