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## **APPENDICES**



## APPENDIX A

**TABLE A-1 Concentrations of different drugs ( $\mu\text{g/L}$ ) as measure in waste water, surface waters, groundwater, and drinking water. (Kümmerer, 2001)**

Active substance/ Group	Waste- water	Surface water	Groundwater (GW), Drinking water (DW)	References
Analgesics/ Antirheumatic agent	2.4	Up to 0.5		UBA (1997)
	20	Up to 0.5	0.006 (DW)	Ternes et al. (1997)
Antibiotic		Up to 0.5		Heberer et al. (1997)
		Up to 1.7		Hirsch et al. (1999)
	Approx. 1 0.1-1.7	Up to 6 <sup>a</sup>		UBA (1997)
Lipid lowering agent	Up to 1	Up to 1		Ternes et al. (1997)
	1.7 up to 1		0.17 (DW)	Richardson and Bowron (1985)
		0.55		Stan et al. (1994)
			7.5 (GW)	Ternes et al. (1997)
Psychopharmacological Agents	<1		0.07 (DW)	Heberer et al. (1997)
	Up to 6.1			UBA (1997)
				Ternes et al. (1997)
Cytostatic agents	Up to 5	Up to 0.02 Up to 4 <sup>a</sup>		Aherne et al. (1990)
X-ray contrast media		9 <sup>a</sup>		Kümmerer et al. (1997)
		Up to 3.1 <sup>a</sup>	Up to 0.07	Steger-Hartmann et al. (1997)
		0.01-0.15		Kümmerer (1998)
				Steger-Hartmann et al. (1998)
				Hirsch et al. (2000)

<sup>a</sup> STP-effluent (diluted by surface water).

**TABLE A-2 Amount of pharmaceuticals sold (antibiotic and hormone) in Thailand during 1999-2001.**

Custom code	Name	<u>1999</u>		<u>2000</u>		<u>2001</u>		<u>Total</u>	
		Kgs.	Baht (Million)	Kgs.	Baht (Million)	Kgs.	Baht (Million)	Kgs.	Baht (Million)
<b>Antibiotic</b>									
2941.100-008	Penicilin and derivatives	546,027	768.2	700,899	900.2	N/A	1122.8	1,246,926	2791.2
2941.200-004	Streptomycin	18,708	19.3	14,155	11.8	16,816	15.2	49,679	46.4
2941.300-102	Aureomycin	13,217	13.8	10,424	10.3	7,858	6.4	31,499	30.5
2941.300-203	Terramycin (oxytetracycline)	253,615	124.7	239,000	92.5	220,275	70.0	712,890	287.3
2941.300-904	Tetracycline and derivatives	115,225	40.1	64,523	51.7	59,962	44.1	239,710	135.9
2941.400-003	Chloramphenical and derivatives	84,436	62.0	71,250	60.0	56,290	57.5	211,976	179.5
2941.500-005	Erythromycin and derivatives	119,653	230.9	161,999	338.6	176,346	436.9	457,998	1,006.4
<b>Hormone</b>									
2937.21.006	Cortisone, Hydrocortisone, Predisone, and Prenisolone	952	23.4	1,084	25.5	N/A	N/A	2,036	48.9
2937.21.006	Halogenated derivatives of Corticosteroid hormones	457	87.7	9,440	91.8	10,495	102.7	20,392	282.2
2937.21.006	Other steroid hormone and derivatives	167	5.6	2,318	7.9	267	13.5	2,752	27.0
2937.21.006	Oestrogen and Progestogen	1,682	135.5	1,250	56.9	2,326	98.2	5,258	290.6
2937.21.006	Pituitang and derivatives (and similar hormone)	165	4.7	187	5.3	155	5.6	507	15.7

**TABLE A-3 Classification of mineral grains in soil. (Lagrega et al.)**

<b>Classification</b>	<b>Description</b>	<b>Size</b>
Clay	Microscopic mineral particals of a colloidal nature, laminated as layers of plates	<0.002-mm diameter (effective diameter)
Silt	Fine particals composed of minerals from the parent formation	>0.002-mm diameter <0.075-mm diameter
Sand	Granular particals composed of minerals from the parent formation	>0.075-mm diameter <2-mm diameter
Gravel	Granular particals composed of minerals from the parent formation	>2-mm diameter <75-mm diameter

