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## **APPENDIX**

**Table 1.** Recommended and Permissible and Exposure Limit (REL) and (PEL) for toxic metals (NIOSH, 1994)

Metal	Recommended and Permissible and Exposure Limit (REL) and (PEL)
Cd	OSHA PEL : TWA 0.005 mg/m <sup>3</sup>
Cr	NIOSH REL : TWA 0.5 mg/m <sup>3</sup> OSHA PEL : TWA 1 mg/m <sup>3</sup> [*Note: The PEL also applies to insoluble chromium salts.]
Cu	NIOSH REL : TWA 1 mg/m <sup>3</sup> [*Note: The REL also applies to other copper compounds (as Cu) except Copper fume.] OSHA PEL : TWA 1 mg/m <sup>3</sup> [*Note: The PEL also applies to other copper compounds (as Cu) except copper fume.]
Mn	NIOSH REL : TWA 1 mg/m <sup>3</sup> STEL 3 mg/m <sup>3</sup> [*Note: Also see specific listings for Manganese cyclopentadienyl tricarbonyl, Methyl cyclopentadienyl manganese tricarbonyl, and Manganese tetroxide.]
Ni	NIOSH REL : TWA 0.015 mg/m <sup>3</sup> [*Note: The REL does not apply to Nickel carbonyl.] OSHA PEL : TWA 1 mg/m <sup>3</sup> [*Note: The PEL does not apply to Nickel carbonyl.]
Pb	NIOSH REL : TWA (8-hour) 0.050 mg/m <sup>3</sup> [*Note: The REL also applies to other lead compounds (as Pb)] OSHA PEL : TWA 0.050 mg/m <sup>3</sup> [*Note: The PEL also applies to other lead compounds (as Pb)]
<p><u>Note.</u> The <b>PEL (Permissible Exposure Limit)</b> is the maximum amount or <u>concentration</u> of a <u>chemical</u> that a worker may be exposed to under <u>OSHA regulations</u>.</p> <p>PEL's can be defined in two different ways as discussed in the OSHA regulation on air contaminants.</p> <ol style="list-style-type: none"> <li>1. <b>Ceiling values (C)</b>- at no time should this exposure limit be exceeded.</li> <li>2. <b>8-hour Time Weighted Averages (TWA)</b> - are an average value of exposure over the course of an 8 hour work shift.</li> </ol> <p>The <b>REL (Recommended Exposure Limit)</b>, also called NIOSH REL, is an exposure limit recommended by NIOSH (National Institute for Occupational Safety and Health) scientists to OSHA (the Occupational Safety and Health Administration). RELs are science-based recommendations rather than legal standards.</p> <p>A REL is defined in up to three ways:</p> <p>A time-weighted average (TWA) concentration that NIOSH recommends not be exceeded for up to a 10-hour workday during a 40-hour workweek.</p> <p>A ceiling value, which NIOSH recommends not be exceeded at any time during the workday (unless noted otherwise).</p> <p>A short-term (STEL) value, which NIOSH recommends not be exceeded for longer than 15 minutes during a workday (unless noted otherwise).</p>	

**Table 2. Metal concentrations data ( $\mu\text{g}/\text{m}^3$ )**

Sites	Date	Al	Cd	Cr	Cu	Fe	K	Mn	Na	Ni	Pb	Zn	TSP