## APPENDIX B

**TABLE B-1 Sorption kinetic data for nalidixic acid onto alumina.**

**Initial concentration 10 mg/L**

Time (hr)	samples			$C_{eq}$			Average ( $C_{eq}$ )	Stdev.	Ads Conc (mg/L)			q (mg/g alumina)			Ave (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.130	0.187	0.163	1.020	1.436	1.261	1.239	0.209	8.980	8.564	8.739	1.727	1.713	1.748	1.729	0.018
2	0.105	0.147	0.099	0.838	1.144	0.794	0.926	0.191	9.162	8.856	9.206	1.779	1.771	1.770	1.773	0.005
3	0.081	0.071	0.080	0.663	0.590	0.656	0.636	0.040	9.337	9.410	9.344	1.867	1.882	1.869	1.873	0.008
6	0.067	0.063	0.074	0.561	0.532	0.612	0.568	0.041	9.439	9.468	9.388	1.888	1.894	1.878	1.886	0.008
12	0.056	0.059	0.060	0.481	0.503	0.510	0.498	0.015	9.519	9.497	9.490	1.867	1.899	1.898	1.888	0.019
24	0.059	0.059	0.055	0.503	0.503	0.473	0.493	0.017	9.497	9.497	9.527	1.899	1.899	1.868	1.889	0.018
48	0.070	0.068	0.062	0.583	0.568	0.524	0.558	0.030	9.417	9.432	9.476	1.883	1.886	1.895	1.888	0.006

**TABLE B-2 Sorption kinetic data for nalidixic acid onto silica.**

**Initial concentration 10 mg/L**

Time (hr)	samples			$C_{eq}$			Average ( $C_{eq}$ )	Stdev.	Ads Conc (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.987	0.976	0.966	7.271	7.191	7.118	7.194	0.077	2.729	2.809	2.882	0.052	0.054	0.055	0.054	0.001
2	0.954	0.960	0.952	7.031	7.074	7.016	7.040	0.030	2.969	2.926	2.984	0.057	0.056	0.057	0.057	0.001
3	0.931	0.935	0.939	6.863	6.892	6.921	6.892	0.029	3.137	3.108	3.079	0.060	0.060	0.059	0.060	0.001
6	0.896	0.884	0.897	6.608	6.520	6.615	6.581	0.053	3.392	3.480	3.385	0.065	0.067	0.065	0.066	0.001
12	0.846	0.846	0.840	6.243	6.243	6.199	6.228	0.025	3.757	3.757	3.801	0.072	0.072	0.073	0.073	0.000
24	0.846	0.845	0.844	6.243	6.236	6.228	6.236	0.007	3.757	3.764	3.772	0.072	0.072	0.073	0.072	0.000
36	0.845	0.847	0.844	6.236	6.250	6.228	6.238	0.011	3.764	3.750	3.772	0.072	0.072	0.073	0.072	0.000
48	0.844	0.845	0.849	6.228	6.236	6.265	6.243	0.019	3.772	3.764	3.735	0.073	0.072	0.072	0.072	0.000

**TABLE B-3 Sorption kinetic data for nalidixic acid onto porapak.**

**Initial concentration 10 mg/L**

Time (hr)	samples			$C_{eq}$			Average ( $C_{eq}$ )	Stdev.	Ads Conc (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	1.214	1.249	1.242	8.927	9.182	9.131	9.080	0.135	1.073	0.818	0.869	0.206	0.164	0.174	0.181	0.022
2	1.223	1.240	1.225	8.993	9.117	9.007	9.039	0.068	1.007	0.883	0.993	0.196	0.177	0.191	0.188	0.010
3	1.214	1.235	1.216	8.927	9.080	8.942	8.983	0.085	1.073	0.920	1.058	0.215	0.184	0.212	0.203	0.017
6	1.193	1.223	1.218	8.774	8.993	8.956	8.908	0.117	1.226	1.007	1.044	0.245	0.201	0.209	0.218	0.023
12	1.192	1.205	1.195	8.767	8.861	8.788	8.805	0.050	1.233	1.139	1.212	0.242	0.228	0.242	0.237	0.008
24	1.177	1.181	1.170	8.657	8.686	8.606	8.650	0.041	1.343	1.314	1.394	0.269	0.263	0.273	0.268	0.005
36	1.171	1.170	1.168	8.613	8.606	8.592	8.604	0.011	1.387	1.394	1.408	0.272	0.279	0.271	0.274	0.004
48	1.178	1.173	1.167	8.664	8.628	8.584	8.626	0.040	1.336	1.372	1.416	0.267	0.274	0.278	0.273	0.005

**TABLE B-4 Sorption kinetic data for 17-a-ethynylestradiol onto porapak.**

**Initial concentration 6 mg/L**

Time (hr)	samples			$C_{eq}$			Average ( $C_{eq}$ )	Stdev.	Ads Conc (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.146	0.147	0.143	5.600	5.631	5.447	5.559	0.099	0.400	0.369	0.553	0.160	0.147	0.221	0.176	0.039
3	0.135	0.133	0.134	5.165	5.055	5.129	5.116	0.056	0.835	0.945	0.871	0.334	0.378	0.348	0.353	0.022
6	0.122	0.123	0.123	4.643	4.678	4.678	4.667	0.020	1.357	1.322	1.322	0.543	0.529	0.529	0.533	0.008
12	0.107	0.108	0.107	4.063	4.078	4.039	4.060	0.020	1.937	1.922	1.961	0.775	0.769	0.784	0.776	0.008
24	0.084	0.084	0.079	3.141	3.149	2.949	3.080	0.113	2.859	2.851	3.051	1.144	1.140	1.220	1.168	0.045
30	0.075	0.073	0.070	2.816	2.706	2.612	2.711	0.102	3.184	3.294	3.388	1.274	1.318	1.355	1.316	0.041
48	0.062	0.054	0.062	2.282	1.992	2.290	2.188	0.170	3.718	4.008	3.710	1.487	1.603	1.484	1.525	0.068
72	0.050	0.049	0.052	1.804	1.773	1.910	1.829	0.072	4.196	4.227	4.090	1.678	1.691	1.636	1.668	0.029
96	0.049	0.051	0.052	1.776	1.843	1.906	1.842	0.065	4.224	4.157	4.094	1.689	1.663	1.638	1.663	0.026

**TABLE B-5 The sorption data for acetaminophen on alumina, adsorbent: solution ratio 1:100.**

Initial Conc. (mg/L)	samples			$C_{eq}$			Average ( $C_{eq}$ )	Stdev.	Ads. Conc. (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.079	0.077	0.081	0.880	0.850	0.910	0.880	0.030	0.120	0.150	0.090	0.012	0.015	0.009	0.012	0.003
3	0.213	0.218	0.212	2.880	2.955	2.865	2.900	0.048	0.120	0.045	0.135	0.012	0.005	0.013	0.010	0.005
5	0.344	0.346	0.344	4.836	4.866	4.836	4.846	0.017	0.164	0.134	0.164	0.016	0.013	0.016	0.015	0.002
8	0.546	0.542	0.544	7.851	7.791	7.821	7.821	0.030	0.149	0.209	0.179	0.015	0.021	0.018	0.018	0.003
10	0.677	0.683	0.678	9.806	9.896	9.821	9.841	0.048	0.194	0.104	0.179	0.019	0.010	0.018	0.016	0.005

**TABLE B-6 The sorption data for nalidixic acid on alumina, adsorbent: solution ratio 1:500.**

Initial Conc. (mg/L)	samples			$C_{eq}$			Average ( $C_{eq}$ )	Stdev.	Ads. Conc. (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	( $C_{eq}$ )	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.005	0.005	0.006	0.059	0.059	0.068	0.062	0.005	0.941	0.941	0.932	0.188	0.184	0.183	0.185	0.003
2	0.012	0.010	0.013	0.120	0.103	0.129	0.117	0.013	1.880	1.897	1.871	0.369	0.365	0.374	0.369	0.005
5	0.023	0.024	0.026	0.216	0.225	0.242	0.227	0.013	4.784	4.775	4.758	0.920	0.918	0.915	0.918	0.003
7	0.032	0.031	0.032	0.294	0.285	0.294	0.291	0.005	6.706	6.715	6.706	1.265	1.291	1.265	1.274	0.015
9	0.042	0.041	0.042	0.381	0.372	0.381	0.378	0.005	8.619	8.628	8.619	1.626	1.659	1.657	1.648	0.019
10	0.051	0.053	0.052	0.460	0.477	0.468	0.468	0.009	9.540	9.523	9.532	1.871	1.867	1.906	1.881	0.022