CH	Wed 15/3/2006	1.27735	0.00051	0.00508	0.31997	1.30782	2.82896	0.03809	8.64941	0.00508	0.04063	2.04173	90.25252
HCH	15/3/2006	1.22179	0.00139	0.00837	0.19526	1.51748	3.54822	0.06695	8.26522	0.01116	0.10600	1.84106	168.09395
MST	15/3/2006	3.60625	0.00119	0.00954	0.16696	1.77927	5.98657	0.06440	16.43325	0.00716	0.06201	6.00565	118.92041
RPO	15/3/2006	6.55774	0.00247	0.01547	0.29695	8.30235	11.55957	0.15466	31.05029	0.02784	0.74548	10.95019	245.17294
CH	Mon 27/3/2006	9.84624	0.00052	0.01302	0.98931	1.87448	11.74155	0.05207	39.15065	0.01822	0.04686	15.33431	112.88551
HCH	27/3/2006	9.03379	0.00089	0.01192	0.20863	3.00133	11.14396	0.10432	37.13959	0.02384	0.04769	14.00521	180.13937
MST	27/3/2006	3.13481	0.00048	0.00721	0.15626	0.93756	4.82482	0.02885	17.48427	0.00481	0.01442	6.15904	65.91758
RPO	27/3/2006	1.88896	0.00028	0.00564	0.32704	4.98461	3.58903	0.05639	14.07136	0.00564	0.01692	3.60876	88.18919
CH	Sun 2/4/2006	10.92407	0.00082	0.01096	0.94527	1.65491	21.68100	0.03836	47.46913	0.00822	0.02740	15.63947	85.92393
HCH	2/4/2006	9.37774	0.00084	0.01116	0.25669	1.85546	12.24045	0.05301	39.15994	0.00837	0.03348	13.59367	125.78055
MST	2/4/2006	5.17140	0.00044	0.00889	0.09774	0.87745	6.92852	0.02221	22.94255	0.00444	0.01999	7.79487	50.51447
RPO	2/4/2006	0.97975	0.00065	0.00327	0.28413	0.96015	2.35792	0.01959	8.80465	0.00327	0.01306	1.76681	57.60903
CH	Sat 8/4/2006	9.44806	0.00065	0.01083	0.32923	1.92124	10.85163	0.04982	35.60026	0.00866	0.03466	11.98661	107.69317
HCH	8/4/2006	10.26367	0.00084	0.01126	0.34353	1.86126	12.60925	0.05632	38.20508	0.01126	0.03661	13.43429	135.94792
MST	8/4/2006	3.09956	0.00059	0.00986	0.11436	1.45514	5.25467	0.04141	16.03216	0.00592	0.02169	5.30988	88.05761
RPO	8/4/2006	1.47779	0.00103	0.01033	0.32036	5.41513	3.18983	0.08267	13.75828	0.01033	0.04823	2.66967	160.24912
CH	Wed 26/4/2006	4.69585	0.00066	0.00881	0.75327	1.89420	8.32346	0.04405	27.39319	0.00661	0.05727	8.71331	100.04009
HCH	26/4/2006	7.74280	0.00056	0.01120	0.22122	1.75858	10.80912	0.05041	38.18474	0.01400	0.02520	12.29327	115.98797
MST	26/4/2006	1.16451	0.00045	0.00673	0.09873	1.00520	2.45691	0.03814	7.71626	0.00673	0.02244	2.19215	64.88932
RPO	26/4/2006	3.94774	0.00068	0.00677	0.29769	11.68762	5.98758	0.08795	19.40381	0.01015	0.03383	6.05523	99.38703
CH	Mon 8/5/2006	10.44478	0.00070	0.01623	0.60062	1.99434	12.41130	0.05102	41.07880	0.01160	0.03479	13.91169	86.68429
HCH	8/5/2006	10.54357	0.00112	0.01123	0.24983	1.79937	12.78085	0.05614	42.43254	0.00842	0.03088	13.98511	106.83929
MST	8/5/2006	1.65505	0.00046	0.00925	0.10402	1.30370	3.42798	0.03236	10.52897	0.00693	0.03236	2.92407	85.20258
RPO	8/5/2006	3.15072	0.00068	0.00681	0.14987	7.87168	5.81094	0.07494	18.93496	0.01022	0.03066	5.64404	96.39490

Sites	Date	Al	Cd	Cr	Cu	Fe	K	Mn	Na	Ni	Pb	Zn	TSP
CH	Sat 20/5/2006	1.26362	0.00023	0.00922	0.36202	1.67176	1.24748	0.03689	22.15950	0.00461	0.02075	0.18216	86.33213
HCH	20/5/2006	1.42423	0.00087	0.00867	0.21667	0.99378	1.65245	0.02600	26.47970	0.00578	0.02889	0.23400	74.30262
MST	20/5/2006	0.91015	0.00145	0.00724	0.12312	1.32781	1.46059	0.03380	15.31085	0.00483	0.04104	0.27039	102.65176
RPO	20/5/2006	14.25940	0.00204	0.01359	0.16992	5.66162	17.26353	0.06457	57.84641	0.01019	0.06117	18.91851	112.48479
CH	Thr 1/6/2006	6.52068	ND	0.01401	0.70999	2.06224	8.03174	0.04204	22.60285	0.00934	0.03737	10.15237	115.23299
HCH	1/6/2006	1.70951	ND	0.00837	0.19242	0.95655	1.85732	0.01952	27.05936	0.00558	0.01952	0.18127	72.34050
MST	1/6/2006	1.56398	ND	0.01045	0.10664	1.37162	1.65180	0.02718	23.22975	0.00627	0.02509	0.18191	78.19916
CH	Tue 13/6/2006	2.26832	0.00093	0.01396	0.63746	1.65413	2.15199	0.04188	34.12480	0.00698	0.07677	0.29546	100.27127
HCH	13/6/2006	2.51157	0.00084	0.00844	0.13781	0.90563	2.59032	0.02250	43.80207	0.00281	0.05063	0.25875	68.79405
MST	13/6/2006	2.08055	0.00067	0.00891	0.10692	1.37886	2.14515	0.03119	36.59895	0.00446	0.06460	0.30518	94.53800
RPO	13/6/2006	3.20161	0.00066	0.00993	0.19203	2.42355	3.43005	0.05297	55.94366	0.00662	0.05297	0.41717	87.07571
CH	Mon 19/6/2006	2.17952	0.00070	0.01408	0.99944	1.69154	2.12087	0.04692	35.83427	0.01408	0.02815	0.26276	107.73273
HCH	19/6/2006	2.42019	0.00056	0.00836	0.20609	0.91906	2.44248	0.02785	46.99188	0.00836	0.02785	0.22559	71.51968
MST	19/6/2006	1.44845	0.00063	0.00843	0.09699	0.98250	1.36201	0.02530	23.63061	0.00633	0.02319	0.16024	76.82901
RPO	19/6/2006	2.85015	0.00097	0.00968	0.17107	9.58013	2.90825	0.10329	46.93552	0.01937	0.05164	0.37443	126.91732
CH	Sun 25/6/2006	2.22389	0.00139	0.01387	0.67503	1.84476	2.05282	0.05086	36.21329	0.01387	0.05086	0.35370	109.85353
HCH	25/6/2006	1.68583	0.00056	0.00840	0.15682	0.90732	1.81745	0.03360	36.96226	0.00560	0.02240	0.16802	69.00144
MST	25/6/2006	1.41521	0.00170	0.00850	0.09562	1.39396	1.64683	0.04250	25.40788	0.00850	0.04037	0.24437	93.19977
RPO	25/6/2006	2.04999	0.00160	0.01279	0.15991	4.81317	2.55210	0.08315	35.75175	0.01599	0.04797	0.55647	135.66412
CH	Fri 7/7/2006	2.34710	0.00052	0.01294	0.84620	2.31864	1.94600	0.05952	36.14589	0.01035	0.03623	0.25101	122.66001
HCH	7/7/2006	1.98260	0.00057	0.00855	0.17946	1.29325	2.36716	0.03988	34.30811	0.00855	0.03703	0.25067	107.27694
MST	7/7/2006	1.80774	0.00044	0.01102	0.10582	2.07449	1.99512	0.04630	27.42248	0.00661	0.03968	0.24471	126.80608
RPO	7/7/2006	2.94132	0.00177	0.01064	0.16676	5.75492	2.79940	0.09225	45.99320	0.01064	0.04967	0.59607	159.59070
CH	Tue 25/7/2006	2.10038	0.00050	0.01246	0.40612	2.14274	2.13277	0.05481	27.58648	0.00747	0.05980	0.27656	123.38174