**TABLE B-7 The sorption data for 17- $\alpha$ -ethynylestradiol on alumina, adsorbent: solution ratio 1:100.**

Initial Conc. (mg/L)	samples			$C_{eq}$			Average (q)	Stdev.	Ads. Conc. (mg/L)			q (mg/g alumina)			Average q	Stdev.
	abs1	abs2	( $C_{eq}$ )	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.031	0.026	0.028	0.911	0.716	0.794	0.807	0.098	0.089	0.284	0.206	0.036	0.114	0.082	0.077	0.039
3	0.079	0.075	0.078	2.778	2.623	2.739	2.713	0.081	0.222	0.377	0.261	0.089	0.151	0.104	0.115	0.032
5	0.130	0.132	0.129	4.763	4.840	4.724	4.776	0.059	0.237	0.160	0.276	0.095	0.064	0.111	0.090	0.024
8	0.207	0.208	0.210	7.759	7.786	7.856	7.800	0.050	0.241	0.214	0.144	0.096	0.086	0.058	0.080	0.020
10	0.259	0.256	0.255	9.782	9.665	9.626	9.691	0.081	0.218	0.335	0.374	0.087	0.134	0.149	0.123	0.032

**TABLE B-8 The sorption data for acetaminophen on silica, adsorbent: solution ratio 1:100.**

Initial Conc. (mg/L)	samples			$C_{eq}$			Average (q)	Stdev.	Ads. Conc. (mg/L)			q (mg/g alumina)			Average q	Stdev.
	abs1	abs2	(q)	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.040	0.042	0.047	0.298	0.328	0.402	0.343	0.054	0.702	0.672	0.598	0.070	0.067	0.060	0.066	0.005
3	0.172	0.176	0.166	2.268	2.328	2.179	2.258	0.075	0.732	0.672	0.821	0.073	0.067	0.082	0.074	0.008
5	0.335	0.308	0.287	4.701	4.298	3.985	4.328	0.359	0.299	0.702	1.015	0.030	0.070	0.102	0.067	0.036
8	0.501	0.502	0.489	7.179	7.194	7.000	7.124	0.108	0.821	0.806	1.000	0.082	0.081	0.100	0.088	0.011
10	0.631	0.627	0.628	9.120	9.060	9.075	9.085	0.031	0.880	0.940	0.925	0.088	0.094	0.093	0.092	0.003

**TABLE B-9 The sorption data for nalidixic acid on silica, adsorbent: solution ratio 1:50.**

Initial Conc. (mg/L)	samples			C <sub>eq</sub>			Average (C <sub>eq</sub> )	Stdev.	Ads. Conc. (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.036	0.042	0.033	0.335	0.379	0.313	0.342	0.033	0.665	0.621	0.687	0.013	0.012	0.014	0.013	0.001
2	0.115	0.104	0.105	0.911	0.831	0.838	0.860	0.044	1.089	1.169	1.162	0.022	0.023	0.023	0.023	0.001
5	0.354	0.354	0.373	2.654	2.654	2.793	2.700	0.080	2.346	2.346	2.207	0.047	0.047	0.044	0.046	0.002
7	0.541	0.541	0.556	4.018	4.018	4.128	4.055	0.063	2.982	2.982	2.872	0.060	0.060	0.057	0.059	0.001
9	0.763	0.740	0.762	5.637	5.470	5.630	5.579	0.095	3.363	3.530	3.370	0.067	0.070	0.067	0.068	0.002
10	0.859	0.878	0.859	6.338	6.476	6.338	6.384	0.080	3.662	3.524	3.662	0.073	0.070	0.073	0.072	0.002