HCH	25/7/2006	2.09041	0.00029	0.00878	0.34840	1.21209	2.30999	0.03806	37.32873	0.00586	0.19909	0.29570	79.28329
MST	25/7/2006	1.99745	0.00066	0.01537	0.11414	2.08086	1.88990	0.04829	29.73572	0.00878	0.65192	0.54217	113.74512
RPO	25/7/2006	3.40791	0.00107	0.01426	0.20319	5.58954	3.07995	0.07842	45.15122	0.01069	0.60244	0.49550	163.97884

Sites	Date	Al	Cd	Cr	Cu	Fe	K	Mn	Na	Ni	Pb	Zn	TSP
CH	Mon 31/7/2006	1.22622	0.00062	0.01237	0.46782	1.32308	1.33957	0.04328	20.46032	0.00824	0.04122	0.33180	84.94906
HCH	31/7/2006	1.87536	0.00028	0.00559	0.13695	0.74344	2.16044	0.02515	35.45017	0.00559	0.02236	0.24036	61.04003
MST	31/7/2006	1.80416	0.00046	0.00915	0.11433	1.35598	1.66925	0.03201	27.71871	0.00457	0.02744	0.21952	87.02969
RPO	31/7/2006	2.44642	0.00071	0.00712	0.15669	2.13662	2.54257	0.04273	37.32311	0.00712	0.43445	0.27776	104.76536
CH	Sun 6/8/2006	1.78254	0.00046	0.01141	0.57060	1.78026	1.70951	0.04793	26.42546	0.00913	0.05934	0.29443	80.75081
HCH	6/8/2006	1.90785	0.00084	0.00840	0.14568	1.19626	2.17400	0.03082	31.15317	0.00560	0.13167	0.19611	75.75376
MST	6/8/2006	2.00223	0.00130	0.00870	0.10218	1.55439	1.67396	0.03044	29.56816	0.00652	0.03261	0.21522	86.35008
RPO	6/8/2006	2.38339	0.00107	0.01067	0.20632	2.18774	2.45809	0.04980	39.39711	0.00711	0.20988	0.56561	109.63602
CH	Fri 18/8/2006	1.63920	0.00084	0.01055	0.62868	1.69616	1.58013	0.03797	27.22083	0.00844	0.12447	0.27847	91.55886
HCH	18/8/2006	1.76685	0.00084	0.00843	0.17135	1.10112	2.04494	0.03371	29.10955	0.00562	0.05618	0.25000	78.59551
MST	18/8/2006	1.88360	0.00117	0.01172	0.21298	2.04968	2.02038	0.04885	26.56384	0.00782	0.10160	0.33412	116.84571
RPO	18/8/2006	2.98288	0.00109	0.01455	0.34922	5.01270	3.43395	0.07639	44.81233	0.01455	0.55292	0.48017	153.50925
CH	Mon 11/9/2006	2.19575	ND	0.01355	0.82905	2.27707	2.11216	0.04744	28.48823	0.01129	0.03163	0.35014	121.17269
HCH	11/9/2006	1.81448	ND	0.00837	0.30707	1.46275	2.14667	0.03350	30.30176	0.00558	0.02512	0.25403	113.00003
MST	11/9/2006	1.03082	ND	0.00656	0.14258	0.77517	0.93085	0.01311	14.82320	0.00328	0.01311	0.12455	50.90201
CH	Sun 17/9/2006	1.73544	ND	ND	ND	1.63915	1.97725	0.03852	24.85256	ND	ND	0.45151	89.87495
HCH	17/9/2006	1.67201	ND	ND	ND	0.96667	2.57405	0.03653	30.83797	ND	ND	0.28663	82.22335
RPO	17/9/2006	2.18781	0.00677	0.01355	0.23368	2.41134	3.21399	0.05419	34.43266	0.01693	0.19982	0.82974	104.58154
CH	Fri 29/9/2006	1.89006	ND	0.01425	0.81919	2.12276	1.68823	0.04986	25.53485	0.00950	0.08548	0.37041	116.96545
HCH	29/9/2006	2.30861	ND	0.00841	0.16810	0.79849	2.68685	0.01681	31.99561	0.02802	0.02802	0.34741	65.50414
MST	29/9/2006	1.69863	0.00419	0.01678	0.22858	1.91882	1.87478	0.04404	24.20857	0.01468	0.07759	0.39425	128.13092
RPO	29/9/2006	2.20956	ND	0.01435	0.26902	2.69022	3.28206	0.04663	36.42194	0.01076	1.26261	1.52446	108.68474