**TABLE B-10 The sorption data for 17- $\alpha$ -ethynylestradiol on silica, adsorbent: solution ratio 1:100.**

Initial Conc. (mg/L)	samples			C <sub>eq</sub>			Average (C <sub>eq</sub> )	Stdev.	Ads. Conc. (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.057	0.046	0.059	1.938	1.498	2.012	1.816	0.278	-0.938	-0.498	-1.012	-0.375	-0.199	-0.405	-0.326	0.111
3	0.093	0.105	0.101	3.339	3.794	3.619	3.584	0.230	-0.339	-0.794	-0.619	-0.135	-0.318	-0.247	-0.233	0.092
5	0.144	0.154	0.150	5.296	5.681	5.529	5.502	0.194	-0.296	-0.681	-0.529	-0.118	-0.272	-0.212	-0.201	0.078
8	0.237	0.220	0.218	8.907	8.272	8.179	8.453	0.396	-0.907	-0.272	-0.179	-0.363	-0.109	-0.072	-0.181	0.158
10	0.275	0.298	0.293	10.389	11.288	11.086	10.921	0.472	-0.389	-1.288	-1.086	-0.156	-0.515	-0.434	-0.368	0.189

**TABLE B-11 The sorption data for acetaminophen on porapak, adsorbent: solution ratio 1:100.**

Initial Conc. (mg/L)	samples			C <sub>eq</sub>			Average (C <sub>eq</sub> )	Stdev.	Ads. Conc. (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.055	0.040	0.043	0.522	0.298	0.343	0.387	0.118	0.478	0.702	0.657	0.048	0.070	0.066	0.061	0.012
3	0.132	0.136	0.141	1.671	1.731	1.806	1.736	0.067	1.329	1.269	1.194	0.133	0.127	0.119	0.126	0.007
5	0.264	0.270	0.264	3.642	3.731	3.642	3.671	0.052	1.358	1.269	1.358	0.136	0.127	0.136	0.133	0.005
8	0.465	0.463	0.466	6.642	6.612	6.657	6.637	0.023	1.358	1.388	1.343	0.136	0.139	0.134	0.136	0.002
10	0.592	0.592	0.596	8.538	8.538	8.597	8.557	0.034	1.462	1.462	1.403	0.146	0.146	0.140	0.144	0.003

**TABLE B-12 The sorption data for nalidixic acid on porapak, adsorbent: solution ratio 1:100.**

Initial Conc. (mg/L)	samples			C <sub>eq</sub>			Average (C <sub>eq</sub> )	Stdev.	Ads. Conc. (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
1	0.109	0.099	0.091	0.867	0.794	0.736	0.799	0.066	0.133	0.206	0.264	0.013	0.021	0.026	0.020	0.007
2	0.214	0.218	0.214	1.633	1.662	1.633	1.643	0.017	0.367	0.338	0.367	0.037	0.034	0.037	0.036	0.002
5	0.516	0.523	0.498	3.836	3.887	3.705	3.809	0.094	1.164	1.113	1.295	0.116	0.111	0.130	0.119	0.009
7	0.745	0.755	0.733	5.506	5.579	5.419	5.501	0.080	1.494	1.421	1.581	0.149	0.142	0.158	0.150	0.008
9	0.924	0.950	0.944	6.812	7.001	6.958	6.924	0.099	2.188	1.999	2.042	0.219	0.200	0.204	0.208	0.010
10	1.033	1.053	1.056	7.607	7.753	7.775	7.711	0.091	2.393	2.247	2.225	0.239	0.225	0.223	0.229	0.009