CH	Thr 5/10/2006	2.24395	0.00449	0.01348	0.85131	2.14961	2.14736	0.05166	27.70902	0.01797	0.04043	0.39084	118.77861
MST	5/10/2006	1.58201	0.00343	0.00857	0.22625	1.26835	1.68999	0.03428	20.80441	0.03428	0.02914	0.24339	86.52221
RPO	5/10/2006	3.59536	ND	0.01917	0.18398	11.94364	3.65669	0.08816	50.31201	0.01150	0.03833	0.34114	121.81286

Sites	Date	Al	Cd	Cr	Cu	Fe	K	Mn	Na	Ni	Pb	Zn	TSP
CH	Wed 11/10/2006	2.37029	0.00048	0.01189	1.02705	1.66895	2.11590	0.04517	38.45239	0.00951	0.03566	0.28529	104.32120
HCH	11/10/2006	2.52627	0.00055	0.00832	0.14420	0.81251	2.42922	0.02496	44.16683	0.00277	0.02218	0.19966	67.16397
MST	11/10/2006	1.70198	0.00052	0.01223	0.17998	1.78761	1.63907	0.04543	23.42235	0.00699	0.03320	0.29531	137.83607
RPO	11/10/2006	3.09065	0.00151	0.02270	0.23454	5.14856	3.52190	0.09457	50.28637	0.02270	0.15510	0.76037	166.82681
CH	Mon 23/10/2006	2.22462	ND	ND	ND	1.60154	1.96616	0.03462	29.24086	ND	ND	0.29077	102.92339
HCH	23/10/2006	2.37660	ND	ND	ND	1.51086	2.51065	0.03072	32.65247	ND	ND	0.24855	110.92679
RPO	23/10/2006	2.49348	ND	ND	ND	2.47223	3.03185	0.04959	38.56044	ND	ND	0.48170	131.97042
CH	Fri 10/11/2006	2.26000	0.00150	0.01250	0.76750	2.27250	2.69750	0.07500	29.74750	0.01000	0.07750	0.47500	163.70000
HCH	10/11/2006	2.43990	0.00112	0.00837	0.33221	1.70290	2.79164	0.06142	30.70528	0.00558	0.05025	0.45225	141.36880
MST	10/11/2006	2.09314	0.00119	0.01388	0.19623	2.39443	2.60454	0.07929	24.24758	0.00991	0.05550	0.44400	172.52589
RPO	10/11/2006	3.35350	0.00373	0.01494	0.44813	7.87213	4.86220	0.14564	51.50497	0.01494	0.20166	0.88879	239.45030
CH	Thr 16/11/2006	2.57317	0.00134	0.01341	0.76905	2.70507	2.67601	0.08495	27.63420	0.01118	0.06483	0.30851	170.39713
HCH	16/11/2006	2.64803	0.00112	0.00837	0.26229	1.76907	3.08890	0.06418	36.84078	0.00558	0.05860	0.32368	137.22864
MST	16/11/2006	2.57400	0.00360	0.01441	0.17652	2.72351	2.71630	0.09186	25.63918	0.18553	0.12609	0.37827	151.08994
RPO	16/11/2006	4.84611	0.00803	0.02008	0.51392	6.09076	6.14295	0.16060	55.94100	4.60922	0.19272	0.78293	313.57150
CH	Tue 28/11/2006	3.35521	0.00458	0.02063	0.43544	4.18714	2.74559	0.10084	32.45435	0.11230	0.05500	0.61191	200.44186
HCH	28/11/2006	2.68247	ND	0.01678	0.38041	1.95521	2.74121	0.04755	34.08614	0.01958	0.04755	0.39160	130.06775
MST	28/11/2006	2.45082	0.00365	0.01641	0.16229	2.86111	2.04600	0.06382	24.13072	0.12400	0.04376	0.28082	167.76443
RPO	28/11/2006	3.55690	0.00725	0.01450	0.31544	10.00718	3.72731	0.10515	46.39560	0.02538	0.06164	0.48223	164.61084
CH	Sat 16/12/2006	2.73919	0.00446	0.00892	0.66026	2.52059	2.69904	0.10484	28.44027	0.00892	0.08699	0.29444	140.26071
HCH	16/12/2006	3.25575	0.00554	0.00831	0.27986	2.21114	3.27237	0.07758	35.27293	0.55971	0.05819	0.39623	147.35384