**TABLE B-13 The sorption data for 17- $\alpha$ -ethynylestradiol on porapak, adsorbent: solution ratio 1:100.**

Initial Conc. (mg/L)	samples			$C_{eq}$			Average ( $C_{eq}$ )	Stdev	Ads. Conc. (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
	abs1	abs2	abs3	no.1	no.2	no.3			no.1	no.2	no.3	no.1	no.2	no.3		
5	0.042	0.042	0.043	1.821	1.818	1.850	1.829	0.018	3.179	3.182	3.150	1.272	1.273	1.260	1.268	0.007
6	0.051	0.049	0.057	2.188	2.103	2.387	2.226	0.146	3.812	3.897	3.613	1.525	1.559	1.445	1.509	0.058
7	0.065	0.058	0.061	2.687	2.437	2.537	2.554	0.126	4.313	4.563	4.463	1.725	1.825	1.785	1.778	0.050
8	0.072	0.079	0.072	2.990	3.231	2.962	3.061	0.148	5.010	4.769	5.038	2.004	1.908	2.015	1.976	0.059
9	0.080	0.081	0.086	3.292	3.330	3.513	3.378	0.118	5.708	5.670	5.487	2.283	2.268	2.195	2.249	0.047
10	0.095	0.097	0.095	3.861	3.918	3.865	3.881	0.032	6.139	6.082	6.135	2.456	2.433	2.454	2.447	0.013

**TABLE B-14 The pH study of nalidixic acid onto alumina, adsorbent: solution ratio 1:500.**

**Initial concentration 10 mg/L**

pH actual			Average (pH)	Stdev.	samples			C <sub>eq</sub>			Ads Conc (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
1	2	3			abs1	abs2	abs3	no.1	no.2	no.3	no.1	no.2	no.3	no.1	no.2	no.3		
11.03	11.03	10.90	10.987	0.075	1.103	1.104	1.099	9.084	9.092	9.052	0.916	0.908	0.948	0.178	0.175	0.181	0.178	0.003
9.90	10.10	9.95	9.983	0.104	1.090	1.094	1.103	8.980	9.012	9.084	1.020	0.988	0.916	0.196	0.192	0.183	0.190	0.007
8.98	8.92	9.10	9.000	0.092	1.014	1.011	1.034	8.373	8.349	8.533	1.627	1.651	1.467	0.307	0.317	0.293	0.306	0.012
7.86	7.99	7.91	7.920	0.066	0.598	0.589	0.578	5.050	4.978	4.891	4.950	5.022	5.109	0.980	0.985	1.002	0.989	0.011
7.09	7.06	7.01	7.053	0.040	0.152	0.156	0.161	1.488	1.520	1.560	8.512	8.480	8.440	1.669	1.663	1.671	1.668	0.004
5.95	5.97	5.92	5.947	0.025	0.029	0.027	0.026	0.506	0.490	0.482	9.494	9.510	9.518	1.880	1.865	1.866	1.870	0.008
4.98	4.85	4.90	4.910	0.066	0.137	0.135	0.124	1.368	1.352	1.264	8.632	8.648	8.736	1.723	1.730	1.713	1.722	0.008
3.89	3.96	4.15	4.000	0.135	0.460	0.458	0.453	3.948	3.932	3.892	6.052	6.068	6.108	1.198	1.190	1.198	1.195	0.005

**TABLE B-15 pH study of nalidixic acid onto alumina, adsorbent: solution ratio 1:1000.**

**Initial concentration 10 mg/L**

pH actual			Average (pH)	Stdev.	samples			C <sub>eq</sub>			Ads Conc (mg/L)			q (mg/g alumina)			Average (q)	Stdev.
1	2	3			abs1	abs2	abs3	no.1	no.2	no.3	no.1	no.2	no.3	no.1	no.2	no.3		
10.96	10.83	10.92	10.903	0.067	1.263	1.265	1.269	9.743	9.758	9.789	0.257	0.242	0.211	0.224	0.201	0.176	0.200	0.024
9.85	9.95	9.88	9.893	0.051	1.263	1.261	1.260	9.743	9.728	9.720	0.257	0.272	0.280	0.214	0.227	0.224	0.222	0.007
8.99	8.82	8.87	8.893	0.087	1.233	1.244	1.242	9.513	9.597	9.582	0.487	0.403	0.418	0.406	0.366	0.380	0.384	0.020
8.05	7.99	7.93	7.990	0.060	1.045	1.033	1.042	8.070	7.978	8.047	1.930	2.022	1.953	1.755	1.685	1.628	1.689	0.064
7.04	7.04	6.94	7.007	0.058	0.504	0.507	0.503	3.918	3.941	3.910	6.082	6.059	6.090	5.289	5.269	5.295	5.284	0.014
6.01	6.02	6.08	6.037	0.038	0.133	0.134	0.130	1.071	1.078	1.048	8.929	8.922	8.952	8.118	8.111	8.139	8.122	0.015
4.98	4.90	4.98	4.953	0.046	0.456	0.455	0.451	3.550	3.542	3.511	6.450	6.458	6.489	3.192	5.871	5.899	4.987	1.555
4.09	4.04	4.07	4.067	0.025	0.710	0.730	0.747	5.499	5.652	5.783	4.501	4.348	4.217	3.462	3.478	3.514	3.485	0.027

**TABLE B-16 Octanol-water partitioning of nalidixic acid, octanol: water ratio 1:1 (V/V).**

**Initial concentration 10 mg/L**

pH actual			Average (pH)	Stdev.	samples				C <sub>eq</sub>			Ads Conc (mg/L)			K <sub>ow</sub>			Average (K <sub>ow</sub> )	Stdev.
1	2	3			abs1	abs2	abs3	no.1	no.2	no.3	no.1	no.2	no.3	no.1	no.2	no.3			
11.00	11.20	11.10	11.100	0.100	1.298	1.311	1.312	9.678	9.774	9.781	0.322	0.226	0.219	0.033	0.023	0.022	0.026	0.006	
10.10	10.00	9.90	10.000	0.100	1.273	1.259	1.264	9.493	9.389	9.426	0.507	0.611	0.574	0.053	0.065	0.061	0.060	0.006	
9.00	9.10	9.00	9.033	0.058	1.053	1.067	1.107	7.863	7.967	8.263	2.137	2.033	1.737	0.272	0.255	0.21	0.246	0.032	
7.90	7.90	7.95	7.917	0.029	0.830	0.842	0.937	6.211	6.300	7.004	3.789	3.700	2.996	0.61	0.587	0.428	0.542	0.099	
7.00	7.00	7.05	7.017	0.029	0.418	0.395	0.371	3.159	2.989	2.811	6.841	7.011	7.189	2.165	2.346	2.557	2.356	0.196	
6.11	6.15	6.10	6.120	0.026	0.164	0.169	0.151	1.278	1.315	1.181	8.722	8.685	8.819	6.826	6.606	7.464	6.965	0.446	
4.90	5.00	4.90	4.933	0.058	0.184	0.168	0.176	1.426	1.307	1.367	8.574	8.693	8.633	6.013	6.649	6.317	6.326	0.318	
3.90	3.90	4.00	3.933	0.058	0.172	0.158	0.161	1.337	1.233	1.256	8.663	8.767	8.744	6.479	7.108	6.965	6.851	0.330	

## APPENDIX C

### Example C-1 Calculation of acid/base dilution

HCl 12.1 N



One proton is dissociated from hydrochloric acid, so 12.1 N equal to 12.1 M

Target concentration 0.1 M in 100 mL volumetric flask

$$\begin{aligned} C_1V_1 &= C_2V_2 \\ 12.1 \text{ M} * V_1 &= 0.1 \text{ M} * 100 \text{ mL} \\ V_1 &= (0.1 \text{ M} * 100 \text{ mL}) / 12.1 \text{ M} \\ &= 0.83 \text{ mL} \end{aligned}$$

(b) NaOH 50% (w/w)

It means that there is NaOH 500 g in water 1000 g

Density of water ( $\rho_w$ ) = 1 g/cm<sup>3</sup>

$$\begin{aligned} \text{NaOH 50\% (w/w)} &= (500\text{g}/1000\text{g}) * (1\text{g}/\text{cm}^3) \\ &= 500\text{g}/\text{L} \end{aligned}$$

Molecular weight (Mw) of NaOH = 40 g/mole

$$\begin{aligned} \text{Thus, NaOH 50\% (w/w)} &= (500\text{g}/\text{L}) / (40\text{g}/\text{mole}) \\ &= 12.5 \text{ M} \end{aligned}$$

Target concentration 0.1 M in 100 mL volumetric flask

$$\begin{aligned} C_1V_1 &= C_2V_2 \\ 12.5 \text{ M} * V_1 &= 0.1 \text{ M} * 100 \text{ mL} \\ V_1 &= (0.1 \text{ M} * 100 \text{ mL}) / 12.5 \text{ M} \\ &= 0.8 \text{ mL} \end{aligned}$$



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