MST	16/12/2006	2.45893	0.00406	0.01219	0.37189	2.25368	2.26181	0.05487	25.77609	0.04674	0.03658	0.23776	123.75936
RPO	16/12/2006	3.86573	0.00705	0.01057	0.20439	4.93699	4.09126	0.13743	42.26573	0.26077	0.08810	0.56030	195.99966
CH	Thr 28/12/2006	3.80484	0.00545	0.01907	0.74626	4.15073	4.18342	0.10350	37.93400	0.82252	0.08171	0.43850	231.01393
HCH	28/12/2006	3.36185	0.00555	0.01110	0.19155	2.59843	4.61387	0.11104	36.95818	20.02676	0.05830	0.36922	180.50181
RPO	28/12/2006	5.11911	0.00740	0.01851	0.21468	10.49363	7.50285	0.19248	51.26516	5.53738	0.13695	0.76250	361.92831



Sites	Date	Al	Cd	Cr	Cu	Fe	K	Mn	Na	Ni	Pb	Zn	TSP
HCH	Wed 3/1/2007	2.97745	0.00557	0.00835	0.14748	1.83934	4.05434	0.06122	37.43238	2.32631	0.03896	0.24766	138.46531
MST	9/1/2007	3.84079	0.00440	0.01979	0.16709	5.02359	3.53740	0.15170	27.58028	1.54775	0.06156	0.38914	253.31205
HCH	Sat 20/1/2007	2.58669	ND	0.00836	0.25086	1.36303	2.55324	0.03624	35.33281	0.00557	0.02230	0.22857	95.94158
MST	20/1/2007	1.96661	0.00321	0.00803	0.11398	1.66801	1.59737	0.03532	24.00875	0.00482	0.02248	0.15893	86.37048
RPO	20/1/2007	3.31084	ND	0.00671	0.47298	3.24039	3.11292	0.03019	50.83995	0.01677	0.01342	0.16101	75.27372
HCH	Fri 2/2/2007	3.89670	0.00554	0.01386	0.16906	3.27035	5.62056	0.14412	38.81735	1.71277	0.21895	0.58201	251.09612
MST	2/2/2007	3.08167	0.00398	0.01393	0.17905	4.30518	4.19377	0.14722	24.69711	0.10345	0.15120	0.48941	259.98209
CH	Sun 20/2/2007	2.11044	ND	0.01291	0.95518	2.03299	1.89531	0.04948	29.22346	0.63249	0.02366	0.29258	92.46351
HCH	20/2/2007	2.48238	ND	0.00838	0.29878	1.58604	2.35673	0.04468	34.90970	1.55533	0.02234	0.28482	91.25331
RPO	20/2/2007	3.13478	ND	0.01011	0.32359	2.34940	2.63254	0.03371	45.42727	0.91684	0.01685	0.16854	83.39176
MST	Sun 4/3/2007	1.57757	0.00319	0.00479	0.05742	1.18996	1.70359	0.02712	21.69204	0.28553	0.01436	0.14675	70.53622
CH	Sat 10/3/2007	2.16758	0.00427	0.00854	0.90547	1.60807	2.24446	0.03844	32.54147	0.70900	0.01922	0.21569	75.42754
HCH	10/3/2007	2.78373	ND	0.01122	0.29746	1.49289	2.80338	0.04490	40.79067	0.56124	0.02526	0.31429	96.02757
RPO	10/3/2007	2.99971	ND	0.00665	0.23944	4.16367	2.93319	0.02993	48.70367	0.85801	0.00998	0.10642	76.35619

## **BIOGRAPHY**

Miss. Thitima Rungratanaubon was born on March 20, 1974 in Chantaburi province. She received her B.Sc in General Science (concentrated in Environmental Science) from Chulalongkorn University. She also received B.P.H in Occupational Health and Safety, B.Ed in Educational Administration, B.Ed in Measurement and Evaluation from Sukhothai Thammathirat Open University. She obtained her Master's degree in Environmental Science from Chulalongkorn University. She has worked as lecturer at Department of Environmental Science, Faculty of Science Kasetsart University since 1997 to present.